Examining the health and well-being of Fly-in Fly-out workers and their partners: a multi-method approach

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This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University (Australia)
and the University of Aberdeen (UK)

May 2023

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made. This thesis contains no material which has been accepted for any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated 2018. The research project was approved by the Curtin University Human Research Ethics Committee, Approval reference numbers: HRE2020-0693 and HRE2020-0180 (Appendix A).

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Date: 10.05.2023

Acknowledgements

Firstly, I give thanks and adoration to the almighty God for abundant mercy and grace of life, favour, strength and protection from the start through to the end of this PhD journey.

I express my sincere gratitude to my supervisors: Professor Suzanne Robinson, Dr Dominika Kwasnicka, Dr Daniel Powell, Dr Marshall Makate and A/Professor Richard Norman and thesis chair: A/Professor Delia Hendrie for their immerse support and excellent guidance throughout my PhD journey. My special thank you goes to Professor Suzanne Robinson, Dr Dominika Kwasnicka, and Dr Daniel Powell for their infinite support, mentorship and immerse contributions to the work in this thesis. I enjoyed the cordial and jovial atmosphere and the joyous moments we shared at every single PhD meeting throughout this journey. Thank you, team, for making this journey a memorable one.

I would like to dedicate this thesis to my family: my lovely wife-Henrietta Yaa Yeboaa, my daughters-Ama Kusiwaa Yeboah Asiamah-Asare and Yaa Asorsika Yeboah Asiamah-Asare, my siblings-Eric Afriyie, A/Professor Bismark Dwumfour-Asare, Doris Mprengo-Asare, Ing James Agyarko-Mensah, and Cecilia Animboaa-Asare- and parents-Asare Bediako and Rose Dapaah, for their continuous love, prayers, and complete support.

A huge thank you goes to the Aberdeen-Curtin Alliance International Postgraduate Research Scholarship and Research Stipend Scholarship of the University of Aberdeen, Scotland and Curtin University, Australia for funding and making this project possible. I extend appreciation to Mineral Resources Limited (Australia) for also providing funding support to the research and granting me the opportunity to visit a FIFO mining operation site at their Windarling site. I say thank you, Mineral Resources, for the awesome FIFO experience. Special thanks go to Chris Harris for making this trip possible and memorable.

I express my sincere gratitude to all the FIFO workers and the partners of FIFO workers who took the time to participate and contribute to the success of this PhD research.

I would like to extend my sincere gratitude to Professor Christopher Reid, Dr Elizabeth Thomas, Dr Jacquita Affandi, Mr Chris Harris, Mr Chris Ellison, Mr Myles Schammer, Mr Paul Brown, and Mr Pilbeam Matthew for their contributions to the additional work presented in this thesis.

I express my sincere gratitude to Ms Diana Blackwood and Ms Vanessa Varis, Librarians for the Faculty of Health Sciences at Curtin University for their professional assistance in developing the review search strategy.

Lastly, a huge thank you goes to my friends and all those who supported me; including Dr and Mrs KJ Adusei of Christian Impact Centre (CIC), Mr Micheal Weston (Workplace Peer Support Coach and Mentor), Mr Enock Badu Fordjour, Sylvester Dodzi Ndanunu, Matthew McDonald, my housemates: Dr Ainalem Nega, and Fisal Asiri, and to my dearest Ms Vanessa Nana Akua Mensah, thank you for the support.

Acknowledgement of Country

We acknowledge that Curtin University works across hundreds of traditional lands and custodial groups in Australia, and with First Nations people around the globe. We wish to pay our deepest respects to their ancestors and members of their communities, past, present, and to their emerging leaders. Our passion and commitment to working with all Australians and peoples from across the world, including our First Nations peoples are at the core of the work we do, reflective of our institutions' values and commitment to our role as leaders in the Reconciliation space in Australia.

Abstract

Introduction: Fly-in fly-out (FIFO) work is a regular employment arrangement in the resources industry in Australia involving relatively long periods rotating between being at work or home. There is mixed evidence on the impact of such work arrangements on the health and well-being of workers and their partners, with evidence relatively absent on physical health, health-related behaviours, and its impact on work productivity. In addition, it is well-known that occupational stress, psychological states, and health-related behaviours can vary day-to-day, yet there are few studies examining within-person dynamics of the FIFO lifestyle during on- and off-shift days. This thesis aimed to address the following objectives:

1. Synthesise the existing evidence identifying common health outcomes and behaviours in FIFO workers and their families;
2. Examine the psychological well-being, physical health and health-related behaviours of FIFO workers and their partners during on and off-shifts periods of a FIFO roster cycle;
3. Evaluate the work productivity loss cost associated with the common health and related health behaviours of FIFO workers;
4. Examine changes in affective states and health-related behaviours in FIFO workers and their partners over the course of a FIFO roster cycle and examine within-person work-related determinants.

Methods: The research approaches employed multimethod designs in three phases. Phase 1, involved undertaking three systematic reviews using a narrative synthesis approach to address objective 1. Phase 2 consisted of a series of three cross-sectional surveys to address research objectives 2-3. Phase 3 employed ecological momentary assessment (EMA) and multilevel modelling to examine daily assessments of theoretical determinants of occupational stress and health outcomes to address research objective 4.

Results: Findings from phase 1 suggested a higher prevalence of psychological distress in onshore FIFO workers than in offshore FIFO workers and the general population. Workers generally perceived their physical health status as good with high physical activity levels. However, there were relatively high rates of overweight and obesity. They had more sleep problems, poorer nutrition and higher levels of smoking during work periods; and higher alcohol intake during off-site days. The findings also suggested that the impact of FIFO work on the mental health and well-being of partners and children of workers were mixed, but shows a tendency towards negative impact.

Phase 2 results confirm the higher prevalence of psychological distress, smoking and alcohol consumption and low consumption of fruits and vegetables, perceived good physical health, and sufficient physical activity among FIFO workers and partners. In FIFO workers, a high risk for poor health outcomes was associated with 3.87% more productivity loss and accounted for an annual additional productivity loss cost of AUD 20.96 million per 1000 workers.

Phase 3 findings indicated that workers showed significantly lower positive affect, poorer sleep quality, and consumed less alcohol during on-shift compared to off-shift days. Partners reported higher depressed affect during on-shift days and higher alcohol consumption during off-shift days. The research found that within-person job demand was associated with higher anxiety and within-person job control was associated with lower anxiety and depressive affect, higher positive affect, and increased physical activity and alcohol consumption among FIFO workers. Similarly, in partners, findings suggested daily increases in job demands were associated with high anxiety, whereas daily increases in job control and social support were associated with lower depressed affect and positive affect.

Discussion/conclusion: The research presented in this thesis makes a substantive contribution to the existing body of evidence examining the health impact of FIFO work on workers and their families. This work demonstrates that psychological distress, smoking, alcohol intake, sleep problems and overweight/obesity are recurrent and ongoing concerns among many FIFO workers and their partners and their important impact on productivity loss. The research provides evidence of important daily variability in potentially modifiable aspects of FIFO work that could be targeted in future interventions to help alleviate its impact on health and well-being.

COVID-19 Statement

The original intention was to conduct a comparative study between onshore FIFO mining workers in Western Australia and offshore FIFO oil and gas workers in Aberdeen, Scotland. Unfortunately, due to the COVID-19 pandemic and the accompanying restrictions, I could not travel to Scotland to engage companies, recruit and conduct the study among offshore FIFO workers, and as such the comparative aspect of the research had to be abandoned. Furthermore, due to COVID-19 restrictions in Western Australia we were unable to work/collaborate with several FIFO mining organizations during the data collection stage as initially intended as several of these companies limited their operations and/or there were restricts on access to offices, worksites and workers and that may have resulted in the lower number of participants recruited in the research.

Additionally, COVID-19 restrictions occasioned changes in FIFO work arrangements including prolonged FIFO rosters and restricted workers travelling back home. These measures and increases in stress caused by COVID-19 have been potentially associated with the negative impact on the health outcomes variables assessed in the research including psychological distress (and affective states) and health behaviours (alcohol intake, smoking, fruits and vegetable intake, and physical activity) and could/will have impacted the results of this research. However, the pandemic allowed us to extend some of our research activity to conduct two additional systematic reviews to the one initially intended. It also provided an opportunity for additional work on the impact of COVID on the FIFO workforce, which was not initially planned.

Financial support

The PhD project was funded by the Aberdeen-Curtin Alliance International Postgraduate Research Scholarship and Research Stipend Scholarship of the University of Aberdeen, Scotland and Curtin University, Australia (Curtin ID: 17619778; Aberdeen ID: 51987326).

The Mineral Resources Limited, Australia also supported this PhD project by providing shopping vouchers to the winners of a raffle draw as reimbursement for study participation in the project.

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I acknowledge that these represent my contribution to the above research output and I have approved the final version.
Signed: 03/05/2023</td></tr>
</table>

Note: *The* contribution presented above stands for each paper the contributor was involved.

Peer-reviewed publications included in the thesis

1. **Asare BY**, Kwasnicka D, Powell D, Robinson S. Health and well-being of rotation workers in the mining, offshore oil and gas, and construction industry: a systematic review. BMJ Global Health. 2021;6(7):e005112. doi: 10.1136/bmjgh-2021-005112

2. **Asare BY**, Robinson S, Powell D, Kwasnicka D. Health and related behaviours of fly-in fly-out workers in the mining industry in Australia: a cross-sectional study. International Archives of Occupational and Environmental Health. 2022;96:105–120. doi: 10.1007/s00420-022-01908-x

3. **Asare BY**, Makate M, Powell D, Kwasnicka D, Robinson S. Cost of Health-Related Work Productivity Loss among Fly-In Fly-Out Mining Workers in Australia. International Journal of Environmental Research and Public Health. 2022;19(16):10056. doi: 10.3390/ijerph191610056

4. **Asare BY**, Powell D, Robinson S, Kwasnicka D. Rotation work in the resources sector: a systematic review of the impact on workers' families. Psychology and Health. 2023. 1-30. doi: 10.1080/08870446.2023.2190348.

5. **Asare BY**, Kwasnicka D, Robinson S, Powell D. Health and related behaviours of partners of fly-in fly-out workers in Australia: a cross-sectional study. Community, Work & Family. 2022:1-20. doi: 10.1080/13668803.2022.2100741

6. **Asare BY**, Robinson S, Kwasnicka D, Powell D. Application of Ecological Momentary Assessment in studies with rotation workers in the resources and related construction sectors: A systematic review. Safety and Health at Work. 2022;14(1): 10-16. doi: 10.1016/j.shaw.2022.10.004

Articles under consideration for publication and included in the thesis

1. **Asare BY**, Robinson S, Powell D, Kwasnicka D. Impact of Fly-in Fly-out work on health behaviours and affective states: a daily diary study. Stress and Health. [Manuscript under review].

2. **Asare BY**, Robinson S, Kwasnicka D, Powell D. Impact of Fly-in Fly-out work on health behaviours and affective states of partners of workers: a daily diary study. Coomunity, Work and Family. [Manuscript under review].

Additional peer-reviewed publications relevant to the thesis

1. **Asare BY**, Thomas E, Affandi JS, Schammer M, Brown P, Pilbeam M, Harris C, Ellison C, Kwasnicka D, Powell D, Reid CM. Mental Well-Being during COVID-19: A Cross-Sectional Study of Fly-In Fly-Out Workers in the Mining Industry in Australia. International journal of environmental research and public health. 2021;18(22):12264. doi: 10.3390/ijerph182212264

2. **Asare BY**, Thomas E, Affandi JS, Schammer M, Harris C, Kwasnicka D, Powell D, Reid CM, Robinson S. Multiple health-related behaviours among Fly-In Fly-Out workers in the mining industry in Australia: A cross-sectional survey during the COVID-19 pandemic. PLoS One. 2022;17(10):e0275008. doi: 10.1371/journal.pone.0275008

3. Perski O, Keller J, Kale D, **Asare BY**, Schneider V, Powell D, Naughton F, Ten Hoor G, Verboon P, Kwasnicka D. Understanding health behaviours in context: A systematic review and meta-analysis of Ecological Momentary Assessment studies of five key health behaviours. Health psychology review. 2022;16(4):576-601. doi: 10.1080/17437199.2022.2112258

4. Perski O, Kwasnicka D, Kale D, Schneider V, Szinay D, Ten Hoor G, **Asare BY**, Verboon P, Powell D, Naughton F, Keller J. Within-person associations between psychological and contextual factors and lapse incidence in smokers attempting to quit: A systematic review and meta-analysis of Ecological Momentary Assessment studies. Addiction. 2023. doi: 10.1111/add.16173

5. Kwasnicka D, Kale D, Schneider V, Keller J, **Asare BY**, Powell D, Naughton F, Ten Hoor GA, Verboon P, Perski O. Systematic review of ecological momentary assessment (EMA) studies of five public health-related behaviours: review protocol. BMJ open. 2021;11(7):e046435. doi: 10.1136/bmjopen-2020-046435

Conference presentations

1. **Asare BY**, Kwasnicka D, Powell D, Robinson S. Health and well-being of rotation workers in the mining, offshore oil and gas, and construction industry: a systematic review. Presented at the 35th Annual Conference of the European Health Psychology Society, Virtual event. 2021. Oral presentation. URL:https://osf.io/jytvx/

2. **Asare BY**, Kwasnicka D, Powell D, Robinson S. Rotation work in the resources sector: A systematic review of the impact on workers' families. Psychology and Health. Presented at the Australian Public Health Conference 2021, Canberra, Australia. Poster presentation (Virtual).

3. **Asare BY,** Kwasnicka D, Robinson S, Powell D. Health and related behaviours of partners of fly-in fly-out workers in Australia: a cross-sectional study. Presented at the 36th Annual Conference of the European Health Psychology Society, Bratislava, Slovakia. 2022. Poster presentation (Virtual).

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List of Abbreviations

ANOVA: Analysis of variance

AUD: Australian dollars

AUDIT-C: Alcohol Use Disorders Identification Test-Concise

AWST: Australian Western Standard Time

BIBO: Bus-In Bus-Out

BMI: Body Mass Index

CI: Confidence Interval

COVID-19: Coronavirus disease

DIDO: Drive-In-Drive-Out

TAFE: Technical and Further Education

FIFO: Fly-In Fly-Out

ICCs: Intraclass Correlation Coefficients

IPAQ: International Physical Activity Questionnaire

IQR: Inter Quartile Range

JBI: Joanna Briggs Institute

JDR: Job Demand and Resources

LDC: Long Distance Commuting

MET(s): Metabolic Equivalent Minute(s)

MVPA: Moderate Vigorous Physical Activity

PANAS-X: Positive and Negative Affect Schedule - Expanded Form

PCS: Physical Component Summary

PSA: Probabilistic Sensitivity Analyses

OR: Odd Ratio

SCM: Spillover-Crossover Model

SISO: Ship-In Ship-Out

SMS: Short Messaging Service

WA: Western Australia

WPAI-GH: Worker Productivity and Activity Impairment-General Health

VIF: Variance Inflation Factor

Chapter 1: Introduction

Preface

This chapter introduces the concept of Fly-In Fly-Out (FIFO) work, provides an overview of the research problem addressed in this thesis, and the significance of this research. It outlines the research aim and objectives, provides an overview of the research approach, and concludes by outlining the structure of the thesis.

1.1 Introducing Fly-In Fly-Out (FIFO) work

Globally, Fly-In Fly-Out (FIFO) work is increasingly used in the natural resources sector (1), including onshore mining in Australia, oil sands mining in Canada, offshore oil and gas in the North Seas of Norway and the UK, the Gulf of Mexico in the USA, and oil/gas extraction in the Arctic/Far North (1–4). Initially designed to staff operations in remote offshore oil fields in the Gulf of Mexico (1), FIFO work has become a common practice in onshore mining sectors. FIFO work in onshore mining sectors has primarily been driven by improved flexible and low-cost transportation and communication systems (2,3) compared to the cost associated with developing, maintaining, and decommissioning of 'single-industry communities' (3,5), and the associated comparative simplicity of start-up, closure, build-up and scale-down (1).

FIFO work involves travelling long distances to work in isolated areas, with schedules made up of a continuous period working (and living) onsite followed by another period spent at home on days off (2). FIFO work is characterised by a 'rotational work schedule' (referred to as a roster system), e.g., eight days at work followed by six days at home (5–7), transportation paid for by the employer and the provision of onsite accommodation (1). Typically, FIFO shifts are relatively long, with a standard of 12 hours per day (5), and have various shift patterns with rotations including regular day shifts, regular night shifts, or a mix of days and nights (7).

FIFO work practices in the oil sands in Canada are similar to those in Australia (1). Offshore workers in Norway and the UK and oil/gas extraction workers in the Arctic/Far North are mostly on longer rotations than onshore FIFO workers in Australia. A typical rotation for offshore workers may include two weeks at work followed by two weeks at home, two weeks at work followed by three weeks off, or four weeks at work followed by four weeks at home (8) with up to 7.4 weeks (52 consecutive days) at work (4). Workers are also more likely to work overtime (9), have their accommodation shared by two workers and have leisure activities facilities confined to the work installations (8,10).

In Australia, Fly-In-Fly-Out (FIFO) is the most common arrangement for rotation work in the onshore mining sector (7,11). It is estimated that 50% of all natural resources and construction work sectors have some form of work requiring long-distance commuting (12), accounting for about 17% of all employment in the regional areas (13,14). In Australia, a typical rotation can include eight days at work followed by six days at home or two weeks at work followed by one week at home (2,7,8). Onshore mining onsite accommodation and recreational facilities are often not confined and could be nearby the worksites (1).

1.2 FIFO work challenges and benefits

FIFO work involves a unique lifestyle primarily dictated by the working pattern. Given these FIFO rotation cycles, workers usually would have to step away from at-home domestic responsibilities and commitments to the family (15–17). However, when workers are home, again for a prolonged period, they have time to focus on family commitments.

While managing a FIFO lifestyle may be difficult, the work arrangements may also benefit workers and employers. FIFO work arrangements usually attract relatively high salaries (18,19), provide relatively long periods of leave for workers to be with family and friends (3), keep work and home commitments separate, and offer the chance for families to continue living urban lives and maintaining social connections (3,20). Organisations rely on

FIFO work arrangements to supply skilled labour to operations in remote areas where there is a labour shortage (1,2,21) and as ways of moving workers during construction phases and between short-life mining sites (3). Over the last decade, the mining industry has increasingly preferred FIFO working due to flexible and cost-effective FIFO work arrangements (11). FIFO work arrangements are not limited to the resources sector (5), with similar approaches in Australia's health and education sectors (22). However, there are challenges associated with the FIFO lifestyle, including the social and health impact on workers and their families (23–25), with calls for more research on the health impact of FIFO work (25).

1.3 Research problem statement

1.3.1 Limited and conflicting evidence on the impact of FIFO work on health

The impact of FIFO work on the physical and mental health, and health behaviours, of workers and their families, has become a concern in Australia (7,25,26). A government investigation has highlighted the impact of FIFO work, particularly on workers' mental health, as an ongoing concern in Australia (25). Studies have demonstrated that the FIFO lifestyle may be a source of stress that is over and above what one would expect to see in the general population (7,23,27,28). Data has shown higher levels of psychological distress (27–29) and health-risk behaviours such as high alcohol intake (7,23,30,31), and suicide risk (32). However, there are mixed findings across mental health and well-being outcomes and relatively few studies on physical health and health-related behaviours.

(25)(25)(25)The FIFO lifestyle of consistently separating workers from their families is indicated to increase physical and emotional demands on at-home partners; it can be a potential source of distress for workers' families (15,22). FIFO work arrangements are indicated to directly impact FIFO workers' families (27), including at-home partners and their children. Studies have documented a higher prevalence of psychological distress (7,33) and loneliness (34) and alcohol intake (7,35) in partners than in the general population. Similar to

FIFO workers, there are mixed findings across mental health and well-being outcomes and relatively few studies on physical health and health-related behaviours in partners of workers. Furthermore, the impact of FIFO work on workers and their families has not been contextualised within available theories and theoretical frameworks (7,36).

The Job Demands and Resources (JD-R) model is used as the wider theoretical framework to explain the impact of FIFO work-related characteristics on the health of FIFO workers and their partners throughout the thesis. The JD-R model suggests that job-related strains are caused by factors broadly classified as job demands (aspects that need persistent mental and/or physical exertion or abilities and so related to physical and mental costs) and job resources (job features that support attaining work objectives, lessen demands of the job and the related physical and mental consequences) (37,38).

Some FIFO work characteristics are pertinent to the JD-R model. For instance, the emotional demands of dealing with living away from families, loneliness and social isolation, concerns about keeping family and social relationships, and absence from significant family occasions during extended work periods (15,39). The workload inherent within FIFO roles with high demands of compressed rosters, and long shift hours, are indicated as important stressors among FIFO workers (40). On the other hand, FIFO workers often earn higher wages relative to similar occupations (2), have long leave periods and, during work periods, are not involved in domestic commitments (15). The JDR is applied to synthesize available evidence, explain the findings of primary studies and its constructs assessed to explain the within-person health of workers and their partners in several chapters of the thesis. Other theories and models have also been highlighted, including Work-Family Conflict Theory (41) and the Spillover-Crossover Model (42) to explain how the pressures of rotation work demand impact the well-being of workers and their families; and Attachment Theory (43) and

Social Ecological Theory (44) to explain the potential effects on partners and children of temporary separations due to FIFO work.

1.3.2 Limited empirical research on the impact of FIFO work on work productivity

Work productivity, related to work impairment, is an essential determinant of efficiently accomplishing an organisation's workplace tasks and goals (37). The level of work impairment indicates how much health problems make it challenging to complete duties at work (37). Health problems that cause work impairment relate to absenteeism (i.e., absences of a worker from work) and presenteeism (i.e., present at work but not able to function fully) (38). Work impairments provide a strong indication of the health status of workers (45), and are associated with work productivity loss, a valuable economic indicator, providing significant evidence of the economic consequences of health problems (45).

Studies have shown that psychological distress (46) and multiple chronic and modifiable health behaviours (47) are associated with high indirect productivity loss costs from absenteeism and presenteeism. Economic evidence on the impact of work impairments and productivity is essential for organisations planning and rationalising investments into health interventions (39). Available studies are limited to Australia's general mining population where there may be differences in health outcomes between FIFO workers and other mining work groups (30,32,48); the only available study specifying work productivity loss cost for FIFO mining workers is limited to job stress outcome (49).

1.3.3 Limited research examining within-person processes in FIFO work

Health-related behaviours, as well as many psychological processes, vary day-to-day and even moment-to-moment. However, the current evidence examining the impact of FIFO work arrangements on health (7) has limited exploration of how within-person fluctuations (dynamics) in FIFO work and workload over time and between contexts impact the health of the worker and the partner (50). Examining within-person factors across time will allow for a deeper understanding of FIFO work lifestyles and provide evidence to inform the management and support offered to FIFO workers and their partners (7,51).

The existing within-person studies in FIFO work have shown that there are daily variations in health behaviours (13), sleep (52,53), emotional exhaustion, and work engagement (51) throughout the FIFO work cycle. The only known within-person design study examining the effects of FIFO job stress indicated that day-to-day variations in job demands, including higher daily workload and emotional demands, were associated with higher emotional exhaustion. In contrast, day-to-day variations in job resources, such as higher daily job autonomy, were associated with higher daily engagement (51). Previous research examining the effects of FIFO job demands and resources has been limited to on-shift work periods and construction FIFO workers in Australia. At the time of writing, no studies have explored FIFO mining workers over a complete FIFO work cycle in Australia. The lack of evidence is a concern and limitation given the variety in work patterns and conditions and the impact this can have on workers and their families (15).

1.4 COVID-19 pandemic and FIFO work

Common health outcomes of FIFO workers may be impacted by stressful events such as infectious outbreaks (54). In early 2020, the COVID-19 pandemic reached Australia, with the country recording its first case in January (55), prompting various public health measures, including social distancing, lockdowns, self-isolation or quarantine, and changes to work arrangements intended to reduce the spread of the virus (56). Western Australia (WA) at the time the research was conducted had the lowest COVID-19 infection rates in Australia. It also had very strict border controls and government policies around testing, contact tracing and quarantine for infectious individuals and those arriving in the state. These measures meant extended FIFO work periods for workers, prolonged separations from their families, and increased onsite solitude (57). The findings from the research have been considered within the context of the COVID-19 pandemic and the implications in terms of strengths and limitations are considered within the thesis. The pandemic allowed us to extend some of our research activity and provided an opportunity for additional work on the impact of COVID on the FIFO workforce. Evidence of the negative emotions, distress experiences, and risky behaviours among the vulnerable groups could inform and help provide practical support to lessen these negative experiences in FIFO work populations during stressful global events. The findings from these related studies are published online (58,59) and are included in Appendix B.

1.5 Significance of this research

This research is one of the first to present a broad overview of health-related outcomes in both FIFO workers and their families. From a within-person perspective, it is one of the first studies to examine job stress factors in FIFO work related to health and well-being outcomes in workers and their partners across the FIFO work roster cycle (on-and off-work periods). This research is also the first in Australia to test the moderation (buffering) of job resources on the effect of job demands on health outcomes, as proposed by the job demands-resources model (37,38) using within-person design in the FIFO mining context. The job demands-resources model is a popular model for considering occupational stress and informing interventions owing to its generality and flexibility (60), and organisations can use it to enhance the well-being of workers and motivation while also enhancing a number of organisational goals (38). In addition, this research is one of the few in Australia to provide insight into the productivity loss cost from absenteeism and presenteeism explicitly associated with the health outcomes of FIFO workers.

The research in this thesis addressed psychological and economic perspectives around FIFO work, with inputs from industry partners. The collaborations with the industry sector allowed for the generation of findings that could help inform future FIFO-related work and health policies. The present thesis builds on existing research and addresses current research gaps, including calls by Government investigations in Australia for more studies into the health impact of FIFO work arrangements (25,26) to clarify the key FIFO health outcomes in workers and their partners. This research has the potential to guide policy processes and practice, contributing to the understanding of within-person processes in FIFO job engagements (51) and guiding occupational health/health promotion practitioners' understanding of the mechanisms that support and impair daily job-related well-being of FIFO workers and their partners to guide interventions. This research also presents a financial justification for workplace health interventions.

1.6 Research Aim and Objectives

This research aimed to examine the health and cost of health-related work productivity loss in FIFO workers and their partners in Australia. This thesis aims to address the following objectives:

1. Synthesise the existing evidence identifying common health outcomes and behaviours in FIFO workers and their families;
2. Examine the psychological well-being, physical health, and health-related behaviours of FIFO workers and their partners during on-and off-shift periods of a FIFO roster cycle;
3. Evaluate the work productivity loss cost associated with the common health and related health behaviours of FIFO workers;
4. Examine changes in affective states and health-related behaviours in FIFO workers and their partners throughout a FIFO roster cycle and examine within-person work-related determinants.

1.7 Research Overview

This research contains three main elements, including 1) a series of literature reviews of health-related outcomes in both FIFO workers and their families that identified gaps in the existing literature; 2) a series of cross-sectional studies, including studies investigating the associations between aspects of FIFO work and health-related outcomes in workers and partners; and an economic costing study that focused on work productivity loss (absenteeism, presenteeism and both) among FIFO workers; and 3) the use of Ecological Momentary Assessment (EMA) methodology and within-person designs to explore within-person perspectives on job stress factors in FIFO work related to health and well-being outcomes in workers and their partners. An overview of the research focus and approach is outlined in Figure 1.

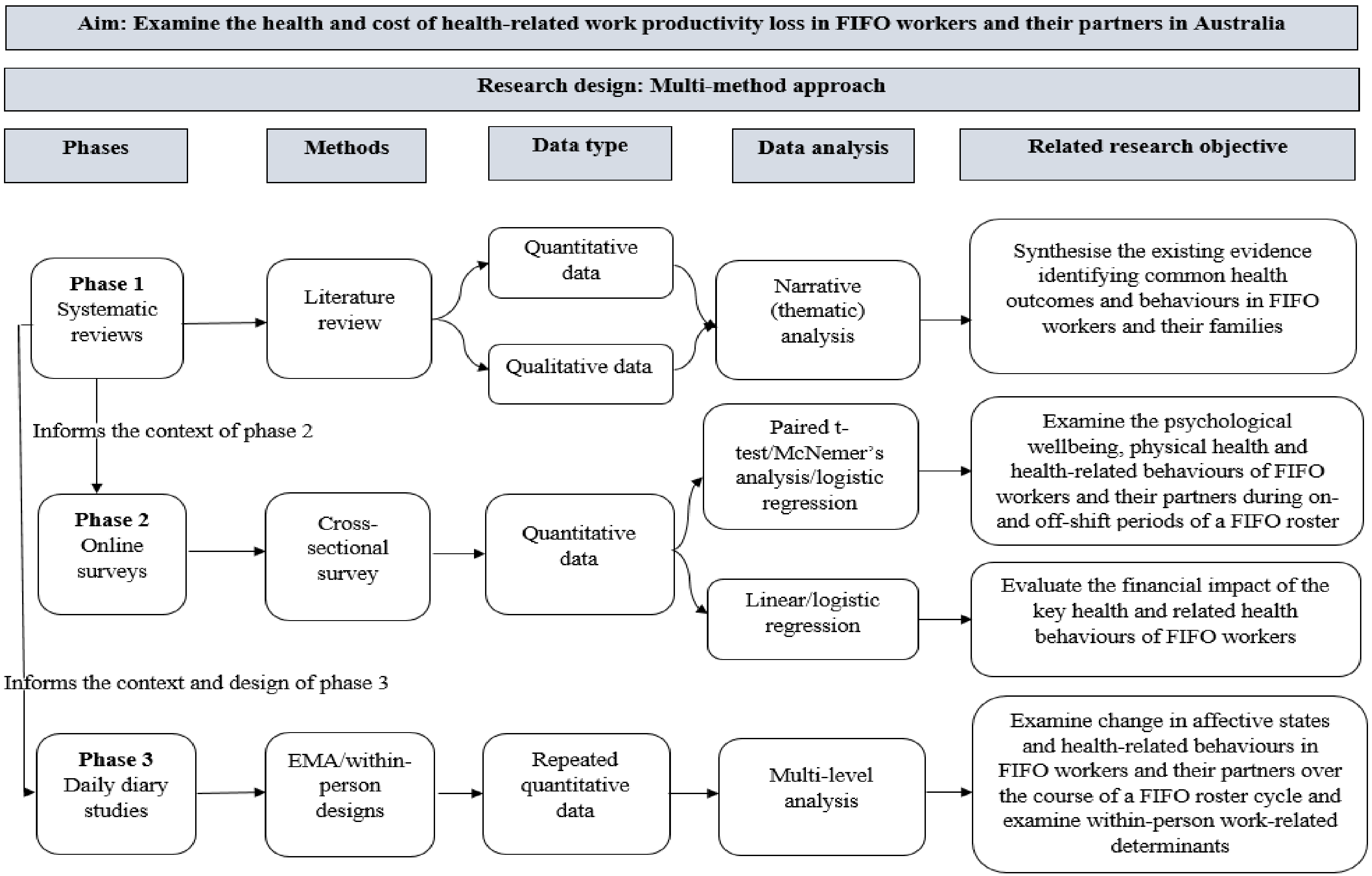

Figure 1. Overview of the research program

1.8 Structure of the Thesis

The thesis consists of 10 chapters divided into three parts that align with the above-mentioned phases (see Figures 1 and 2). Information on the content and focus of these chapters will be outlined below. The thesis begins with an introductory chapter (Chapter 1) that sets the context for the research, including an introduction to the FIFO work arrangements, an overview of the existing research and knowledge gaps, and the research objectives and significance.

Part 1 comprises three chapters (2-4) that explore the health and well-being of FIFO workers and economic analysis of FIFO work productivity costs. Part 2 includes Chapter 5, which focuses on the health and well-being of FIFO workers' families. Chapter 6 focuses on the psychological distress, physical health and related behaviours among the partners of FIFO workers. Part 3 (Chapters 7-9) explores the individual perspective of the health and well-being of FIFO workers and their family members, presenting evidence from the EMA/within-persons studies on the affect states, sleep and health behaviours of FIFO workers and partners. Chapter 10 provides a detailed discussion and conclusions of the key research findings. Below is a summary of each chapter:

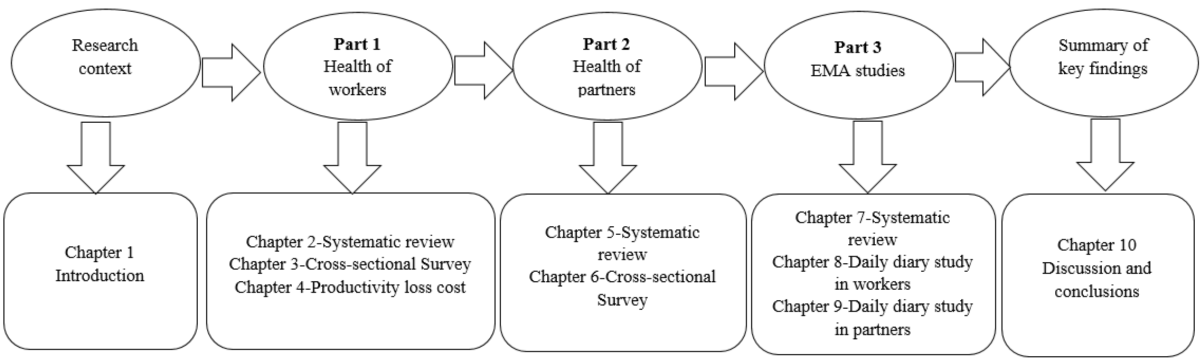

Figure 2. Flow diagram of thesis structure

Part One

Chapter 2 (published: (40)). Presents a systematic review of quantitative and qualitative studies of the impact of FIFO work on workers' health and well-being. The review identified the most prevalent issues, including distress, sleep, smoking, alcohol consumption, and potentially important theoretical determinants such as job demand and control. The review identified inconsistencies in psychological well-being and a need for more evidence in findings on the physical health and related behaviours of FIFO workers.

Chapter 3 (published: (61)). Reports on a cross-sectional questionnaire study among workers, analysis of the prevalence of psychological distress and poor physical health status, and inferential analysis showing their FIFO work-related predictors. The study (measuring sleep and health behaviours for two time-points) further identified the differences in the health behaviours of workers during on-and off-shift periods of the FIFO work cycle.

Chapter 4 (published: (62)). Presents a cross-sectional study of the work productivity loss costs associated with workers' key health and behavioural outcomes. The study estimated the cost due to work productivity losses through absenteeism and presenteeism, and assessed their FIFO work-related predictors.

Part Two

Chapter 5 (published: (63)). Provides a systematic review of the evidence relating to the impact of FIFO work on the health and well-being of families of FIFO workers. The review identified inconsistencies and a dearth of evidence in findings on the psychological well-being, physical health and behaviours of partners of FIFO workers. The review identified the most-prevalent issues, including psychological distress, sleep, and alcohol consumption.

Chapter 6 (published: (64)). Presents a cross-sectional study of the prevalence of psychological distress and poor physical health status and inferential analysis of FIFO work-related predictors in partners of workers. Furthermore, the study (measuring sleep and health behaviours for two time-points) identified the differences in sleep, physical activity, smoking, and alcohol consumption across on-and off-shift periods of the FIFO work cycle.

Part three

Chapter 7 (published: (65)). Presents a systematic review of EMA studies that assessed the health outcomes of FIFO workers. The review highlighted the critical methodological characteristics/features for a successful EMA/daily diary design in the FIFO work context.

Chapter 8 (under review). Presents the first EMA/daily diary study incorporating a multilevel analysis of the daily variations of affective states and health behaviours of FIFO workers and job-stress determinants across on-and off-shift periods. The study identified the within-person job demand and control determinants of daily health outcomes.

Chapter 9 (under review). Presents the first EMA/daily diary study that utilises multilevel analysis of daily variations of affective states and health behaviours in partners of FIFO workers and job-stress determinants across on-and off-shift periods. The study identified the within-person job demand and resources (control and social support) determinants of daily health outcomes.

Chapter 10. Provides a discussion of the key research findings. The chapter outlines the strengths and limitations of the research and concludes by providing implications for policy, practice and future research in FIFO work arrangement.

PART ONE: FIFO workers

Chapter 2: Study One

Preface

This chapter presents the first published study included in this thesis and is cited as:

> **Asare BY,** Kwasnicka D, Powell D, Robinson S. Health and well-being of rotation workers in the mining, offshore oil and gas, and construction industry: a systematic review. BMJ Global Health. 2021;6(7):e005112. doi: 10.1136/bmjgh-2021-005112

The paper's content here is as it appears in print, however, it has been formatted to be in keeping with the rest of this thesis. This review was an important initial step in the thesis, to identify key mental health outcomes, physical health outcomes, and health-related behaviours relevant to rotation workers, and to begin to identify potentially modifiable determinants where poorer outcomes were found in workers. It also served to highlight relevant research gaps and limitations in the extant literature, which could be addressed in later chapters within the thesis.

Author contributions: BYA, DK, DP and SR conceived and designed the study protocol. BYA developed the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment and drafted the initial manuscript. DK, DP and SR reviewed and contributed to the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment. BYA drafted the article and DK, DP and SR have reviewed and approved the final written manuscript.

Study One: Health and well-being of rotation workers in the mining, offshore oil and gas, and construction industry: a systematic review

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Acknowledgements

The authors extend their sincere gratitude to Ms Diana Blackwood and Ms Vanessa Varis, Librarian for the Faculty of Health Sciences, at Curtin University for their professional assistance in developing the review search strategy.

Competing interests

None declared.

Funding

The study was funded by Aberdeen- Curtin Alliance.

2.1 Abstract

Introduction. Rotation work, characterised by travelling long distances to work in isolated areas where workers typically rotate consecutive days working and living on-site with periods at home, is increasingly used in the resources and construction sectors globally. Such employment practices may have an impact on workers' health and well-being. This systematic review explores the impact rotation work has on mental and physical outcomes in rotation workers in the resources and construction sectors.

Method. The PubMed, Medline, EMBASE, CINAHL, PsycINFO, and Scopus databases were systematically searched on 1 May 2020 to identify quantitative, qualitative and mixed-method studies addressing the health of rotation workers published in peer-reviewed journals. Findings from the studies were summarised narratively.

Results. Of 6268 studies retrieved, 90 studies were included in the review. Studies suggested a higher prevalence of psychological distress in onshore rotation workers and higher overweight/obesity rates among rotation workers as compared with the general population. We found more sleep problems and higher levels of smoking during work periods compared with off- site days; and higher alcohol intake during off-site days compared with on-site days. Workers generally perceived their physical health status as good. High-perceived job demands (such as workload, and repetitive work) were associated with mental distress and exhaustion, sleep problems and perceived poor physical health status, while high-perceived job resources (such as job clarity/control, and support) were associated with low mental distress and exhaustion, less smoking and alcohol intake, and better sleep.

Conclusion. Rotation work is associated with several poorer health behaviours and outcomes, such as sleep problems, smoking, alcohol consumption and overweight/obesity. Interventions needed to improve rotation workers' health should include maximising available job resources and reducing job demands. Further longitudinal studies are needed to

explore the long-term health effects of rotation work and the short-term contextual effects of the different aspects of rotation work.

Keywords: rotation work, FIFO, long-distance commute, offshore oil and gas, mining, construction, systematic review

Key questions

What is already known?

- Rotation work arrangements of rotating consecutive days working and living on-site with periods at home are increasingly used in the resources and construction sectors around the world.
- Rotation employment is reported to be associated with several health and well-being issues among workers.

What are the new findings?

- Prevalence of psychological distress varied between onshore and offshore rotation workers; onshore rotation workers showed a higher prevalence than offshore workers and the general population.
- Studies suggested both onshore and offshore rotation workers had poorer sleep and more fatigue during on-shift days; smoked more, consumed more alcohol, and were more overweight and obese than the general population.
- Job demands of rotation work were associated with poor physical and mental health outcomes while available job resources were associated with better physical and mental health outcomes of workers.

What do the new findings imply?

- Studies are needed to identify the causal determinants of poorer health outcomes in rotation work, and investment in interventions to minimise their impact.

- There is a need for creating workplace environments that minimise the negative aspects of rotation workstyle and maximise the positive aspects to support rotation workers to reduce job stress and promote health.

2.2 Background

Rotation work is characterised by travelling long distances to work in isolated areas: workers typically rotate consecutive days working and living on-site with periods at home (2). Rotation work is commonly referred to as *Long Distance Commuting* due to the distance between work-site and home, which could be more than 100km. Other terms used to describe this type of work are: *Fly-In-Fly-Out* (FIFO), *Drive In Drive Out* (DIDO), *Bus In Bus Out* (BIBO) or *Ship-In Ship-Out* (SISO) based on the means of transport used (1,66). Rotation work differs from other mobile work arrangements by its 'rotational work schedule' of pre-specified consecutive days of work followed by leave periods, known as roster systems, which vary and can be even or uneven periods; e.g. 2 weeks work/2 weeks home, or 8 days work/6 days home (67). Other typical characteristics of rotation work are: extended working hours ranging between 10 to 14 hours (5) with an average of 12 hours per shift considered as standard (1,68); provision of accommodation at or near the worksite; living without families; and transportation arrangements between the worksite and home, commonly paid for or subsidised by companies (1,2). Working days are compressed into day and/or night shift patterns described as fixed/regular day shift or night shift and irregular/swing/rotational shift of day and night (68).

Rotation work is increasingly practised around the world in the resources sector, originally in the offshore oil and gas sector (5,66) where daily commuting is practically impossible (1) and, more recently, within onshore mining and related construction sectors, particularly in Australia and Canada (21,66). Rotation work is increasingly used as a result of resources boom leading to high demand for skilled labour; to staff operations in remote areas where labour is in shortage (1–3,21); and as a way of moving workers during construction phases and between short-life extraction sites (3) and cutting down the cost associated with developing, maintaining and decommissioning of 'single-industry communities' (3,5). Furthermore, the increasing use of rotation work in the onshore mining and related construction sectors has also been attributed to the lack of social amenities in remote communities preventing families from relocating nearby (1,3), and the improved flexible and low-cost transportation and communication systems (2,3).

However, the employment practices of workers differ between onshore sites and offshore installations. Offshore workers are mostly on more extended rosters; for example, typically 2 weeks on/2 or 3 weeks off in the UK (8) or 4 weeks on/4 weeks off in China (69) and work overtime (averaging more than 16 hours per week) (9), whereas onshore mining and construction-related sites mostly work shorter and asymmetric rosters (22); for example, 8 days on/6 days off in Australia (6,7). Offshore rotation workers typically share their on-site accommodation with another worker, leisure activities and facilities are normally confined to the work sites (with limited space, reduced illumination and aeration) (8,70) and are exposed to varying weather conditions such as strong wind and cold (68,71). Onshore rotation workers have typically not shared onsite accommodation, recreational facilities are often not confined and could be nearby worksites (1), and workers may be faced with dry and hot temperatures (72).

Working in a FIFO job usually attracts relatively high salaries with relatively long periods of leave to be with family and friends (3). Nevertheless, rotation employment is often associated with several health and well-being issues among workers (67,73). A narrative review of 26 studies has documented high levels of occupational stress, poor mental well-being, high body mass index (BMI, overweight and obese), musculoskeletal disorders, poor diet, limited physical activity, high rates of smoking and alcohol intake in offshore oil and gas workers (74). Another review of 53 studies to examine the impact of FIFO work on mental health and well-being highlighted higher levels of mental health problems among FIFO workers (mostly onshore) compared to the general population in Australia (7). Another review highlighted sleep disruptions and accumulated fatigue among rotation workers (67). The high risk of health problems among rotation workers has been associated with rotation work characteristics (67) including long work hours and shift patterns (68), demanding workload or tasks and occupational and environmental stressors (68), such as the lack of social support from supervisors and work colleagues (74). Two reviews that focused on offshore oil and gas workers (68,75) found offshore night shift workers experienced more sleep problems than dayshift workers, and that adaption to night work was faster than re-adaption to daytime work or at home. In the review by Parkes (68), offshore shift patterns were found to be associated with gastric complaints and impaired mental health. The research outlined suggests several possible psychosocial and health effects associated with rotation work. Although previous systematic reviews have highlighted the health impact of rotation work on workers, these reviews have focused on the effects of shift pattern arrangement on specific health outcomes (68,75), general health issues (19,74), and impact on mental health and well-being (7).

Meanwhile, these reviews were limited to specific working populations in the resource industry (e.g., offshore oil and gas workers) (19,68,74,75), and specific geographical settings (e.g. Australia and the North Sea, UK) (7,68). This current systematic review covers all the occupational populations in the resource (mining and offshore oil/gas) and construction sectors and is not limited to any geographical setting or specific health condition, to give a broad overview of the health impact of rotation work globally.

The objectives of this review are to synthesise: 1) the reported physical and mental health outcomes and health-related behaviours of rotation workers in the resource and construction sectors, and 2) work-related factors associated with the physical and mental health and health-related behaviours of the rotation workers.

2.3 Method

2.3.1 Study design

This study is a narrative systematic review of literature conducted following the guidelines of Joanna Briggs Institute (JBI) for quantitative and qualitative reviews (76) and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (77). The protocol of this review was pre-registered on PROSPERO (ID=CRD42020167649).

2.3.2 Eligibility criteria

The review included quantitative, qualitative and mixed-method studies, original articles, and published in peer-reviewed journals and English Language. The review included studies with participants who were rotation workers or *Long Distance Commuting* (LDC), or *Fly-In Fly-Out* (FIFO) or *Drive-In-Drive-Out* (DIDO) or *Bus-In Bus-Out* (BIBO) or *Ship-In Ship-Out* (SISO) and worked in the resource (offshore oil and gas, and mining) and construction industry. Rotation workers were defined as those who travel long distances to work in remote areas, operate long work hours (mostly for 12 hrs) and work shift patterns for a specified number of days, after which they come back home to spend another specified number of days. Studies which drew data from rotation workers, comparing them with other groups were included. Studies with more than 50% of participants classified as LDC, DIDO, FIFO, BIBO, SISO workers in the resources (mining and oil and gas) were also included.

Quantitative studies were included in the review if they measured and reported physical and mental health outcomes, health-related behaviours and/or work-related factors associated with health outcomes among rotation workers. Qualitative studies that discussed the impact of rotation work arrangement on the physical and mental health and well-being of rotation workers and the perception of the rotation work characteristics that influence their health and well-being were also included. Mental health is defined as a condition of mental well-being that allows individuals to deal with life's stressors, recognise their potential, pursue education and employment productively, and bring value to their society (78). The study considered the common indicators of mental health including psychological distress, depression, anxiety, stress, emotional exhaustion and burnout, suicide and psychological well-being.

We excluded studies that were reviews, research reports, editorials, book chapters, letters, conference proceedings, laboratory studies, study designs not clearly defined, or used proxy data (medical records or administrative data) as opposed to recruited participants' data. Studies that reported on adaption and re-adaption of circadian rhythm and cancers were excluded. The quantitative or qualitative components of mixed-method studies which do not report on participants' characteristics, data collection and analysis methods were excluded. Grey/unpublished literature was excluded due to time and resource constraints. Laboratory studies were also excluded so as to consider studies that reflected measures in the free-living population.

2.3.3 Data sources and search procedure

Six electronic databases including PubMed, Medline, EMBASE, CINAHL, PsycINFO, and Scopus were searched for peer-reviewed relevant publications with no restrictions on study designs, date of publication and geographical location. The search strategy used included two groups of terms related to health and rotation work. Health included search terms such as sleep, anxiety, depression, stress, fatigue, alcohol, smoking, "physical activity", exercise, overweight, obesity, "body mass index", diet, "mental health", "psychological distress", "physical health", sick*, ill*, well-being. Rotation work included search terms such as "Fly-in fly-out", FIFO, "long-distance commuting", "rotation shift", "rotation work shift", "Drive-in Drive-out", and offshore. The two main groups of terms were combined with ‘AND’ and the search terms within each group were combined with ‘OR’. Full search strategy including key terms and subject headings for each of the databases used are presented in Appendix C: Supplementary Information S1. Hand-searching for other relevant articles was done by reviewing the reference list of the included articles. Searches were conducted on 1st May 2020.

2.3.4 Study screening and selection

The citations identified were uploaded into Endnote and later to the *Covidence* software (79) and all duplicates were removed. Two of the authors (BYAA and DK) then screened the titles and abstracts of articles for eligibility. Full texts for all potentially eligible studies were retrieved and screened again for eligibility against the inclusion criteria. Differences that arose were resolved through the discussion, and suitable articles were included in the systematic review. Articles excluded at the full-text screening were recorded and the reasons that informed the exclusion of studies per the inclusion criteria were reported (Appendix C: Supplementary Information S2; Figure S1).

2.3.5 Assessment of methodological quality

The articles included in the review were evaluated for methodological quality independently by two of the reviewers (BYAA and DK). The tools for appraisal of quantitative descriptive studies in the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) and Joanna Briggs Institute Qualitative Assessment and Review Instrument (JBI-QARI) (80) were respectively used to assess the quantitative and qualitative studies included in the review. Issues of any differences that arose were resolved through discussion. Each tool has a checklist of items rated 'Yes', 'No', 'Unclear' and 'Not applicable' and was assigned a score of 1 for 'Yes', 0 for 'No' and 'Unclear', and not applicable items were excluded from the scoring. Studies were rated against the items on the checklists; tools for analytical cross-sectional and cohort studies included 9 to 11 items with possible scores between 0 and 11 while the tool for qualitative study assessment included 10 items and a study score ranged between 0 and 10. Scores were subsequently converted to give a percentage score (81) with scores below 50% considered low quality, 50-69% considered medium quality, and scores above 70% representing high quality. The quality assessment was not used to exclude studies from the review (82) and as stipulated by Luca *et al* (83) strictly using quality criteria for exclusion may exclude relevant studies based on not conforming with a specific reporting criterion. The quality assessment results were recorded and reported in the review to inform the interpretation of the findings.

2.3.6 Data extraction and Strategy for data synthesis and analysis

Standardised data extraction sheets (Appendix C) were developed based on the templates from the JBI-MASt ARI data extraction tool for quantitative data and JBI-QARI for the qualitative studies and piloted specifically for this study and were used to extract data from selected studies. For quantitative studies, the key information extracted included authors, year of publication, study design, aims/objectives, study setting and participants' characteristics, health outcomes, mode of measurement, and key findings. For qualitative studies, together with the study characteristics, perceptions of the physical and mental well-being and work-related characteristics that influence their well-being were extracted. One reviewer (BYAA) did data extraction and another researcher (DK) crosschecked 10% of the data. Any differences that arose were resolved through discussion.

Quantitative and qualitative data were extracted in terms of the studies' characteristics and key findings and table summaries were presented. The review aimed to explore health outcomes and related behaviours reported among rotation workers, and as such thematic analysis was done. Based on previous literature (7,67,68,74,75), we expected that studies would fit into four broad themes: mental health outcomes, physical health outcomes, sleep, and broadly defined "lifestyle" behaviours. Studies were narratively reviewed within these themes and further organised into subthemes as they emerged from the reviewed literature. Meta-analysis was not performed due to the high heterogeneity of study designs and assessment of health outcomes. We report effect sizes in-text where this was possible to do so briefly and meaningfully (for example, standardized effect sizes, were reported) and further methodological and statistical details can be found in Appendix C: Supplementary Information S3.

2.4 Results

2.4.1 Characteristics of studies

The initial searches retrieved 6,268 studies, of which 269 full texts were screened for eligibility, and 90 studies (76 quantitative, 10 qualitative and 4 mixed method studies) were included in the review (Figure S1). Included studies (Appendix C: Supplementary Information S3); published between 1987 and 2020, were conducted in several countries around the world: 25 in the United Kingdom (UK), 23 each in Australia and Norway, 6 in China, 3 in Iran, 4 in the Netherlands, 2 in Brazil, and 1 each in Sweden, the United States, Croatia and Canada. Forty-two of the studies examined outcome data on mental health and well-being, 38 studies on sleep problems and fatigue, 20 on BMI, 15 on perceived physical health status, and 14 studies each on alcohol intake and smoking, 11 each on physical activity and musculoskeletal disorders, 7 on diet/nutrition and 6 on gastric problems.

The majority of studies (*n*=64) were conducted with offshore oil and gas workers, 16 studies with mining workers, 5 with FIFO workers predominately from mining sectors, 3 with construction rotation workers, 1 with onshore oil workers and 1 with mining and construction workers. The majority of participants in the studies were males (average 91.2%), and all were aged between 16 and 68 years (mean of study means= 39.31±9.44 years). The majority (89.25%) of studies were rated medium-to-high on the JBI Quality Rating Scale: 58

of 90 studies e.g.,(13,29,32,51,84–94) rated ≥70% (high), 23 studies e.g., (73,95–100) rated 50-69% (medium), and 9 studies e.g.,(10,28,72,101–106) rated < 50% (low) (Table 1).

Table 1. Summary of characteristics of included studies

Characteristics	Number of studies	Reference
Study design		
Quantitative studies		
Cross-sectional studies	53	(9,10,27–29,32,69–73,84,93,94,96,97,99,101,103–105,107–138)
Longitudinal studies	23	(13,51–53,85–87,89–92,98,139–147)
Qualitative studies	10	(15,39,100,148–153)
Mixed method	4	(33,88,154,155)
Country		
United Kingdom	25	(9,92,96,97,100,101,104,105,107,109,112,113,120–125,127,133,134,142–144,147)
Australia	23	(13,15,27–29,32,33,39,51–53,72,73,84,98,99,110,131,132,148–151,153)
Norway	23	(71,89–91,93,94,103,114–118,126,128–130,139,141,145,146,154–156)
China	6	(69,70,135–138)
The Netherland	4	(85–88)
Iran	3	(108,111,140)
Brazil	2	(10,102)
Sweden	1	(95)
United States	1	(106)
Croatia	1	(119)
Canada	1	(152)
Industry		
Offshore oil and gas	64	(9,10,69–71,90–94,96,97,100–109,111–130,133–147,153–156)
Mining	14	(29,32,39,52,53,72,84,89,98,110,148–151)
Construction	3	(28,51,95)
Mining & construction	1	(27)
Onshore oil workers	1	(152)
FIFO/DIDO*	5	(13,15,99,131,132)
Health outcomes		
Mental health and well-	42	(13,15,27–

being		29,32,33,39,51,71,73,84,88,89,92,99,101,102,104,107,109,110,114,115,119–123,127,129,131,132,135–137,140,145,151,152,154,155)
Physical health		
Perceived physical health and complaints	15	(13,88,90,91,93,94,109,110,115–117,128,130,139,146)
Gastric problems	6	(69,90,93,94,118,123)
Musculoskeletal disorders	11	(70,88–90,93–95,108,123,152,155)
Sleep problems and fatigue	38	(9,10,13,39,52,53,85–89,91,93–95,98,102,107–111,113,118,121,122,124–126,128,140–144,146,148,156)
Lifestyle behaviours		
Alcohol	14	(13,29,39,72,88,98–100,104,105,109,132,138,149)
Smoking	14	(13,52,88,91,98–100,104,109–113,138)
Illicit drugs	2	(29,109)
Physical activity	11	(13,72,98–100,108–110,138,149)
Diet	7	(13,88,99,100,103,106,109)
BMI*	20	(10,52,85,87,88,96–99,108–110,112,133,134,140,142,143,147,156)
Quality rating*		
High	58	(9,13,15,27,29,32,33,39,51,52,69–71,84–90,92–94,113–138,145,146,148,150–153,156)
Medium	23	(53,73,91,95–100,108–111,139–144,147,149,154,155)
Low	9	(10,28,72,101–106)

*BMI=Body mass index; DIDO=Drive-in Drive-out; FIFO=Fly-in Fly-out
*High:scores≥70; medium: scores=50-60%; low: scores<50%

Based on their findings, studies were categorised into four main themes of health outcomes and related behaviours; (1) mental health and well-being, (2) physical health, (3) sleep, and (4) lifestyle behaviours. Below, findings for each theme are summarised in terms of outcomes and predictors for each theme.

2.4.2 Mental health and well-being

Psychological distress. Studies examined prevalence using cut-offs on validated scales. Prevalence rates of psychological distress varied across eight studies: onshore workers

(10.0-36.3%, n=6 studies) (27–29,33,73,110) and offshore workers (8.0-14.0%, n=2 studies) (123,145). No study recruited a general population comparison group, only comparing these rates to secondary data sources reflecting the general population (typically ranging from 7.6%-13%) in five studies (27–29,33,145).

Depression. Studies showed mixed findings for depression and depressive symptoms in rotation workers. Studies employed a mixture of methods to identify cases of depression within rotation workers, including cut-offs on validated scales (32,73,84,101,114,119) and symptoms checklist (110,131,132,140). Six studies examined the prevalence of depression among rotation workers: onshore workers (28.3-32.3%, n=3 studies) (32,73,84); offshore workers (16.7-28.0%, n=3 studies) (101,114,119). No general population comparison groups were recruited in any study, though two studies(32,84) made reference to a secondary source (157) reporting a prevalence of depressive episodes (4.1%) and affective disorders (6.2%) in Australia. One study recruited both offshore rotation workers (16.7% prevalence) and onshore non-rotation petroleum workers (22.8%) but statistical comparisons were not performed (114).

Seven studies examined the levels of depressive symptoms among rotation workers using a symptoms checklist (32,73,101,110,131,132,140). Using the cut-offs belonging to the scales used, the sample means suggested that, on average, rotations workers had minimal depressive symptoms in four studies (1 offshore, 3 onshore) (110,131,132,140) and moderate in 1 study (73). Two studies with a comparison group compared fathers with onshore rotation jobs to other fathers in cross-sectional surveys, but the difference was not statistically significant (131,132). Two other studies with comparison groups compared rotation workers to onshore non-rotation workers and found depressive symptoms to be statistically significantly lower in rotation workers in one study (marginal mean scores 15.5;95%CI=14.3-16.6 vs 19.7;95%CI=17.0-22.4), p=0.01) (32) but no differences in the other study (101).

Anxiety. Studies regarding anxiety among rotation workers also showed mixed findings. Studies employed a mixture of methods to identify cases of anxiety within rotation workers using cut-offs on validated scales (73,101,114,119) and symptoms checklist (110,120,127,132). Four studies examined the prevalence of anxiety among rotation workers (73,101,114,119): 22.3% among onshore rotation workers (73) and 11.4-15% among offshore rotation workers (101,114,119). Only one study recruited and compared offshore rotation workers (11.4% prevalence) to onshore non-rotation petroleum workers (13.9%) but statistical comparisons were not performed (114).

Furthermore, nine studies examined the level of anxiety symptoms among rotation workers using a symptoms checklist (101,110,120–122,127,129,131,132). Of these studies, seven reported low levels of anxiety symptoms: one study described their samples as having low levels of anxiety symptoms based on their sample means being below some threshold on the scale used (110) and the remaining studies also reported sample means below any threshold for normal/mild anxiety (120–122,129,131,132).

No study recruited a general population comparison group, only comparing the mean scores to secondary data sources and reported comparable scores among onshore rotation workers in one study (110) but higher scores among offshore rotation workers in another study (127). Four studies with comparison groups compared rotation jobs to non-rotation workers in cross-sectional surveys: one study found offshore rotation had a higher level of anxiety symptoms than onshore non-rotation petroleum workers (3.62±3.42 vs 2.43±2.18, $p<0.01$) (120), but no statistically significant differences were reported in three studies (101,131,132).

Stress. Six studies examined levels of stress symptoms among rotation workers using a symptoms checklist (73,89,107,110,131,132). Using the cut-offs and scores based on the scales used, the sample means suggested rotation workers had low levels of stress symptoms in five studies (73,89,107,110,132) and moderate in one study (131). Two cross-sectional studies with comparison groups compared fathers working onshore rotation jobs to fathers working non-rotation jobs, but the differences were not statistically significant (131,132). No study recruited a general population comparison group; one study only compared mean scores on a DASS-21 scale to secondary data sources in the non-clinical general population and reported comparable scores among onshore rotation workers but no statistical comparison was done (110).

Emotional exhaustion and worn-out. Four studies examined emotional exhaustion and feeling "worn-out" among rotation workers using a symptoms checklist (51,117,154,155). Both emotional exhaustion and "worn-out", defined by "*symptoms of emotional liability, tiredness, and cognitive confusion*", have been operationalized by the same Worn-out scale from the General Well-being Questionnaire (GWBQ) (117,154,155). Based on the mean scores and cut-offs of scales used, the sample means suggested rotation workers had low emotional exhaustion and low "worn-out" in three studies (117,154,155). One longitudinal study documented a daily increase in emotional exhaustion and a decrease in work engagement over the course of up to 28 days onshore rotation work period, but there was no comparison group (51). Only one study with a comparison group compared offshore rotation workers to onshore non-rotation petroleum workers, and found statistically lower worn-out levels than in onshore non-rotation oil workers (mean score 13.82 vs 15.11, $p<0.001$) (154). No study recruited a general population comparison group; two studies only compared mean scores to secondary data sources in factory workers and reported comparable scores among offshore rotation workers but no statistical comparison was done (154,155). Qualitative evidence suggested offshore rotation workers experienced mental exhaustion due to the long shift hours associated with rotation work (88).

Suicide risk. Only two studies examined suicide risk among rotation workers, but both utilized the same sample (onshore rotation workers in Australia). In these studies, suicide risk was determined using the Beck Hopelessness Scale, with scores above 9 indicating elevated risk for suicide intentions and behaviour. Here, suicide risk prevalence was reported as 26.7% (32,84). One of these studies found suicide risk was lower among onshore rotation mining workers (26.7% prevalence) than onshore non-rotation mining workers (27.4%) (p=0.02)[1] (32). No general population comparison groups were recruited, though both studies made reference to a secondary source reporting a prevalence of one in six of the general population (32,84). There was no study that examined suicide intention or behaviour among offshore rotation workers.

Psychological well-being. Studies showed inconsistent findings. Studies employed a mixture of methods to examine the levels of psychological well-being within rotation workers using symptoms checklist (104,115,120,127,137), cut-points on validated scales (88,109) and self-reported diagnosis of mental health problems (13,99). Sample mean scores suggested good mental well-being among offshore rotation workers in three cross-sectional studies (115,120,137) and a daily diary study also reported low daily use of medication for mental health problems among onshore rotation workers across on-shift and off-shift days (13).

Five studies compared the psychological well-being of rotation workers to other work groups (99,104,115,120,127). Three of the studies with comparison groups compared rotation workers to non-rotation workers and found the prevalence of mental health problems to be statistically significantly lower in rotation workers in one study (7.7%; 95%CI=4.4–11.0 vs 13.0%; 95%CI=12.1–13.9, p<0.01) (99), higher mean scores (i.e., high levels of poor mental health symptoms) among rotation workers in one study (8.75±3.76 vs 7.64±2.94 ; p<0.05) (120), but comparable psychological health complaints in the other study (no statistical

[1] The percentages are unadjusted percentages do not relate to the reported p-value, which was obtained from an adjusted model

analysis was done) (115). Two studies did not recruit a comparison group, but compared sample mean scores to secondary data sources in non-rotation industrial workers and reported comparable levels of mental health well-being among offshore rotation workers but no statistical comparisons were done (104,127). No study recruited a general population comparison group, two studies compared mean scores to secondary data sources and reported higher mental functioning and mental well-being in offshore rotation workers than in the normative population (88,109), but no statistical comparisons were done.

Similarly, qualitative evidence was also mixed. Eight qualitative studies reported that onshore rotation workers experience high mental distress due to the demands and challenges of rotation work lifestyle (15,39,88,102,150–153); for instance experiencing isolation and loneliness (15,153), work-home conflicts (15,88,151,152), family and social disruptions (15,39,152,153), worries of delegating house chores to partners (15,39) and 'pre-boarding stress syndrome' characterised by symptoms including anxiety and bad mood in the last days of leave periods (102). However, four of the qualitative studies also reported onshore rotation workers expressed job and life satisfaction with their work, highlighting financial rewards, enough quality time to spend with family/friends on leave periods, freedom from home stressors/chores and less effect on their mood (15,39,88,153).

2.4.3 Predictors of mental health outcomes

Job demands. Five studies showed high job demands were associated with poor mental health outcomes (27,51,71,114,136,154). For instance, one cross-sectional study reported an increase in job demands was associated with an increased level of mental distress (114). Bowers *et al* in another cross-sectional study also found workers who were stressed by job tasks were more likely to experience higher mental distress than those who were not stressed at all by their job task (OR=6.2; 95%CI =1.8-21.2) (27). A daily survey study found that increases in workload and emotional demands were associated with a daily increased level of emotional exhaustion (51). Another longitudinal study also found high job demands to be correlated with increased symptoms of work-stress worn-out (indicative of poor well-being) (r=-0.382; p<0.001) (154).

Two cross-sectional studies identified job types/categories as a predictor of psychological health (115,120). Parkes reported working in higher roles such as supervisory or managerial roles was associated with a high level of anxiety (120).

Job control and clarity. Four studies found a significant association between job control/autonomy and better mental health outcomes (51,114,115,154). For instance, a daily diary study reported an increase in job autonomy was associated with increased levels of engagement (51). Further, a cross-sectional study found increase in job control was associated with a decreased level of mental distress (114). Bergh *et al* in another cross-sectional study found rotation workers' control over their job was also correlated with less work-stress worn-out (r=-.472; p<0.001) (154).

Two cross-sectional studies also found job clarity was associated with better mental health outcomes (114,154). One study showed an increase in job clarity was associated with a decreased level of mental distress (114). The other study found rotation workers' clarity on their jobs was also correlated with less work-stress worn-out (r=-.415; p<0.001) (154).

Roster characteristics. Three cross-sectional studies found significant associations between roster type/length and shift length with mental health (27,29,119). One study found that the odds of high psychological distress, defined by a score of 22-50 on a scale of 10-50, was higher in workers with 2 weeks on/1 week off roster (OR=2.4; 95%CI=1.7-3.4; p<0.001) and 1 week on/1 week off roster (OR=1.6; 95%CI=1.00-2.5; p=0.039) compared to a 4-weeks on/1 weeks off roster (27). Another study in offshore workers on a long roster cycle found the odds of higher-level of anxiety symptoms (defined by a higher score on a scale of 0-21) were higher in those on 56 days on/ 28days off than those on 28 days on/28 days off roster cycle

(OR=1.53; 95%CI=1.15–2.04) (119). Additionally, one study found workers who were stressed by the length of their shifts had increased odds of high psychological distress (OR=2.4; 95%CI=1.2-5.1; p=0.017) than workers who were not (27). Another study reported workers on longer shifts (>12 hours) had higher odds of high psychological distress (scores of 22-50 on a scale of 0-50) than those on shorter shifts (<12 hours) (OR=1.61; 95%CI=1.17-2.30) (29). Similarly, evidence from a qualitative study indicated workers experience mental exhaustion following long shift hours (88).

Work-home interference. Four cross-sectional studies have also established high work-home interference *(undesired interaction between work and home domains/roles)* was associated with poor mental health outcomes (71,92,127,136). For instance, Ljosa *et al.* established that an increase in levels of shift work–home interference was associated with increased mental distress among offshore rotation workers (71). Similarly, one study found that an increase in stress from work-home interference was associated with increased poor mental well-being (92). Another study also reported that feeling socially isolated while on-site was strongly related to high psychological distress (r^2= 0.61) (28).

Similarly, qualitative evidence showed psychological/emotional strain due to social life disruptions (15,39,88,102,151,152): six studies noted many rotation workers had difficulties balancing work and home/social life, leading to social and domestic conflicts (15,88,102,151,152), and difficulties in maintaining family and social relationships (15,39,152). Another qualitative study indicated absence from family made rotation workers feel isolated and lonely, and the ‘physical and psychological distance’ caused tension and distrust which put a strain on the relationship with partners (15). Three qualitative studies again indicated rotation workers experience the worries of delegating their domestic responsibilities to their partners (15,39) and missing out on family events (15,39,88).

Financial situation. Two cross-sectional studies found an association between workers' finances and psychological distress. One study found workers experiencing financial stress were more likely to report high psychological distress (OR=6.0; 95%CI=2.7-13.1) (27) than those who were not stressed at all by their financial situation. Another study also found that working primarily for financial reasons was associated with increased odds of high psychological distress (OR=1.34; 95%CI=1.12-1.61) (29).

Evidence from three qualitative studies also documented that rotation workers' relatively high income had become a source of stress due to a perceived lack of control or autonomy over their work and career, but being forced or 'trapped' into work rotation due to the financial gain (15,88,152).

Remoteness and living conditions. A cross-sectional study found workers stressed by the remoteness of the living environment were more likely to have high psychological distress than those who were not (OR=3.7; 95%CI=1.6-8.6) (27). Another cross-sectional study found an increase in stress from living in a remote environment (including factors such as sharing accommodation, disturbance in living accommodation and lack of privacy) was associated with increased levels of anxiety and poor mental well-being (127).
Similarly, qualitative evidence showed that sharing accommodation at work made workers experience stress from the lack of privacy (88).

Social support. Five cross-sectional studies found social support was associated with better mental health outcomes (32,71,123,135,154). For instance, one study documented that perceived support from supervisors was associated with a lower risk of psychological distress (RR=0.76; 95%CI=0.63-0.92, $p<0.01$) (123). Likewise, another study found increased social support was associated with lower suicidal risk, and lower levels of depression (32). Similarly, one study found an increase in social support was also associated with a decrease in worn-out from work stress (r=-.457; $p<0.001$) (154).

Similarly, two qualitative studies explored ways of improving the mental well-being of rotation workers and discussed the provision of social support (15,151). Ebert *et al* further noted the availability of confidential, trustworthy and proactive chaplaincy support on the worksite helped break the *'culture of masculinity'* or stigma attached to seeking help for health, and effectively promoted the mental health of rotation workers (151). Workers identified support from employers, colleagues and emotional support from family and other rotation families as ways to improve their mental well-being (15).

Stigmatization and bullying. Five cross-sectional studies identified workplace bullying to be associated with poor mental health outcomes (28,32,84,129,145). Two studies documented that workers who experienced workplace bullying were more likely to have high levels of suicide risk (OR=2.38; 95% CI=1.40–4.05), clinical depression (OR=2.38; 95% CI=1.40–4.05),(84) and psychological distress (OR=1.49; 95%CI=1.07–2.10) (145) than those who did not. Likewise, one study found an increase in workplace bullying was associated with an increased level of anxiety (129). Two other studies reported workers stressed by the fear of workplace stigma attached to mental health problems were much more likely to have high/very high mental distress (OR=23.5; 95%CI=7.5-73.2) than those not stressed at all (27), whereas workers with a high perception of the organisation's commitment to mental health were less likely to have high psychological distress than those who had low perceptions (OR=0.69; 95%CI=0.55-0.85) (29).

Evidence from two qualitative studies similarly highlighted that onshore rotation workers are faced with workplace stigma attached to mental health (15), public stigmatisation of rotation work as being 'dirty' and 'substance abusers' (152), and an under-appreciation of how hard rotation work is, which contribute to worse psychological well-being (15,152). Furthermore, three qualitative studies reported rotation worksites were characterised by the *'culture of masculinity'* which frowns on weakness but upholds hard work, leading to the uptake of behaviours and bullying, and the reluctance to seek help for health and well-being by workers in order to fit in the work environment (15,88,152).

Leadership style of managers. Evidence from four studies showed that the leadership style of managers and supervisors is associated with mental health outcomes among workers (27,114,136,145). One longitudinal study identified workers exposed to laissez-faire leadership style; a style where managers or supervisors are 'passive and avoidant' had higher odds of psychological distress among rotation workers than those who were not exposed (OR=1.69; 95%CI=1.12–2.54) (145). Similarly, one cross-sectional study reported an increase in the experience of fair and empowering leadership was associated with a decrease in mental distress (114). Another cross-sectional study identified workers who were stressed by their immediate supervisors were associated with increased odds of poor mental health (OR=4.3; 95%CI 1.6-11.3) than those who were not stressed at all (27). Chen *et al* in a cross-sectional study also identified an increase in stress from management problems was associated with increased poor mental health among workers (136).

Other occupational stressors. Occupational stressors were identified to significantly predict poor mental health outcomes in five studies (69,92,136,144). One cross-sectional study found an increase in risk perception was associated with increased levels of anxiety among offshore rotation workers (129). Two other cross-sectional studies found an increase in stress from safety concerns was associated with increased poor mental health (92,136). Another cross-sectional study found the motion of offshore platforms had a positive relationship with feelings of depression and anxiety (144). An additional cross-sectional study also identified increase in perceived job dissatisfaction was associated with reduced mental well-being (92). Another cross-sectional study found workers satisfied with rotation work had reduced odds of psychological distress (OR=0.33; 95%CI=0.25-0.43) than workers who were not satisfied (29).

Job insecurity has also been found to be associated with mental distress. One cross-sectional study reported that rotation workers with increased concerns about job loss were more likely to have high psychological distress (OR=3.17; 95%CI=1.96-5.16) than those who were not concerned about losing their jobs (29).

Likewise, evidence from two qualitative studies showed that rotation workers are reluctant to report or seek help for their mental health problems due to the fear of losing their jobs (15,152).

2.4.4 Physical health and well-being

Perceived physical health and subjective health complaints. Studies showed generally good/very good perceived physical health status among rotation workers. Nine studies examined perceived physical health complaints among rotation workers using self-ratings (88,90,91,93,110,139,146), self-reported use of medication for physical health problems (13) and scores cut-offs (88,109). Seven studies reported high proportions (73.4-92.0%) of rotation workers perceived their general physical health as good or very good (88,90,91,93,110,139,146). Additionally, one longitudinal study found low daily use of physical health medication across on-shift days and off-shift days among onshore rotation workers (13). No study recruited a general population comparison group; two studies compared mean scores to secondary data sources and reported higher physical health functioning in offshore rotation workers than in the norm-based population (88,109), but no statistical comparisons were done.

Eight studies examined subjective health complaints among rotation workers using the Subjective Health Complaints Scale (90,91,93,94,115,117,128,145), all within offshore workers. Based on the mean scores on the scale used, the sample means suggested low/some subjective health complaints in seven studies (90,91,94,115,117,128,145). One of these was a longitudinal study, reporting no significant changes in the level of subjective health complaints from the start to the end of a two-week work period (91). However, one cross-sectional study reported a high prevalence of subjective health complaints based on one or more complaints in the last 30 days among offshore rotation workers, and that was significantly higher among workers with shift work disorder (condition of excessive sleepiness and insomnia) than workers without shift work disorder (100% vs 89.9%; $p< 0.001$) (93).

Gastric problems. Studies examining gastric problems reported mixed findings. Six studies examined gastric problems among rotation workers using a symptoms checklist. Two cross-sectional studies documented prevalence (31%) of general gastric problems including indigestion, heartburns and stomach pains (123) and prevalence of poor appetite (56.8%) and localised epigastric pain (52.3%) (69) in offshore rotation workers. Another cross-sectional study reported a high prevalence of gastrointestinal complaints based on one or more complaints in the last 30 days among offshore rotation workers, and that was significantly higher among workers with shift work disorder than workers without shift work disorder (87% vs 50.6%; $p<0.01$) (93). However, based on the mean scores of scales used, sample means suggested in two other cross-sectional studies (94,118) and one longitudinal study (90), low scores on complaints of gastric problems (i.e., low levels) among offshore rotation workers.

Musculoskeletal disorders. Ten studies examined musculoskeletal disorders among rotation workers using a symptoms checklist and the findings were mixed. Seven of these studies reported a prevalence of musculoskeletal disorders: among offshore rotation workers (10.0-56.3%) (70,88,108,123,155) and onshore rotation workers (ranging from 1% headache to 5% pain in the legs) (89). Another cross-sectional study reported a high prevalence of musculoskeletal pain based on one or more complaints in the last 30 days among offshore rotation workers, and that was significantly higher among workers with shift work disorders than workers without shift work disorders (90.9% vs 69.6%; *p*=0.04) (93).

Three other studies, based on the sample mean scores of scales used, reported few subjective musculoskeletal complaints (90,94,95). But, one of these studies compared musculoskeletal complaints among age groups and reported high levels of musculoskeletal complaints among offshore rotation workers aged above 50 years compared to younger workers (16.93±45.19 vs 1.71±5.61, $p<0.001$) (94). Another of the studies found complaints of musculoskeletal pain symptoms increased across a 1 year working period (95). The knees, neck, lower back, and shoulder were the commonly reported locations of musculoskeletal problems among rotation workers in four studies (70,95,108,155).

Qualitative evidence similarly showed that onshore rotation workers frequently experienced physical pain and commonly reported muscle and joint pains, neck and back pains, and leg and feet pains (152).

2.4.5 Predictors of physical health outcomes

Job demands. Two studies reported job demands were associated with perceived poor physical health status and health complaints (115,118). One cross-sectional study reported an increase in physical workload was associated with an increased level of physical strain (118). Another cross-sectional study found an increase in job demand of repetitive work was associated with decreased perceived good physical health status (115).

Job and roster type. Four cross-sectional studies documented job types to be associated with perceived physical health status and complaints (108,115,116,123). For instance, Parkes identified working in managerial (Relative risk (RR)=1.88; 95%CI=1.21-2.91, p<0.01), construction (RR=1.84; 95%CI=1.17-2.89, p<0.01) and drilling (RR=1.64; 95%CI=1.11-2.42, p<0.05) roles were associated with high risk of headache complaints compared to working in maintenance roles (123). Workers in drilling roles (RR=1.68;

95%CI=1.14-2.47, $p<0.01$) were also at increased risk of muscular complaints while working in catering roles (RR=0.50; 95%CI=0.28-0.89, $p<0.05$) was associated with less muscular complaints compared to working in maintenance roles (123). Another study found working in maintenance and modification role was related to perceived poor general health while working accommodation role was related to high symptoms of ill health compared to other work groups (116).

Two cross-sectional studies found rotation work roster type to be associated with physical health complaints (108,123). One of the studies reported working a swing shift (*nights-to-days shift*) roster was associated with a high risk of gastric problems (RR=1.36; 95%CI=1.00-1.84, $p<0.05$) compared to working on a day shift (123). The other study found working tour-scheduling jobs (without regular work hours) to be related to more muscular complaints (108).

Social support. One cross-sectional study found an increase in social support was associated with a decreased level of physical strain (118). Another cross-sectional study further identified workers with perceived high support from their supervisors were at lower risk of gastric problems (RR=0.82; 95%CI=0.72-0.94; $p<0.01$) (123) and complaints of headaches (RR=0.83; 95%CI=0.73-0.94, $p<0.01$) (123).

Leadership style. One cross-sectional study found management prioritisation of safety issues ($r=-.21$; $p<0.01$) and authentic leadership style ($r=-.21$; $p<0.01$) to be associated with fewer subjective health complaints among workers (130).

Other occupational stressors. Experiences of occupational stress were also identified to be associated with perceived physical health status and health complaints. Two cross-sectional studies identified perceived poor safety climate *(perceived importance placed on safety in an organization)* to be associated with subjective health complaints (70,128). For instance, one of the studies identified workers who experienced high stress from safety concerns were identified to be more likely to have more muscular pains in the low back (OR=1.29; 95%CI=1.05–1.59), neck (OR=1.53; 95%CI=1.26–1.93), knees (OR=1.59; 95%CI=1.24–2.06), and shoulder (OR=1.54; 95%CI=1.20–1.99) compared to those who did not (70).

Further two cross-sectional studies identified risk perception to be associated with physical health complaints (118,130). One study found an increase in risk perception was associated with increased physical strain (118). Likewise, the other study also reported stress from risk perception was positively related to more health complaints (r=.24; $p<0.01$) (130). Similarly, one cross-sectional study reported an increase in stress from communication and participation in work decisions was associated with increased physical strain (118). Additionally, another cross-sectional study found an increase in occupational stress was also associated with increased complaints of ulcer-like symptoms (69).

Two cross-sectional studies identified stress from the physical work environment was associated with muscular pain complaints (70,123). For example, one of the studies reported workers who experienced high stress from the physical work environment were more likely to complain of muscular pains in the low back (OR=1.37; 95%CI=1.11–1.69), neck (OR=1.43; 95%CI=1.14–1.79) and shoulder (OR=1.32; 95%CI=1.03–1.68) compared to those who did not (70).

One cross-sectional study also found workers who experienced stress from the interface between job and family/social life were more likely to have muscular pains including in the low back (OR=1.46; 95%CI=1.18–1.82) and shoulder (OR=1.35; 95%CI=1.02–1.71) compared to those who did not (70). Furthermore, one cross-sectional study found an increase in workers' satisfaction with employee relations and extrinsic satisfaction with working conditions was associated with increased levels of strain (118).

2.4.6 Sleep problems and fatigue

Perceived sleep problem. Studies' findings were inconsistent. Seven studies examined the levels of perceived sleep problems using self-rating (93,110,123) and checklists (89,107,118,128). Of these, three cross-sectional studies reported a prevalence ranging from 45-79.4% for perceived sleep problems during work periods (93,110,123). Based on the sample mean scores of scales used, three studies reported scores below the threshold for subjective sleep problems (i.e., low levels) (89,107,128) whereas one study reported moderate levels for sleep difficulties (118) during work periods. Similarly, one longitudinal study also reported workers show no sleep deterioration over a 2-year period (89).

Evidence from a qualitative study showed offshore workers experience poor sleep during the first and the last 2-3 days of the leave periods (102).

Sleep duration. Evidence from the studies was mixed but generally suggested short sleep duration in rotation workers during work periods. Fourteen studies examined sleep duration among rotation workers (52,53,85,87,98,108,113,121,122,124,125,140,142,143). Of these, two cross-sectional studies reported that 33.1-51.2% of workers slept for less than 6 hours during work periods (108,140). Four longitudinal studies (87,98,142,143) further reported shorter sleep duration of less than 7hrs during work periods; with offshore rotation workers reporting an average acute sleep loss of 1.32 hrs per day (95%CI: 88.6–94.9mins), and chronic sleep loss of 21.20 hrs (SD=08.10hrs) per rotation or work period (87). Seven of the studies compared and found shorter sleep duration during on-shifts than on off-shifts, for both day and night shifts (52,53,85,113,121,122,124,125). For instance, one longitudinal study found '*total sleep time'* for days off (7.0±1.9hrs) was longer than day (6.0±1.0hrs) and night (6.2±1.6hrs) shifts ($p<.001$) (52). Another longitudinal study reported short *'total sleep time'* during work periods for both day (6.1±1.0 hrs) and night (5.7±1.5 hrs) shifts than days off (7.3±1.2 hrs) ($p<.0001$) (53). However, in two of the studies comparing sleep among offshore rotation workers and non-rotation onshore oil workers, one cross-sectional study showed longer sleep duration among offshore workers than onshore petroleum workers during day-(6.84±1.00 hrs vs 6.58±0.96 hrs) and night- (6.57±1.38 hrs vs 5.62±1.33 hrs) shifts (p<.001) (113), while another showed long sleep duration on night shifts (7.20±1.3 hrs vs 5.86±1.26 hrs) but shorter on day shifts (6.99±1.18 hrs vs 7.07±0.82 hrs) than onshore petroleum workers (p <.0001) (124).

Sleep quality. Studies' findings were mixed but generally suggested poor sleep quality in rotation workers during work periods. Thirteen studies examined sleep quality among rotation workers. Using cut-points on validated scales, three studies found a prevalence (67-72%) of poor sleep quality among offshore rotation workers (109,111,140). Ten of the studies examined sleep quality during work and leave periods. In eight of the studies, sample means based on the scales used, suggested generally poor sleep quality on both day-shifts and night-shifts compared to leave periods (13,85,91,113,121,122,124,125). For instance, one longitudinal study found sleep quality was lower (on a scale of 1-5) during on-shift periods (3.3±0.8) compared to pre-on-shift (3.5±0.8) and post-on-shift (3.5±0.8) days (p<0.001) (85).

However, two studies showed better sleep quality during work periods (52,95). For example, one longitudinal study found no significant differences in sleep quality during on-shifts (both day and night shifts) and off-shift days among onshore rotation workers (52). The other longitudinal study among onshore rotation workers found high sleep efficiency and good sleep quality but decreased towards to end of the work period (95). Furthermore, two cross-sectional studies compared sleep quality and found better sleep quality among offshore workers than onshore petroleum workers during day shifts (113) and night shifts (113,124).

Sleepiness and insomnia. Studies show sleepiness and insomnia among rotation workers. Five studies examined sleepiness and insomnia among rotation workers using cut-points (91,93,140) and symptoms checklist (85,91,93,95,140). Two of these studies found a 23.3-27.0% prevalence of Shift Work Disorder characterised by excessive sleepiness and insomnia (93,140), and one of the studies reported 67% of offshore rotation workers had insomnia (140). Based on the mean scores of scales used, the sample means suggested high levels of sleepiness and insomnia during work periods in three studies (85,91,95). For example, one longitudinal study found more insomnia complaints (higher score on a scale of 0-42) at the end of work periods compared to the start of a two-week work period (13.8±9.6 vs 7.1±6.8; $p<0.0005$) (91). Another longitudinal study reported complaints of insufficient sleep increased across 1 year period while severe sleepiness accumulated across the work period and was highest on the last morning shifts during work periods (95). Additionally, another longitudinal study found morning sleepiness levels was highest during work periods, whilst evening sleepiness also increased during offshore work periods and decreased during post-offshore work period (85).

Fatigue. Findings from studies suggested high fatigue during work periods. Seven studies examined fatigue among rotation workers using cut-points (88), self-ratings (86,87,95) and symptoms checklist (53,98,107). Based on the mean scores of the scale used, the sample means suggested high levels of fatigue during work periods in five studies (53,86,87,95,98) and generally low fatigue in one study (107). Another cross-sectional study reported 73% of offshore rotation workers indicated experiencing prolonged fatigue during on-shift periods (88). A longitudinal study reported fatigue was lower during pre-shift than post-shift periods, but increased and accumulated faster by 0.03 points per day (on a 1-9 scale) (95%CI: 0.00–0.07; p=0.037) in post-shifts compared to pre-shift periods (87). A similar longitudinal study found that daily subjective post-shift fatigue increased by 0.05 points per day (on a 1-9 scale) (95%CI=0.02-0.08, p=0.004) and over a 2-week offshore work period (86), though daily objective fatigue (e.g., performance on a reaction time task measured by reaction times) was stable (1.00; 95%CI=0.99-1.00) over the course of the offshore work period (86). Another longitudinal study reported among onshore rotation workers critical levels of fatigue at the end of day 1 to 3 of night shifts and after the 7th day of a day shift (98). Furthermore, onshore rotation workers reported higher pre- and post-sleep fatigue and significantly higher post-sleep fatigue ratings during onsite days for both day and night shifts than days off in another longitudinal study (53).

Similarly, two qualitative studies reported onshore and offshore rotation workers indicated fatigue as one of their main occupational health and safety issues (88,148). Another qualitative study reported fatigue among some onshore rotation workers which was indicated to affect their mood and social life at home (39).

2.4.7 Predictors of sleep and fatigue

Shift/roster pattern. Evidence showed working night shift and/or swing/rotation shift was likely to be associated with more sleep problems than working day shifts. Four studies examined the relationship between general sleep problems and roster/shift patterns (10,123,141). Three of the studies found night/swing shifts to be related to sleep problems (10,123,141). One cross-sectional study found workers on night/swing shifts were at increased risk of more sleep problems compared to day workers (RR=1.81; 95%CI=1.36-2.42, $p<0.001$) (123). Additionally, one longitudinal study reported sleep efficacy was higher among offshore day shift workers than night (93% vs 88%; $p<0.001$) and swing shift workers (93% vs 88%; $p<0.05$) (141). However, a longitudinal study reported subjective sleepiness did not differ between day-, night- and swing shift work periods (156).

Four studies examined the relationship between sleep duration and roster/shift patterns. Three studies found night- and/or swing- shifts to be related to short sleep duration (10,121,141). For instance, one cross-sectional study found workers on a fixed-day shift reported significantly longer sleep duration than those on a swing shift (*nights-to-day* *shift;7N/7D*) (121). Another cross-sectional study found more night/swing shift workers to have short sleep episodes than day shift workers (44.1% vs 16.3%; $p<0.01$) (10). However, a cross-sectional study among offshore rotation workers documented longer sleep duration in swing-shift workers than day shift workers (94).

Eight studies examined the relationship between sleep quality and roster/shift patterns and evidence was unclear. Three of the studies reported night and/or swing shift was related to poor sleep quality (121,126,146). For instance, one longitudinal study found night shift and swing shift workers reported poor sleep quality throughout the 14 days of leave periods than day shift workers (146). In contrast, two studies found better sleep quality working night and swing shifts (124,141). One of the studies showed better sleep quality (higher score on a scale of 0-6) in night shift workers than day shifts workers (3.66±1.03 vs 3.20±1.84; $p<0.01$) (124). The other longitudinal study reported better sleep quality (higher score on a scale of 1-5) during swing shifts than during day (3.40±0.49 vs 3.37±0.61; $p<0.01$) and night (3.40±0.49 vs 3.32±0.62; $p<0.05$) shifts for the first week of work period (141).

Three other studies found no significant relationship between sleep quality and shift schedules (52,91,111). For example, one longitudinal study reported no significant differences in the proportion of workers with better sleep quality at the start (27.8% vs 26.9%; $p=0.96$) and end (33.3% vs 44.1%; $p=0.09$) of the work period between day and swing shifts (91). Another cross-sectional study reported no differences in the proportion of workers with impaired sleep quality working fixed day (66.1%), fixed night (66.6%) and swing (83.3%) shifts ($p=0.34$) (111).

Only two studies examined the relationship between fatigue and shift/roster pattern. A longitudinal study found pre-sleep fatigue was higher in working night shifts compared to day shifts, but recovery of sleep on night shift was higher than on day shift (53). In contrast, another longitudinal study reported no significant differences in fatigue measures such as physical and mental tiredness during night shift, and swing shift compared to day shift workers (146).

Qualitative evidence study showed perceived high fatigue among onshore rotation attributed to roster patterns and sleep difficulties which improved after a change of roster from a rapid swing roster of 7 nights on/7 days on/ 7 days off to a longer swing roster of 8 days on/ 6 day off/ 8 night on/ 6 days off (148). Another qualitative study suggested high perceived fatigue was attributed to the long shift hours of rotation work (88).

Job demand and control. Two studies reported job demands and control were associated with sleep problems (9,125). One cross-sectional study reported an increase in workload was associated with decreased sleep duration (125). Furthermore, an increase in job demands among older rotation workers was associated with decreased sleep quality than in their younger counterparts (125). Similarly, Parkes in a cross-sectional study reported an increase in job demand was associated with reduced sleep duration in rotation workers who work overtime (9). One cross-sectional study reported an increase in job control was also associated with increased sleep quality (125).

Three cross-sectional studies reported working overtime was associated with short sleep duration and poor sleep quality (9,121,122). For instance, one of the studies found offshore rotation workers working overtime of >16 hrs per week during night shifts were associated with short sleep duration than those not working overtime (121). Another study found an increase in working overtime was associated with decreased sleep quality among day-shift workers (9).

Social support. Two cross-sectional studies found social support was associated with longer sleep duration and better sleep quality (9,125). One of the studies found an increase in social support was related to increased sleep quality and sleep duration in day-shift rotation workers (125). The other study reported an increase in support from supervisors was associated with increased sleep duration in day shift workers working overtime (9).

Other occupational stressors. One cross-sectional study found an increase in risk perception to be associated with reduced sleep quality (126). Further, the study reported an increase in perceived safety climate was associated with increased subjective sleep quality (126).

Three cross-sectional studies reported adverse physical environment was associated with sleep problems (9,123,125). For instance, one of the studies reported workers with a high perception of adverse physical environment had an increased risk of sleep problems (RR=1.16; 95%CI=1.01-1.33, $p<0.05$) (123). Two of the studies reported an increase in perceived adverse physical environment was associated with decreased sleep quality among offshore rotation workers (9,125).

A longitudinal study also found the increase in motion of offshore platforms was related to a high incidence of physical tiredness, mental tiredness, poor sleep quality, and short sleep duration (144). Similarly, qualitative evidence showed that rotation workers perceived sleep disturbances to be caused by work environmental stressors such as motion and noise of platforms, and accommodation arrangements (88).

2.4.8 Lifestyle behaviours

Alcohol consumption. Studies showed higher alcohol consumption among rotation workers on off-shift days than in other workgroups and the general population. Eight studies described the regular alcohol intake of rotation workers (13,72,88,92,105,109,138): the proportion of consuming 'any' alcohol ranged from 22.1-84.1% across three studies (72,88,138) and the proportion consuming alcohol above recognized safe limits ranged from 16.0-54.3% across four studies (72,92,105,109). One longitudinal study found alcohol consumption was typically within the healthy consumption limit (average 1.05 standard drinks/day) among onshore workers across both on and off-shift days (13).

Furthermore, two longitudinal studies reported inconsistent drinking among rotation workers during on-shift days; one documented that drinking on on-shift days was at high-risk levels [median 3.0 (inter-quartile range (IQR) 2.0-6.0) standard drinks per session] (72) while the other reported daily drinking of average: 2(1.7-2.8 units/day) during day shifts and 1(median 0.6-1.4 units/day) during night shifts (98). Similarly, two other longitudinal studies compared drinking on on-shift days to off-shift days (13,98); and one of the studies reported drinking was less during on-shift days compared to off-shift days (13). Muller *et al* also reported rotation workers on off-shift days engage in high-risk drinking with a median of 6 (IQR 3–10) standard drinks per session and a median of 4 (IQR 2–6) standard drinks per session during on-shift (98).

Additionally, three cross-sectional studies compared drinking in rotation workers with non-rotation workgroups and the general population and found drinking to be consistently higher among rotation workers (99,105,132). One study with a comparison group compared rotation workers to onshore non-rotation workers and found more rotation workers drink alcohol at levels that have a high risk for both short-term health (more than four alcoholic drinks per day) [29.8%; 95%CI=22.8–36.8 vs 21.5%; 95%CI=20.2–22.9] and long-term health (more than two alcoholic drinks per day) [64.7%; 95%CI=57.5–71.9 vs 50.9%; 95%CI=49.4–52.4] harm ($p<0.01$) (99). Another study did not recruit a comparison group, only comparing the means of alcohol intake per week among offshore rotation manual workers to secondary data sources in onshore non-rotation manual industrial male workers, and reported statistically significantly higher mean units of alcohol intake per week among offshore rotation workers (49.3 units vs 21.4 units, $p<0.005$) (105).

One study recruited a general population comparison group, compared onshore rotation workers to non-rotation fathers and found higher alcohol intake scores on an AUDIT scale (i.e., high alcohol intake) in rotation workers drink than in non-rotation work fathers (5.52 ± 3.97 vs 3.50 ± 2.86, $p<0.05$) (132). Another study did not recruit a general population comparison group, only comparing the prevalence of drinking among offshore rotation workers to secondary data source among the general male population, and reported a higher prevalence of heavy drinkers among offshore rotation workers (approx. 30% vs 10% heavy drinkers) (105).

Similarly, two qualitative studies (39,149) described onshore work camps as having a strong '*culture of drinking'* (149), and another qualitative study (100) noted some offshore workers indicated that the high levels of alcohol consumption among offshore workers should change.

Illicit drug use. Studies examining drug use among rotation workers were limited. Only two cross-sectional studies examined drug use and reported mixed findings: one cross-sectional study found 33% of onshore mining rotation workers were illicit drug users with 4% being previous drug users (29); however, another cross-sectional study reported 5.2% of offshore rotation workers were illicit drug users (109).

Smoking. Studies examining smoking suggested high smoking among rotation during on-shift days than off-shift days and non-rotation workgroups. Fourteen studies described regular smoking in rotation workers and of these, twelve studies showed a prevalence of smoking ranging from 17.7-47.1% across onshore and offshore rotation workers (52,88,91,92,98,99,109,111–113,138,147). One cross-sectional study reported a low proportion (3.3%) of smokers among onshore rotation workers (110). Two studies examined the number of cigarettes smoked and reported rotation workers smoked on average

13.22±8.46 cigarettes per day across both on-and off-shift days in a daily diary study (13) and a mean pack of 3.03±1.9 per day during on-shift days in a cross-sectional study (88).

Two cross-sectional studies with comparison groups, compared smoking among rotation workers to other non-rotation workgroups and reported smoking prevalence to be consistently higher among rotation workers than onshore non-rotation petroleum workers (33.6% vs 20.6%; $p<0.001$) (113) and other employment arrangements (26.7%; 95%CI=20.5–33.0 vs 17.4%; 95%CI=16.3–18.5, $p<0.01$) (99). One daily study examined smoking during on-shift days and off-shift days and reported rotation workers during on-shift days significantly smoke more cigarettes compared to off-shift days (13).

Likewise, evidence from two qualitative studies showed smoking was common on-shift days but not a behaviour accepted by all workers (88), with some workers suggesting smoking behaviour should change (100).

Physical activity. Studies reviewed suggested rotation workers engage in physical activity. Six studies examined the prevalence of physical activity among rotation workers (72,108–110,138,139): five studies reported proportions ranging from 46.7-97.0% to engage in regular physical activity/exercise (72,108–110,139) but one other study reported a high proportion (63.1%) of offshore rotation workers do not engage in any leisure-time exercises after work (138). Four studies examined physical activity/exercise during either on-shift days (72,98,108) or off-shift days (98,139), and documented high levels of physical activity/leisure time exercises at least 2 or more days per week. Two longitudinal studies compared physical activity on on-shift days to off-shift days (13,98). Rebar *et al* reported workers during on-shift days engage in less minutes of exercises and relaxations compared to off-shift days (13), but Muller *et al* reported rotation workers engaged in >30 min of vigorous exercise for more days on on-shift days (median 5 days per week) against median 4 days per week during off-shift days (98).

One cross-sectional study with comparison groups examined physical activity/exercise among the rotation work and non-rotation workgroups and reported the proportion of rotation workers who engaged in inadequate physical activity/exercise during leisure time or work (<30 minutes of physical activity) was not statistically different from that of other employment arrangements (40.4%; 95%CI=33.5–47.4 vs 46.2; 95%CI=44.8–47.6, $p>0.05$) (99).

Qualitative evidence was mixed for onshore and offshore workers. A qualitative study reported that most onshore rotation workers engage in sporting activities more than once a week (149). However, another qualitative study discussed how some offshore rotation workers emphasised the need for a change in behaviour toward increasing physical activity (100).

Diet/nutrition and BMI. Studies suggested poor nutrition or eating behaviour among rotation workers at worksites. Four studies reported perceived poor food/diet quality during work periods (13,88,103,106). Oshaug *et al* reported high consumption of fats and carbohydrates at offshore worksites (103). Another cross-sectional study found a large proportion of offshore rotation workers (45.1%) did not meet the dietary requirement of healthy eating of fruits and vegetables (5 per day fruit and vegetable intake) during on-shift days (109). A cross-sectional study compared nutrition intake on-shift to the general dietary recommendations and reported offshore workers' diet may in the long term predispose them to coronary artery disease (103). One longitudinal study compared onshore workers' perception of nutrition on on-shift days to off-shift days and reported workers during on-shift days perceived their nutritional intake to be poorer compared to off-shift days (13). One cross-sectional study examined the diet among the onshore rotation workers and other workgroups and reported high proportions of workers consuming insufficient fruits (48.9% vs

47.7%) and vegetables (87.7% vs 87.9%) but there were no differences between rotation workers and other non-rotation employment (99).

Similarly, two qualitative evidence (88,100), also highlighted the unhealthy eating behaviours of offshore rotation workers and workers indicated the unhealthy behaviour should change (100).

Sixteen studies reported an average BMI of 26.6±3.1kgm^{-2} (range 22.7-28.9) (10,52,85,87,88,96–98,108,112,133,140,142,143,147,156) indicating rotation workers are usually overweight. Eight studies further reported a large proportion (40.0-76.0%) of rotation workers as being overweight (88,97,99,109,110,112,134,147). Six studies also reported a large proportion (5.5-30.0%) of rotation workers as being obese (88,97,109,112,134,147).

Three studies compared the BMI of rotation workers to other populations (97,99,134). One cross-sectional study compared onshore rotation workers with non-rotation workgroups and found a higher proportion of overweight and obesity among rotation workers than in non-rotation workgroups (79.3%; 95%CI=73.2–85.5 vs 68.0%; 95%CI=66.7–69.4, $p<0.01$) (99). No study recruited a general population comparison group, only comparing BMI to secondary data sources of the general population, found a statistically significantly higher prevalence of overweightness/obesity in offshore rotation workers than in the general population (97,134). For instance, one of the studies found a higher prevalence of overweightness among rotation workers aged 40-49 years compared to the same age group in the general population (66.2% vs 50.0%, $p<0.05$) (97).

2.4.9 Predictors of lifestyle behaviours

Social support. One cross-sectional study found offshore rotation workers who lack social support from supervisors were less likely to smoke (OR=0.34; 95%CI=0.18-0.65), and those who lack support from friends were less likely to consume alcohol (OR=0.54; 95%CI=0.32-0.96) compared to those who had support (138). Further, the study found workers who do have support from both supervisors (OR=1.74; 95%CI=1.113-2.65) and friends (OR=1.68; 95%CI=1.06-2.42) were more likely to engage in leisure-time physical activities (138).

Evidence from two qualitative studies (39,149) suggested alcohol consumption in onshore mining rotation workers at work camps was promoted by a *'culture of drinking'* that influences workers to take part in drinking if they were to fit in the social work environment (39).

Occupational stress. One cross-sectional study found workers who were stressed from the interface between job and family/social life (OR=1.32; 95%CI=1.02-1.70) and organizational structure (OR=1.35; 95%CI=1.06-1.74) were more likely to be current consumers of alcohol compared to those who were not stressed (138). Further, the study found workers who experience high stress from safety concerns were less likely to smoke (OR=0.74; 95%CI=0.58-0.94) and more likely not to undertake leisure-time physical activities (OR=1.44; 95%CI=1.16-1.79) compared to those who did not (138).

Job type. One cross-sectional study demonstrated job type, i.e., working as a manual worker was significantly related to higher alcohol consumption than those in executive roles (49.3 vs 29.5 mean units per week; $p<0.005$) (105).

Other working conditions. Qualitative evidence also cited improvement and maintenance of exercise facilities (100,149) and other work-related characteristics including time constraints due to 'long shift hours and travels times' as barriers to engaging in physical activities/exercises (149). Two other qualitative studies explored rotation workers' perception of a healthy diet (88,100) and indicated workers perceived unhealthy eating of rotation workers to be connected to the availability of unhealthy food or easy access to unhealthy foods at worksites.

2.5 Discussion

2.5.1 Main findings

This review summarised studies investigating the health and well-being outcomes associated with rotation work. The findings of this review may guide and inform policy and strategies aimed at improving the health of rotation workers. Ninety studies with outcome data on mental health and well-being, physical health, sleep problems and lifestyle health-rated behaviours among rotation workers in the offshore oil and gas, mining and construction sectors were included. Evidence from the studies included in the review was unclear concerning rotation workers' mental health status. However, many studies suggested poor mental health and well-being of rotation workers and particularly onshore rotation workers being more likely to experience psychological distress and suicide risk than the general population (27,28,33,158). This finding mirrored that of a previous review of studies with onshore rotation workers where findings, although inconsistent, pointed to a negative impact of rotation work on the mental health of onshore rotation workers (7). The differences in measurement tools including differences in measures used and the length of recall of measurement between the included studies could potentially account for the inconsistent study findings. Some studies have employed mental health outcome measures based on recall over the last 30 days whereas others have used a recall over the last 7 days or recent experiences. These differences may reflect inconsistencies in the experiences of mental health and/or capturing of the general mental health of workers across the work phases (on and off-shifts) of rosters, as has been demonstrated that retrospective studies employing different recall periods are often not comparable (159). It is worth noting for future studies that studies using particularly Kessler psychological distress (K10) scale demonstrated consistent findings of high mental distress among rotation workers compared to others, and in line with previous suggestions, may well be possible to record the mental health of workers in general and across a complete roster cycle (7).

Evidence from the qualitative studies highlighted rotation workers are faced with distress from, for instance, the difficulties of balancing work and home/social life (15,88,102,152) and maintaining family and social relationships, loneliness and social isolation (15,39,152), and worries of overburdening partners with domestic chores (15,39). These point to difficulties for workers in adjusting and maintaining balance in life contributing to negative mental health and well-being, concurring with another review in a general population showing that working irregular shift work schedules was associated with poorer mental health (160). These findings suggest the need for interventions aimed at helping the worker to adapt and maintain balance in life, which may include improved communication with families and social support (15).

There was evidence to show that rotation workers perceived their general physical health as good or very good, with suggested few subjective health complaints and of better physical quality of life. Rotation workers are indicated to be a self-selected population in that those who can adapt to the demands and challenges of rotation work remain in the workforce (68). Generally, rotation workers are a physically healthy population (68), but there was limited information on mental health as most surveys relied on single items, which could not capture the complexities and dimensions of mental health. However, included studies suggested offshore rotation workers have a high prevalence of musculoskeletal disorders, and finding on gastric problems was unclear. The findings on gastric problems suggest the need for more studies as a previous review has found evidence suggesting an association between offshore rotation work shift pattern and gastric complaints (68). Furthermore, there is available evidence that links shift work to gastric problems as shift work disrupts the connection between eating times and diurnal stages of digestive functions such as secretion of gastric juice (161) and the job and environmental stress associated with rotation work propagates smoking, alcohol intake and less physical activity which promote gastric problems (69). Evidence on musculoskeletal disorders is in accordance with the findings reported by a previous review among offshore rotation workers (74). Musculoskeletal pain has been indicated to be a consequence of work-related activity and stress (70,154) and rotation work regarded as a stressful workplace and demanding lifestyle (162) could account for the reported musculoskeletal disorders among rotation workers.

There was evidence that suggests that rotation workers during work periods or on-shift days experience sleep problems, particularly short sleep duration, poor sleep quality and sleepiness. Similarly, earlier reviews have identified sleep as a concern for onshore rotation workers (7) and highlighted sleep problems among offshore rotation workers (74). This is similar to other sectors such as healthcare workers with studies suggesting that long work hours (12 hrs or more) negatively affect sleeping patterns (163). A systematic review has also found working shifts, particularly night and early morning shifts to be associated with sleep disturbances (164). With rotation workers in the resources sector engaged in long work hours typically 12 hours per shift (1,68) and working days compressed into day and/or night shift patterns (68), could explain the associated sleep problems. Shift work and long shifts are indicated to unsettle the *'circadian rhythm'* (165) leading to sleep disturbances (166). Furthermore, a prevalence of 23.3-27% of Shift Work Disorder (SWD) was found in the current review. Working shift is indicated to be associated with the risk of shift work disorder, and a previous review found an estimated prevalence of 10-23% of SWD among rotating shift and night shift workers (166). Differences observed could be due to the differences in methods used by studies (68,75).

We found rotation workers working day shifts to have better sleep outcomes, particularly longer sleep duration than those working on night and swing shift patterns. This is in agreement with the findings from previous reviews among petroleum rotation workers (68,75) where working night and swing shifts were associated with sleep disruptions. Night work disrupts the normal sleep-wake periods (167) and night shifts have been associated with sleep loss and other health consequences such as obesity, cancer diabetes and coronary heart disease (164). McKenna and Wilkes have documented unimpeded morning sleep *'before the first shift'* coupled with afternoon naps could reduce sleep debt prior to starting a roster of night shifts (167). Organizations could encourage workers to take uninterrupted sleep the day before commuting to worksites (167); and look at instituting long changeovers of possibly more than a 24-hour change window, particularly for workers on swing shifts who may change from day shifts to night nights to allow for enough sleep (52). Furthermore, organizations could create an enabling environment such as reducing noise and light, and competing social activities (53) at campsites to promote sleep after a night shift to enable the necessary recovery of sleep.

The evidence reviewed showed a high level of fatigue among rotation workers, which increases and accumulates over the course of work periods. Findings from a previous review have also highlighted increased fatigue among offshore rotation workers (68). Fatigue among rotation workers has been indicated to be due to the long work hours (68,88), roster length (98) and sleep disturbances (39,148). Working long hours (>12 hrs) (168) and shifts (169) have also been found to be associated with high fatigue among other work populations. A high level of fatigue is detrimental to performance and safety (98), particularly in a critical safety risk resource industry. Strategies aimed at training workers could include ways to identify and mitigate fatigue and allow for breaks and enough periods between shifts for rest and recovery (52) amongst others as 'successive days-on-shift and chronic sleep loss' increase the risk of fatigue (87).

Studies reviewed showed a high intake of alcohol in rotation workers during off-shift days. Studies provided information on the pattern of drinking of rotation workers as high above safe limits (72,88,105,109), and very high on off-shift days (13,72,98), and higher than other workgroups(99) and general male population (105,132). These findings are in accordance with the findings of previous reviews on onshore rotation workers (7) and offshore rotation workers (74), which reported high alcohol consumption. Men typically drink more alcohol than women; with per capita consumption of '19.4 litres' compared to '7.0 litres' of undiluted alcohol among women drinkers (170), and with rotation workers being predominately males (7,68,162) could explain the high level of alcohol intake among this working group. Furthermore, the social environment of rotation worksites, particularly onshore sites (e.g., in Australia) has been reported as supportive of alcohol drinking as workers take up drinking to socially fit at the worksite (39,149). Alcohol consumption, particularly among offshore workers during off-shift days has also been indicated to be an expression of freedom from the worksite (171). Given that risky alcohol consumption is a major cause of disability and poor health and contributes to several deaths (172), and as suggested by Rebar *et al* interventions should target both on-site and off-site drinking among rotation workers taking into account personal, social and environmental factors that promote the intake of alcohol at risky levels (13). This may include the restriction of the availability of alcohol at onshore worksites and increasing awareness of the negative health consequences of risky alcohol intake (172).

Evidence on illicit drug use was limited with findings not showing any clear direction of use among rotation workers; therefore, further research examining the use of illicit drugs among rotation workers is required.

Smoking among rotation workers was high (99,109,138) and suggested to be higher than in other workgroups (99,113) and during on-shift days than off-shift days (13).

Similarly, a narrative review has also highlighted a high prevalence of smoking among offshore rotation workers (74). It has been documented that smoking and the desire to smoke are associated with experiencing high levels of stress (173) as such the stressful work conditions associated with rotation work arrangement (74,162) could be driving rotation workers to smoke. Smoking is recognised as a major cause of several health conditions and premature death, and with no safe limits (174). Therefore, evidence from the review suggests the need to provide health interventions that are aimed at the cessation of smoking such as *group behaviour therapy* and *individual counselling* (175), which could include stress management for rotation workers (13).

The main findings from included studies regarding physical activity suggested a large proportion of workers engage in regular leisure-time physical activity/exercise (72,108–110,139), during either on-shift days (72,98,108) or off-shift days (98,139). A previous review also reported offshore rotation workers engaging in physical activity mostly on off-shift days (74). Rotation worksites usually provide recreational facilities (68,149), which may have encouraged rotation workers to engage in physical activity/exercise and help maintain fitness (39). Nonetheless, engaging in physical activities/exercises on-site has been indicated to be restricted by long working hours and fatigue/tiredness from work (149). Long working hours are one of the many negative aspects of rotation work arrangements.

The studies reviewed on nutrition/diet reported findings that suggest poor nutrition among rotation workers at worksites. This is in line with the findings of a previous review where offshore rotation workers perceived their diet as unhealthy (74). Easy access to or availability of unhealthy food at worksites has been noted to promote the unhealthy eating behaviour of workers (88,100). The unavailability of healthy food has been identified as a barrier to healthy eating in workers (176) and one study has demonstrated that providing shift workers with healthy foods effectively improved their dietary intake during working days

(177). Only one study (13) examined nutrition during off-site in relation to on-site days as such not much is known about rotation workers' nutrition during leave periods. Furthermore, studies found high levels of overweight and obesity among rotation workers compared to the general population. A similar finding was reported in a previous review among offshore rotation workers (74). The intake of unhealthy foods has been indicated to be linked to obesity (178). The unhealthy eating behaviour among rotation workers is likely to explain the findings on overweight and obesity. Evidence, therefore, suggests the need to provide healthy food options at rotation worksites which could improve the dietary intake of rotation workers (177).

2.5.2 Work-related factors associated with health outcomes of rotation workers

The evidence reviewed suggested a wide range of work-related factors determining mental health outcomes in rotation workers. These included job demands (job task, workload and emotional demands), roster and shift length, occupational stressors, work-home interference, leadership style, job control/autonomy, role clarity, workplace bullying, and social support.

Evidence on factors determining physical health, sleep problems and lifestyle behaviours were scarce to make firm conclusions, but potentially suggest perceived physical health and complaints to be associated with job type, job demands and occupational stressors; shift pattern (swing shift), social support and occupational stressors to be associated to gastric problems while job type, shift pattern, and occupational stressors (physical environment/workplace) to be associated with musculoskeletal disorders. Furthermore, sleep problems were associated with shift/roster patterns (night/swing shifts), job demands and control (workload, working overtime, long shift hours), environmental stressors (safety climate, risk perception, adverse physical environment) and social support; and lifestyle behaviours were associated with social support, occupation stress from work-home interference and safety climate, job type, long work hours, availability of unhealthy food, and management of recreational facilities. Although most of the factors identified sit either within the JDR model or are FIFO specific work design factors, it may be suggested that more pronounced demands/less support are most consistently associated with the health outcomes of FIFO workers, particularly in the explanation of worse mental health outcomes.

The findings from the review align with the Job Demands-Resources (JD-R) Model (37,162). The JD-R Model stipulates two different categories of intrinsic occupational risk factors: job demands and resources which through "two underlying psychological processes play a role in the development of job strain and motivation" (p313) to influence the well-being of workers (37). These risk factors are the physical, psychological, social, or organisational components of a job. Job demands such as job tasks, workload, emotional demands, high work pressure, harsh physical environment etc. necessitate sustained mental, emotional or physical effort or skills to deal with and contribute to job strain (37). Job resources such as job control/autonomy, role clarity, job security, and social support help in attaining work goals and/or reduce job demands and the associated negative (physiological and psychological) effects, arouse personal learning, and development, and contribute to motivation (37,162). Vojnovic *et al* have discussed similar work-related factors and have stated rotation work is inherent with several job demands and as such available job resources are particularly significant and should be maximised to mitigate employee strain, and subsequent health (162). More research is needed to further examine the work-related factors associated with the health indicators particularly the physical health outcomes, sleep problems and lifestyle behaviours of rotation workers.

2.5.3 Strengths and limitations

This systematic review has several strengths; it provided a comprehensive overview of factors associated with the health and well-being of rotation workers in the resources industry, assessing the literature across different work sectors, countries and all relevant health indicators (covering factors associated with mental and physical health). The inclusion of quantitative and qualitative findings was also a strength as qualitative findings support quantitative evidence by giving in-depth insights into the health outcomes of rotation work, and mixed evidence synthesis has been indicated to enrich the effectiveness of findings and decision-making.

This review is not without limitations that should be acknowledged. The review included only published research and as such, the results of the study might be subject to publication bias. Only studies published in English were included which may have limited the scope, but there is evidence that suggests no systematic bias in reviews where only studies written in English are included (179). The review did not include other health behaviours (e.g., sedentary behaviours), which may be relevant to the FIFO work population. For instance, many of the FIFO roles may entail sitting/driving for most of the 12 hour shift and as such sedentary behaviours may be worth considering in future studies. The review only reviewed significant work-related factors determining health outcomes and health-related behaviours. However, there is evidence of socio-demographic characteristics that are associated with health outcomes and also moderate the associations between work-related factors determining health outcomes (162), which could be explored by future reviews.

2.5.4 Limitations of the assessed iterature

There are few longitudinal studies on health outcome measures, however, the available cross-sectional studies assessed extensively mental health outcomes with a few investigating physical health and health-related behaviour outcomes. Furthermore, most of the studies have used cross-sectional designs and as such making causal interpretations of the findings from these studies is limited.

Studies included had a greatly varied number of participants; quantitative studies included participants ranging from n=19 (90) to n=9,945 (116), with several studies including small sample sizes (33,110,132,140), which affect their conclusions. The qualitative studies included study participants ranging from n=7 (149) to n=68 (88), and while the sample is suitable for the kind of method used, it does not reflect the entirety of the rotation work population (7).

A vast majority of the studies selected study participants using a non-probability convenience sampling technique which has been indicated to be a suitable way to draw responses from a mobile population such as rotation workers (110). This may, however, result in the non-representativeness of the recruited sample. It is also possible that certain characteristics of participants may influence their participation, thus those most negatively impacted by rotation work may be more likely to take part in the survey or equally may be more likely not to take part in the study (7). Some of the studies particularly those that examined health-related behaviours also used non-validated measures which affect the rigour in methods (7). Again the findings of some of the studies were descriptive, e.g.,(105,108,116) and as such interpretations and drawing of general conclusions from the findings of these studies should be done with caution.

2.5.5 Implications for policy and future research

Addressing health challenges faced by rotation workers should be a key task for policymakers and resource industry management. In this regard, organisations should support interventions that identify, prioritise and mitigate mental and physical health problems and promote behavioural changes. Such interventions should also create workplace environments that minimise the negative aspects of rotation workstyle and maximise the positive aspects to support rotation workers to reduce job stress and promote health.

There is clear evidence that considerable efforts are being made in understanding the well-being of rotation workers. However, there is still inconsistency in the findings, particularly on mental health outcomes such as psychological distress (depression, anxiety, and stress) and well-being that require further research to clarify. There are limited rigorous studies that explore physical health problems and health-related behaviours and as such, there is a need for further studies to examine the work-related factors associated with the physical health problems and lifestyle behaviours of rotation workers. There are also limited interventional studies; interventional studies are therefore needed to improve health in this population and the cross-sectional research gives nice foundations for understanding factors that should be addressed in these interventions. Generally, there are limited longitudinal studies that explore the long-term health effects of rotation work and the short-term variations of health outcomes of rotation workers to give insight into how rotation workers experience health issues and their significant predictors change over time and across context.

2.6 Conclusions

Evidence from both qualitative and quantitative studies have suggested psychological distress and suicide risk among onshore rotation workers at higher levels than the general population; and more sleep problems (short sleep duration, poor sleep quality and sleepiness) and fatigue, smoking and poor nutrition during work periods among rotation workers in the offshore oil and gas, mining and construction industries. Evidence has also suggested rotation workers consume higher levels of alcohol during off-shift days and are more overweight and obese than the general population. Rotation workers reported perceived good physical health and engaged in leisure-time physical activity. Job demands of rotation work arrangements were associated with poor physical and mental health outcomes while the job resources available were associated with better physical and mental health outcomes. Hence, interventions could target minimising job demands and maximising the available job resources to support rotation workers to adapt and maintain balance in life, and to reduce job stress to promote health.

2.7 Summary and link to other Chapters

This chapter summarised the key mental and physical health outcomes and related behaviours that arose from the systematic review of the health and well-being of the global rotation FIFO work population. The review identified research gaps regarding inconsistencies in psychological well-being, a dearth of evidence on physical health status and related behaviours of FIFO workers and longitudinal studies to examine within-person health processes. The subsequent chapters offer empirical studies to test further the inconsistencies and research gaps in the evidence. In Chapter 3, we examined further the inconsistencies in psychological well-being and evidence on physical health status and related behaviours of FIFO workers using a cross-sectional study. In Chapter 4 the productivity loss cost associated with the key mental and physical health outcomes and related behaviours was evaluated using cross-sectional study design. In Chapter 8, the within-person variability of short-term health outcomes (psychological states and health behaviours) were tested using multilevel analysis. Applying multiple methods and carrying out a series of studies, the health (psychological well-being, physical health and related health behaviours) and their associated economic impacts among FIFO workers were explored.

Chapter 3: Study Two

Preface

This chapter presents the second published study included in this thesis and is cited as:

> **Asare BY,** Robinson S, Powell D, Kwasnicka D. Health and related behaviours of fly-in fly-out workers in the mining industry in Australia: a cross-sectional study. International Archives of Occupational and Environmental Health. 2022:1-6. doi: 10.1007/s00420-022-01908-x

The content of the article presented here exactly appears as in print, but formatted to be consistent with the rest of this thesis. Having identified potential research gaps including inconsistent findings on psychological well-being and limited rigorous studies that examined physical health and related behaviours in the systematic review, this article assessed the psychological distress, physical health status and related behaviours, and their work-related determinants among FIFO workers. The study highlights cross-sectional/between-persons differences in health behaviours across on and off-shift FIFO work periods and is limited in assessing the within-person differences which could be addressed in later chapters within the thesis.

Author contributions: BYA: conceptualization; methodology; investigation; data curation; formal analysis; visualization; project administration; writing—original draft preparation. SR, DP and DK assisted in conceptualization; funding acquisition; resources; supervision; writing—review & editing. The final manuscript was read and approved by all authors.

Study Two: Health and related behaviours of fly-in fly-out workers in the mining industry in Australia: a cross-sectional study

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Acknowledgements

The authors would like to extend our sincere appreciation to Mineral Resources Limited, Australia for supporting the study and advertising the study to their employees. We also extend our gratitude to all FIFO workers for participating and contributing to this study.

Funding

The study was funded by the Aberdeen-Curtin Alliance. Mineral Resources Limited, Australia also supported the study by providing an AUD 200 shopping voucher to the winner of a raffle draw as reimbursement for study participation. Mineral Resources Limited played no role in the design of the study, data collection and analysis, interpretation of study findings, preparation or decision to submit this manuscript for publication.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval and consent

The Curtin University Human Research Ethics Committee provided the ethical approval for the study (Approval reference number: HRE2020-0693; Appendix A). All study participants provided informed consent online before taking part in the study.

3.1 Abstract

Background: Fly-In Fly-Out (FIFO), which entails travelling mostly from the urban areas to stay and work in remote areas for designated periods and travel back home to spend designated days of leave, has become a common work arrangement in the mining sector globally. This study examined the mental and physical health of FIFO workers and described their health-related behaviours during on-and off-shift periods.

Methods: A cross-sectional study was conducted with FIFO workers ($N = 216$) in the mining industry in Australia who completed an online survey. Paired t-test and McNemar's analysis examined the differences in health-related behaviours during workers' on-and off-shift days. Logistic regression examined the predictors of physical health and psychological distress status of FIFO workers.

Results: Workers reported longer sleep duration (7.5 ± 1.5 h vs 6.3 ± 1.2 h, $p < 0.001$) and better sleep quality (78.2% vs 46.3%, $p < 0.001$) during off-shift nights than on on-shift nights. Smoking prevalence was 26.4%, and workers reported smoking a similar number of cigarettes per day during on-and off-shift days. Most workers reported drinking alcohol (86.1%) and more often at risky levels during off-shift than on-shift days (57.9% vs 34.3%, $p < 0.001$). Fruits and vegetable consumption was low but with higher vegetable intake during off-shift days (2.8 ± 1.4 vs 2.3 ± 1.3 serves, $p < 0.001$). Workers had good physical health status (91.2%), but 71.4% were overweight/obese and 33.4% indicated high levels of psychological distress. Working on long shifts (OR 6.63, 95% CI 1.84–23.91) and smoking (OR 7.17, 95% CI 2.67–19.26) were linked to high psychological distress.

Conclusions: The prevalence of psychological distress and risky health behaviours was high. Interventions should aim to reduce psychological distress and support multiple behaviour changes, considering FIFO work-related characteristics including long shift hours.

Keywords: Psychological distress, Physical health, FIFO, Mining, Health behaviours, Australia.

3.2 Introduction

Rotation work arrangements, which entail travelling mostly from the urban areas to stay and work in remote areas for designated periods and travel back home to spend designated days of leave (2,21), have in recent times become common in the mining sectors (21). Originally designed to staff the remote offshore oil and gas fields (2), rotation work arrangements, frequently denoted as *Fly-in Fly-out (FIFO)*, have come to be a standard practice in the onshore mining industry worldwide, particularly in Australia (2), where the mining operations usually take place in rural and remote areas (21).

Typically, FIFO jobs are associated with comparatively high earnings and lengthy periods off work to spend with families (1,23). But, other features of FIFO work, including recurrent separations from families for a period, long and compressed roster and shift patterns and increased workloads (162), are deemed stressors that could impact negatively the health and well-being of workers (40,162). Workers experience isolation and loneliness (15,110), inability to meet the demands at home when away (15,151) and family and social relationship disruptions (15,39). Workers are also presented with two (work and home) lives, which come with different ways of living, roles and tasks, requiring the assumption of distinct social roles and behavioural patterns (15).

According to the work-family theory (41), interference between the discharge of work and family roles arising from the demands of these roles could result in stress-related problems, such as misuse of substances and mental distress (180), at levels dependent on the significance of the unaccomplished task (41). Again, the Job Demands-Resources (JD-R) Model (37) stipulates that high job demands contribute to strain, including psychological distress.

Mental health problems and suicide concerns (23,181), and risky health behaviours, such as risky alcohol consumption (181), have been highlighted among FIFO workers in Australia. Studies have reported higher levels of psychological distress in FIFO workers than in the general population in Australia (27,29). High rates of depression (32,73), anxiety (73), stress (73) and suicide (32) have also been found among FIFO workers in Australia. However, inconsistent observations have been made on mental health in FIFO workers (40); with other studies reporting a lower prevalence of mental health problems than found in other workgroups in Australia (99) and statistically similar levels of depression and anxiety in FIFO workers and non-FIFO populations in Australia (131,132). Another study has found higher levels of depression and suicide risk among residential/non-FIFO mining workers than in FIFO workers (32).

Additionally, studies have also reported sleep problems such as short sleep duration and poor quality of sleep (52,53), high prevalence of overweight and obesity (99,110), higher alcohol consumption, and smoking rates (99) among FIFO workers compared to other workgroups (99) and the normal population (132) in Australia. A high proportion of FIFO workers engage in insufficient physical activity in Australia (35,99). In contrast, other studies have reported FIFO workers had moderate alcohol consumption (98) and low smoking rates (110) and documented no significant differences in engaging in physical exercise and consuming fruits and vegetables between rotation workers and other employment types in Australia (99).

FIFO work-related characteristics are associated with health issues (181). For instance, studies have demonstrated shift length (27,29), e.g., working shifts of more than 12 hours (29), roster patterns, e.g., 2 weeks on/1 week off (27) and day/night shift rotation (182) as predictors of high psychological distress among FIFO workers in Australia. Shift patterns (day and night shift) (40,68) and working longer shift hours (121) have also been identified to be linked to reduced sleep duration and poorer sleep quality in FIFO workers. Other studies have also found FIFO/rotation job roles/types as predictors of physical health complaints such as musculoskeletal pains (115).

A recent review examining the health and well-being of FIFO workers reported inconsistent findings regarding the impact of FIFO work on mental health outcomes, as well as very few studies examining its impact on health-related behaviours and physical health outcomes (40). There are also limited studies of any work-related factors that may be associated with the health and well-being of FIFO workers (40). More research is suggested to examine the physical and mental health needs of FIFO workers and examine the work-related factors associated with their health outcomes (40). Understanding the health status, lifestyle behaviours during on-and off-shift days and factors that contribute to the health and well-being of FIFO workers is critical for developing interventions to support and improve their health and well-being. The study aimed to examine the lifestyle behaviours of FIFO workers during on-and off-shift days. Secondly, the study aims to assess self-reported mental and physical health and identify the FIFO work-related determinants of mental and physical health outcomes.

3.3 Materials and methods

3.3.1 Study design and participants

A cross-sectional study was carried out among mining workers aged 18 years and above who worked on FIFO schedules in Australia. Participants reported at the same time their sleep and health behaviours separately for both on-and off-shift periods and the overall psychological distress and physical health status in the last 30 days. The sample size needed to detect a small effect size (d = 0.20) difference between on-and off-shift days in a paired samples t-test, with 80% power, was 199 participants. Secondly, we also wanted to estimate the likely prevalence of health outcomes: using psychological distress as an example, we assumed at least 21% of our study participants would experience distress – as the midpoint of estimates from previous studies of FIFO mining workers suggesting prevalence ranging from 10% to 31.6% (27–29,33,110). Using Cochran's sample size formula; $n=Z^2p(1\text{-}p)/e^2$ to capture at least 21% (p) of psychological distress, with a 95% confidence interval (z=1.96), and 5% margin of error (e), we needed 255 participants. Using this larger number, and assuming a 10% dropout rate, we aimed to recruit 280 participants. Data collection was conducted from July to December 2021. During that period, 326 FIFO workers were recruited through a non-probability convenient sampling technique, of which 299 (giving a participation rate of 91.7%) consented to take part in the study.

3.3.2 Study procedure

Recruitment of study participants was done in two ways; first, a large mining company, with multiple mine sites and an estimated FIFO or Drive-in Drive-out (DIDO) work population of 2600 in Western Australia was approached for consent and the advertising materials of the study were sent through the company's intranet weekly communications to invite their workers. Second, the advertising materials of the study were also posted in FIFO work support groups on the social media platform Facebook to recruit general FIFO mining workers in Australia. FIFO workers interested in taking part in the study were directed to use a URL link or QR code to access the online participants' information and a consent form. The participants completed an online questionnaire, administered through the Qualtrics XM online survey software (www.qualtrics.com/au/). All the participants confirmed that they worked in FIFO work. Qualtrics was not set up to record where participants were referred from to determine the proportion of study participants that were recruited through the mining company and/or from Facebook posts. Data collected was done between July and December 2021.

3.3.3 Data collection tool and outcome measures

The study included the following outcome variables: psychological distress, physical health, alcohol use, smoking, physical activity, weight/obesity and fruit and vegetable intake, and the measures are described in detail below. The full questionnaire is presented in Appendix D.

Psychological distress

The Kessler Psychological Distress Scale (K10) (183) was employed to measure the current level of psychological distress of FIFO workers. The scale, consisting of 10 items, measures the negative emotional states in the last 30 days (e.g., *In the last 30 days how often did you feel….nervous, depressed, hopeless, restless or fidgety*). The responses were rated on a 1 *(none of the time)* to 5 *(all of the time)* Likert scale. The K10 scale has been validated with an internal consistency high (α=0.93) (183) and its sensitivity has been established in the Australian population (184). The reliability of the scale was also high (α=0.91) in this study. With the possible scores of 10-50, the psychological distress of participants was characterised as *low (10–15), moderate (16–21), high (22–29) and very high (30–50) levels*.

Physical health

Physical health status was measured using the Physical Component Summary (PCS) of the SF-8 Health Questionnaire (185). The SF-8 has 8 items measuring the quality of life in the last 4 weeks, with a PCS subscale. The PCS subscale has 4 items (e.g., *How much bodily pain have you had during the past 4 weeks?*) and is scored on a 5 and/or 6-point Likert scale and the scores were transformed to generate a total score ranging from 0 to 100)as per the SF-8 scale, with a higher score suggestive of better physical quality of life (185). The test-retest reliability for the subscale PCS-4 has been demonstrated as adequate at 0.73, comparable to 0.78 in this study.

Sleep and lifestyle behaviours

Sleep measures. Participants recalled their sleep duration and sleep quality in the past 30 days for both on-and off-shift days using single items adapted from the *Pittsburgh Sleep Quality Index (PSQI)* (186). Sleep duration was assessed by the item *"How many hours of actual sleep did you get at night during on (or off)-shift days?"* and sleep quality with *"During on (or off)-shift days, how would you rate your sleep quality overall?"* scored on a 4-point Likert scale from 0 (very good) to 3 (very bad) (186). As indicated, separate questions were asked for on-and off-shift days. Single items were chosen for brevity and the use of single items for sleep duration and sleep quality is consistent with a previous study (121).

Alcohol intake. The current alcohol use and related behaviours in the last 1 year were assessed during on-and off-shift days with the *Alcohol Use Disorders Identification Test-Concise (AUDIT-C)* (187). AUDIT-C is a brief validated tool consisting of 3 items: "*How often do you have a drink containing alcohol?"; "How many standard drinks containing alcohol do you have on a typical day when drinking?"; "How often do you have six or more standard drinks on one occasion?"* Each item was scored on a 5-point scale (0 to 4) for screening for risky alcohol consumption. Separate questions were asked for on-shift days and off-shift days and total scores on alcohol use were generated for each shift period. A score of ≥4 among men *(sensitivity 0.86, specificity 0.89)* and ≥3 among women *(sensitivity 0.73, specificity 0.91)* were classified as risky alcohol drinking (187).

Smoking. Smoking status was assessed using 3 items. Participants were asked *"Do you smoke?"* and *"Have you ever smoked?"* (*Yes, No*). Participants were then classified as current smokers, ex-smokers or never smoked. Current smokers were then asked to report the number of cigarettes typically smoked per day separately during on-and off-shift days.

Physical activity. The *International Physical Activity Questionnaire (IPAQ)-short form* (188) was used to measure participants' physical activity during on-and off-shift days. The IPAQ measures the frequency (in days) and duration (in minutes) of mild, moderate-and vigorous-intensity physical activities that lasted for at least continuous 10 minutes in the last 7 days. In this study, we assessed physical activities during leisure time, and separate questions were asked for on-shift days and off-shift days. Moderate physical activities were indicated as activities making one breath to some extent tougher than usual (e.g., lifting lighter weights, biking at moderate speed, or playing tennis in pairs) whereas vigorous activities were activities making one breath considerably tougher than usual (e.g., lifting heavy weights or strenuous exercises). Mild physical activities included walking (188).

The weekly metabolic equivalent minutes (MET minutes) were computed for the various activities by multiplying the minutes and days by their established intensity (in METs): *walking=3.3, moderate=4.0 and vigorous=8.0 METs* (189). The overall weekly physical activity was then estimated by adding mild, moderate and vigorous MET minutes. Using the criteria *"5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum of at least 600 MET-min/week"* (189), which has been deemed sufficient physical activity for health benefits (190), participants' physical activity measures were classified into two categories as insufficient physical activity: scores <600 MET-min/week and sufficient to high physical activity: scores of >600 MET-min/week (191). The test-retest reliability for the IPAQ-short form scale is indicated as high (α<.80) (188).

Fruits and vegetable intake. Fruits and vegetable intake during on-and off-shift days were assessed using the items: "*How many serves of vegetables do you usually eat each day during on-shift days?"* and *"How many serves of fruit do you usually eat each day during on-shift days?"* and scored on an 8 point response scale *(1 serve, 2 serves, 3 serves, 4 serves, 5* *serves, 6 serves or more, 7 less than one serve, 8 Don't eat fruit/vegetables)* (192). Using the Australian daily dietary guidelines on minimum daily recommended serves of 2 or more fruits combined with 5 or more serves of vegetables, participants' intake was classified as either adequate or inadequate intake by whether they usually do (adequate) or do not (inadequate) achieve these guidelines (193).

Overweight and obesity. Participants self-reported their height in meters and weight in kgs. Body Mass Index (BMI) was calculated and categorised as *underweight (BMI < 18.5), normal weight (18.5–24.9), overweight (25–29.9) and obese (BMI ≥ 30)* (194).

Exploratory variables

Socio-demographic characteristics. The socio-demographic characteristics collected included participants' age, sex, ethnic background, relationship status and duration, number of children, and highest educational level.

FIFO work-related measures. This study focused on exploring FIFO specific work design factors highlighted in the previous review chapter. These factors are more likely not to vary day-to-day and therefore we decided to explore them in cross-sectional study design. Work-related measures included current occupational role (management, administrative, services, professional, maintenance, technician, production, drilling, construction, labourer, machinery operator and driver, catering and others), and duration of working in FIFO. Others were regarding their work schedules, including normal FIFO shift pattern (regular fixed day, regular fixed night and rotating shift), the usual number of hours of their normal shift (length), the typical number of consecutive days away at work, and the typical number of consecutive days at home. Previous studies have highlighted these work-related measures as significant factors in exploring the health outcomes of FIFO workers.

3.3.4 Data analysis

STATA version 13 software *(StataCorp LP, College Station, Texas, USA)* was used to analyse the data. Continuous variables were presented in means and standard deviations and the categorical variables in frequencies and proportions for descriptive purposes. The paired t-test and McNemar's analysis were done to examine the difference in sleep outcomes, alcohol consumption, smoking, physical activity, weight/obesity and fruit and vegetable intake over workers' on-and off-shift days. Univariate and multiple logistic regressions (adjusting for sociodemographic, health behaviours and FIFO work-related factors) were conducted at a $p<0.05$ statistical significance level to examine the sociodemographic, health behaviours and FIFO work-related predictors of physical health status and psychological distress of FIFO workers. The existence of multi-collinearity in the model was checked using the tolerance test by estimating the Variance Inflation Factor (VIF) value and the results, (VIF ranging from 1.13 to 1.88) showed no multi-collinearity.

3.4 Results

3.4.1 Background characteristics of the study participants

The characteristics of the participants are outlined in Table 2. Of the 299 participants who consented to take part in the study, 216 fully completed the survey (giving a completion rate of 72.2%) and were included in the analysis. The mean age of the participants was 39.9±11.6 years, with more than half (62.0%) aged above 34 years. The majority of the participants were males (66.2%) and of Caucasian/White ethnic background (84.7%). About one-third of the participants had primary/secondary education or equivalent (32.4%). More of the participants were married (43.0%) or in De-facto/co-habiting /Civil partnership (25.5%) and more than half had at least 1 child (57.9%).

Most of the participants have worked in FIFO work arrangements for 5 years or more (59.7%), spending 8 days or more (80.1%) at the worksite and less than 8 days at home

(86.6%) in a FIFO roster cycle. Furthermore, most of the participants indicated working on rotation shifts of a mixture of day and night (56.0%) or regular fixed day shifts (42.6%), and most of them reported working 12 hours per day or more (86.1%). One-fourth of the participants (25.0%) reported working in management/administrative/services roles (see Table 2).

Table 2. Distribution of demographics and work-related characteristics of FIFO workers

Personal characteristics	Frequency	Percent
Age in years		
≤24	12	5.6
25-34	70	32.4
35-44	67	31.0
45+	67	31.0
Sex		
Male	143	66.2
Female	73	33.8
Ethnicity		
Caucasian/White	183	84.7
Other	33	15.3
Relationship status		
Single/never married	43	19.9
Married	93	43.0
Separated/Divorced/Widowed	25	11.6
De-facto/co-habiting/Civil partnership/Other	55	25.5
Number of children		
None	91	42.1
1	27	12.5
2	51	23.6
3+	47	21.8
Educational status		
Primary/Secondary education and equivalent	70	32.4
Trade/Apprentice	45	20.8
TAFE/College	60	27.8
Bachelor degree	30	13.9
Postgraduate degree	11	5.1
FIFO role		
Management Administration/services	54	25.0
Professional	27	12.5
Maintenance/Technician	39	18.1
Production/Drilling/Construction/Labourer	45	20.8
Machinery operator and driver	35	16.2
Catering/Other	16	7.4
Shift pattern		
Rotation shift (mixture of day/night shift)	121	56.0
Regular shift (fixed day/fixed night)	92	42.6
Other	3	1.4
Shift hours		
<12 hrs	30	13.9
12 hrs	129	59.7

>12 hrs	57	26.4
Consecutive days spent at work		
<8 days	43	19.9
8-14 days	156	72.2
15+ days	17	7.9
Consecutive days spent at home		
<8 days	187	86.6
8-14 days	29	13.4
FIFO duration		
<5 yrs	87	40.3
≥5 yrs	129	59.7

TAFE= Technical and Further Education

3.4.2 Lifestyle behaviours of FIFO workers during on-and off-shift FIFO work periods

Sleep duration and quality

During on-shift days, the participants self-reported shorter sleep duration (6.3±1.2hrs) compared to off-shift days (7.5±1.5hrs) ($p<.001$). More of the participants reported sleeping for 7 or more hours during off-shift days compared to on-shift days (78.2% vs 46.3%, $p<.001$). About 2 in 5 of the participants (40.3%) self-reported poorer sleep quality during on-shift days compared to 15.7% who self-reported poorer sleep quality on off-shift days ($p<.001$).

Smoking and alcohol intake

About 1 in 4 of the participants (26.4%) were current smokers and 29.2% were ex-smokers. The average number of cigarettes smoked per day was similar during on-shift days and off-shift days (11.7±6.9 vs 11.2±7.5, $p=.718$).

The majority (86.1%) reported consuming alcohol in the last month. More consumed alcohol at risky levels (AUDIT-C scores ≥3 for females and 4 for males) during off-shift days compared to on-shift days (57.9% vs 34.3%, $p<.001$).

Fruits and vegetable intake

During off-shift days, the participants self-reported consuming more serves of vegetables per day (2.8±1.4 serves) compared to 2.3±1.3 serves during on-shift days ($p<.001$). A higher proportion reported consuming the recommended 5 or more serves per day during off-shift days compared to on-shift days (9.3% vs 4.2%, *p*=.013). However, the amount of fruits intake reported was similar during on-shift and off-shift days (1.7±1.2 vs 1.7±1.3 serves per day, *p*=.583); with similar proportions of FIFO workers consuming 2 or more serves per day for the period of the on-and off-shift days (52.8% vs 48.6%, *p*=.262).

Physical Activity and Body Mass Index

The study participants reported more MET minutes of mild/moderate/vigorous physical activities per week during on-shift days than on off-shift days (3531.6±4973.2 vs 2762.6±3385.2, *p*=.018). However, the same proportion of FIFO workers was found to engage in sufficient to high mild/moderate/vigorous physical activity per day during the on- and off-shift days (73.1% vs 74.5%, *p*=.755).

The study participants reported an overall average body mass index (BMI) of 28.4±5.9Kg/m^2 and 71.4% of them were classified as overweight or obese.

3.4.3 Physical health and psychological distress

The majority of participants were classified as having good physical health status (91.2%). About one-third of the study participants (33.4%) reported a high to very high risk of psychological distress. The distribution of physical health and risk of psychological distress is presented in Table 3.

Table 3. Health status and lifestyle behaviours of FIFO workers

Lifestyle behaviours	On-shift days, n(%)/mean±sd	Off-shift days, n(%)/mean±sd	*p*-value
Sleep duration	6.3±1.2hrs	7.5±1.5hrs	**<0.001**[ɳ]
<7 hrs	116(53.7)	47(21.8)	**<0.001**[¥]
7+ hrs	100(46.3)	169(78.2)	
Sleep quality			**<0.001**[¥]
Fairly good/very good	129(59.7)	182(84.3)	
Fairly bad/very bad	87(40.3)	34(15.7)	
Alcohol intake			
Non-risky	142(65.7)	91(42.1)	**<0.001**[¥]
Risky	74(34.3)	125(57.9)	
Smoking			
Non-smokers	96(44.4)		
Ex-smokers	63(29.2)		
Current smokers	57(26.4)		
Number of cigarettes smoked	11.7±6.9	11.2±7.5	0.592[ɳ]

per day			
Vegetable intake per day	2.3±1.3	2.8±1.4	**<0.001**[ŋ]
<5 serves	207(95.8)	196(90.7)	**0.013**[¥]
5+ serves	9(4.2)	20(9.3)	
Fruits intake per day	1.7±1.2	1.7±1.3	0.583[ŋ]
<2 serves	102(47.2)	111(51.4)	0.262[¥]
2+ serves	114(52.8)	105(48.6)	
Mild/moderate/vigorous physical activities (MET-n=mins/week)	3531.6 ±4973.2	2762.6±3385.2	**0.018**[ŋ]
Insufficient	58(26.9)	55(25.5)	0.755[¥]
Sufficient to high	158(73.1)	161(74.5)	
Body Mass Index			
Underweight	7(3.2)		
Normal/Healthy weight	55(25.4)		
Overweight	77(35.7)		
Obese	77(35.7)		
Physical health status			
Poor	19(8.8)		
Good	197(91.2)		
Psychological distress			
Low risk	85(39.3)		
Moderate risk	59(27.3)		
High risk	44(20.4)		
Very high risk	28(13.0)		

[ŋ]p value from paired t-test; [¥]Exact McNemar significance probability; Bolden significant at $p<0.05$

3.4.4 Personal and FIFO work-related characteristic associations with physical health and psychological distress

The results of bivariate and multiple variable logistic regression are outlined in Table 4. At the bivariate level, the results showed FIFO workers aged over 44 years compared to those less than 35 years (OR=0.49, 95%CI=0.25-0.99) were at reduced odds of psychological distress. Higher odds of distress were evident in workers who had no children compared to workers with children (OR=2.09, 95%CI=(1.18-3.72), were current smokers compared to those who did not smoke (OR=3.64, 95%CI=1.82-7.28), and those whose shifts lasted for 12 hours or more compared to those on shift less than 12 hours (OR=2.82, 95%CI=1.03-7.70).

However, the odds of poor physical health status were lower in FIFO workers whose shifts lasted for 12 hours or more compared to those on shifts less than 12 hours

(OR=0.35(0.12-0.99). The odds of poor physical health status were higher in current smokers compared to those who did not smoke (OR=3.41, 95%CI=1.08-10.75).

In the multiple logistic regressions adjusting for socio-demographic characteristics (age, sex, ethnicity, marital status), health behaviours and work-related factors, the odds of high psychological distress were higher in those whose shifts lasted for 12 hours or more compared to those on shifts less than 12 hours (OR=6.63, 95%CI=1.84-23.91) and in workers who were current smokers compared to those who did not smoke (OR=7.17, 95%CI=2.67-19.26). On the odds of poor physical health, FIFO workers whose shift lasted for 12 hours compared to those on shifts less than 12 hours (OR=0.18, 95%CI=0.04-0.75) and reported inadequate physical activity (OR=0.19, 95%CI=0.04-0.99) had lower odds, whereas current smokers had higher odds compared to non-smokers (OR=5.65, 95%CI=1.13-28.32) (see Table 4).

Table 4. Logistic regression models of demographic and work-related characteristics predicting high/very high psychological distress and physical health in workers

FIFO work characteristics	High/very high psychological distress		Poor physical health	
	Unadjusted OR(95%CI)	Adjusted OR(95%CI)	Unadjusted OR(95%CI)	Adjusted OR(95%CI)
Age in years				
<35	1	1	1	1
35-44	0.53(0.27-2.30)	0.53(0.20-1.40)	1.02(0.30-3.51)	2.44(0.38-15.53)
>44	0.49(0.25-0.99)*	0.37(0.13-1.06)	2.22(0.76-6.47)	4.99(0.76-32.71)
Sex				
Male	1	1	1	1
Female	1.17(0.64-2.11)	0.83(0.35-1.94)	1.54(0.62-3.83)	2.53(0.60-10.59)
Ethnicity				
Caucasian/White	1	1	1	1
Other	0.60(0.25-1.40)	0.66(0.22-1.99)	0.56(0.12-2.51)	0.18(0.02-1.61)
Relationship status				
Married	1	1	1	1
Single/never married	1.76(0.83-3.74)	1.15(0.36-3.70)	0.40(0.08-1.93)	0.24(0.03-1.85)
Separated/Divorced/Widowed	0.61(0.21-1.79)	0.41(0.11-1.52)	1.13(0.29-4.47)	0.58(0.09-3.60)
De-facto/co-habiting/Civil partnership/Other	1.63(0.81-3.29)	1.04(0.38-2.84)	1.02(0.35-2.97)	0.81(0.19-3.54)
Have children				
Yes	1	1	1	1
No	2.09(1.18-3.72)*	1.84(0.70-4.81)	0.83(0.33-2.09)	1.84(0.43-7.82)
Educational status				
Primary/Secondary education or equivalent	1	1	1	1
Trade/Apprentice	1.09(0.50-2.37)	1.06(0.40-2.81)	0.93(0.21-4.09)	0.98(0.16-6.11)
TAFE/College	0.90(0.44-1.86)	0.70(0.27-1.83)	2.60(0.84-8.09)	3.35(0.82-13.72)
Bachelor/postgraduate degree	0.58(0.24-1.38)	0.55(0.16-1.86)	1.03(0.23-4.54)	1.29(0.15-10.96)
Alcohol intake				
No	1	1	1	1
Yes	1.00(0.44-2.27)	0.57(0.19-1.68)	0.96(0.27-3.50)	1.09(0.21-5.59)
Smoking status				
No smoker	1	1	1	1

Ex-smoker	0.89(0.42-1.86)	1.34(0.54-3.31)	2.28 (0.69-7.52)	2.05(0.42-9.98)
Current smoker	3.64(1.82-7.28)***	7.17(2.67-19.26)***	3.41(1.08-10.75)*	5.65(1.13-28.32)*
Physical activity				
Adequate	1	1	1	1
Inadequate	1.79(0.96-3.33)	1.92(0.86-4.32)	0.42(0.12-1.50)	0.19(0.04-0.99)*
Body Mass Index				
Normal weight	1	1	1	1
Underweight	1.42(0.29-7.02)	0.92(0.11-7.98)	2.89 (0.26-32.35)	5.33(0.28-10.78)
Overweight	0.86(0.41-1.79)	1.24(0.50-3.05)	2.29(0.59-8.90)	3.07(0.50-18.97)
Obese	0.97(0.47-2.00)	1.45(0.58-3.63)	2.01(0.51-7.95)	2.51(0.42-15.05)
FIFO role				
Management /Administration/services	1	1	1	1
Professional	1.33(0.47-3.74)	1.37(0.38-5.00)	0.38(0.04-3.40)	1.50(0.09-24.70)
Maintenance/Technician	1.58(0.63-3.93)	1.63(0.53-5.04)	1.12(0.28-4.47)	3.47(0.55-22.04)
Production/Drilling/Construction/Labourer	2.10(0.89-4.98)	1.53(0.54-4.38)	1.82(0.53-6.14)	2.05(0.44-9.61)
Machinery operator and driver	2.37(0.95-5.91)	0.73(0.22-2.45)	0.59(0.11-3.25)	0.66(0.06-6.84)
Catering/Other	1.43(0.42-4.89)	1.57(0.35-7.05)	1.40(0.24-8.01)	0.82(0.09-7.47)
Shift pattern				
Rotation shift/others	1	1	1	1
Regular shift	0.61(0.34-1.10)	0.76(0.34-1.67)	1.25(0.51-3.09)	1.59(0.46-5.55)
Shift hours				
<12 hrs	1	1	1	1
≥12 hrs	2.82(1.03-7.70)*	6.63(1.84-23.91)**	0.35(0.12-0.99)*	0.18(0.04-0.75)*
Consecutive days spent at work				
8-14 days	1	1	1	1
<8 days	0.94(0.46-1.93)	0.72(0.29-1.78)	1.04(0.32-3.34)	1.21(0.27-5.39)
15+ days	0.81(0.27-2.42)	1.60(0.36-7.11)	2.17(0.55-8.49)	3.29(0.53-20.57)
Consecutive days spent at home				
<8 days	1	1	1	1
8-14 days	0.48(0.19-1.23)	0.48(0.16-1.49)	0.65(0.14-2.97)	0.54(0.08-3.60)
FIFO duration				
≥5 yrs	1	1	1	1
<5 yrs	1.19(0.67-2.11)	0.89(0.41-1.94)	0.90(0.36-2.28)	1.33(0.32-5.52)

*p<0.05; **p<0.01; ***p<0.001; Reference category: used largest category for age, sex, ethnicity, marital status, education, have children, job, shift pattern, days spent at work and at home, and FIFO duration; and normative category for alcohol, smoking, physical activity, BMI and shift hours; TAFE= Technical and Further Education

3.5 Discussion

3.5.1 Main findings

The FIFO lifestyle of working on and off-shift periods presents workers with two different contexts, characterised by different roles and lifestyles, which demand the taking on of diverse social roles and behaviours (15). Our study investigated the self-reported mental and physical health and lifestyle behaviours of FIFO workers during on-and off-shift days.

The study found longer self-reported sleep duration and better sleep quality during off-shift days than during on-shift days. Several studies have also made similar findings of shorter sleep duration during on-shift days than during off-shift days in FIFO workers (16,52). Specifically, sleep duration reported during on-shift days (6.3±1.2hrs) was lower than the recommended 7 or more hours of sleep (195). This aligns with the observations made by previous studies, which reported between 5.7 and 6.7 hours of night sleep during work periods (52,53). Furthermore, the study found FIFO workers reported better sleep quality during off-shift days than during on-shift days. Consistent findings have been documented in previous studies (13,16).

Sleep problems in rotation (FIFO) workers in the resources sector have been highlighted in several reviews (40). FIFO workers typically work long hours (mostly 12 hours) and day or night shifts and swing shifts (a mix of day and night shifts) patterns (21), with early start times for day shifts. Working long hours (163) and shift patterns, particularly night and early morning shifts (164) and swing shifts, which require mid-roster shift changes (from day to night or night to day) (125) have been linked with sleep disorders due to disruptions to the circadian rhythm (196). Early start times for day shifts require that workers sleep early to be up early and ready to catch a bus for work, but early evening hours bedtime is deemed frustrating and does not certainly result in early sleep onset as such the early start times to shifts may truncate sleep periods (53). Our findings suggest FIFO workers may accumulate sleep debt during on-shift days whereas there is an indication of recovery during off-shift days. Sleep duration during on-shift periods was lower than that recorded during off-shift periods (7.5 hrs), which is consistent with the broader literature (40), and comparable to the standard average sleep duration indicated for a normal adult sleep (around 7 hours or more) (195) and may not suggest oversleeping sleep during days off. FIFO campsite or village accommodations are designed to create sleep conditions such as a quiet environment (197) and limited room lighting during daytimes, but competing personal and social activities during non-work times at campsites are deemed to also interfere with sleep (53) and may need to be limited to promote sleep at worksites. Additionally, adjusting early start times to shifts (53) and allowing enough days off (between consecutive rosters) and longer changeover widow among workers on swing shifts, possibly greater than 24 hours or days could allow for sufficient sleep recovery (52). For instance, a qualitative study has suggested that FIFO workers perceived a reduction in fatigue and a positive impact on their general health and well-being when a roster pattern of 7 day-shift/7 night-shift/7 days off changed to 10 day-shift/5 days off/8 night-shift/5 days off, and the latter to 8 day-shift/6 days off/8 night-shift/6 days off (198). Enabling adequate sleep could help address the negative effects that may accompany accumulated sleep loss such as fatigue and impaired performance and related work accidents that can occur as a result of poor sleep or lack of sleep.

Our study showed that 26.4% of the FIFO workers self-reported as current smokers. This is comparable to the findings previously published among FIFO workers (99) and the general mining workers (182) in Australia. These rates are higher than the 11.6% reported among adults in Australia (199). FIFO workers work under stressful conditions such as extended separations from family, working long periods and on compressed shifts with increased work demands/workload (24,162) and report severe distress levels (27,29,73). Increased stress levels are connected with the urge to smoke and more cigarette smoking

(200), and could account for more of the FIFO workers engaged in smoking. Stressors associated with FIFO work may be profound during work periods, and as found in a previous daily diary study, FIFO workers smoked more cigarettes during on-shift days than on off-shift days (13). In contrast, our study found FIFO workers smoked a similar average number of cigarettes per day during on-shift and off-shift days and the number of cigarettes smoked per day during on-shift days and off-shift days in our study was comparable to the 12.9 cigarettes per day reported in the general smoking population in Australia (199).

Consistent with the findings reported in previous studies (7,35), a high proportion of the FIFO workers were found to consume alcohol. The rates of self-reported alcohol intake in the FIFO workers (86%) are higher than the reported rate (77%) of alcohol intake in the last year in the broad Australian populace (201). Again, consistent with other previous studies (35,99), the current study found more FIFO workers consume alcohol at risky levels during on-and off-shift days. Alcohol intake at higher levels among FIFO/rotation workers (40), and in the general mining population in Australia (30,31) has been previously documented. Studies have documented that FIFO workers consume alcohol at higher levels than the general population (132) and other workgroups (99).

FIFO work population are largely men (162) and with men known to typically consume more alcohol (202), this could account for the higher levels of alcohol consumption in FIFO workers. Additionally, FIFO work characteristics such as working rotating shifts and shift lengths of more than 12 hours, and the experience of high levels of psychological distress among the mining work population have been linked to risky/harmful levels of alcohol consumption (31). FIFO workers experience high levels of psychological distress (27,29) as they face increased emotional demands, for instance, dealing with the 'physical and psychological distance', loneliness and isolation due to their absence from families (15), which could also account for the high level of alcohol consumption in this workgroup. The presence of *'wet mess'* at campsites and workplace culture which support social drinking (39,203) is indicated to foster drinking at risky levels (23). However, in line with previous studies (13,16), our study found a high proportion of FIFO workers consumed alcohol at risky levels during off-shift days than on-shift days. The level of alcohol consumption during on-shift days may be related to some level or full alcohol restrictions at some worksites (16) and also the common requirements at almost all worksites for pre-shift breath tests for alcohol and unplanned substances/drugs testing before being allowed to work to ensure workplace safety (17). Such mandatory requirements do not extend to non-work times or off-duty at the campsites, where in places with no or some restrictions workers could engage in risky levels of alcohol intake (204). But, recent industry guidelines require companies to implement campsites measures including limiting the number of drinks taken in a 24-hour window and serving varied strength of alcohol options including 0% alcohol strength beverages to ensure psychological and physical safety (205). Whereas at home, there may be more alcohol available and drinking among workers is seen as a sign of freedom from the worksite restriction (171). Experiencing boredom during off-shift days is also indicated to foster drinking (203).

Interventions and strategies, including stress management (206), limiting the availability and access to alcohol on-site during shift days, for example through restrictions on sales or replacing with non-alcoholic and promoting awareness of the harmful effects of drinking and smoking (170) could help to address the relatively high levels of smoking and alcohol intake among the FIFO workers.

The self-reported daily intake of fruits and vegetables among FIFO workers in the current study was low. However, a comparable proportion of FIFO workers achieved the nationally recommended intake for fruits (52.8% on on-shift days and 48.6% on off-shift days) to that reported in the general adult (51.3%) Australian population (193). More FIFO workers met the daily requirement for vegetable intake during off-shift periods (9.3%) than is typical for the general Australian population (7.5%) (193). A similar study has also reported a high proportion of FIFO workers consuming insufficient fruits and vegetables but was not different from other workgroups in Australia (99). FIFO workers in our study consumed more vegetables during off-shift days than during on-shifts. A daily diary study also found FIFO workers perceived their nutritional intake during off-shift days to be of a higher quality than during on-shift days (13). FIFO workers potentially engage in more unhealthy eating behaviour (consuming food of poorer nutritional quality) (40,74) and that has been attributed to the readily accessible food that may be unhealthy at workplaces (88). However, we did not assess unhealthy intake and meal quality/regularity. Eating during on-shift days is more structured compared to home periods and this could be considered in subsequent future studies. High stress can be associated with unhealthy eating behaviours (207), including a high intake of food high in calories (208) and less intake of foods low in calories such as fruits and vegetables (209). With FIFO workers engaged in stressful work (15,39) and indicated to experience distress at high levels (27,29), this could also explain the low intake of fruits and vegetables among the workers, particularly when on shift.

Furthermore, more than half of participating FIFO workers (71.4%) were classified as overweight or obese based on self-reported height and weight, somewhat higher than the proportion of the broad adult Australian populace (67%) reported as overweight or obese (194). Our finding compares favourably with those reported in the literature, which shows that FIFO workers have a higher prevalence of overweight and obesity than reported in groups working non-FIFO schedules in Australia (99) and the general population (40). There could be fewer healthy food options available at work sites (88) or less priority on healthy food choices among workers. For instance, Sibbel *et al.* (197) have found FIFO workers to be less satisfied with the variety of food options and healthy food options available at campsites.

Also, the potential of stress-induced eating due to high distress (40) seen in FIFO workers is known to contribute to overweight and obesity (210). Organizations should provide more healthy food options at worksites (177), educate workers to choose healthy food options and assist workers to cope better with the stressors inherent within the FIFO 'lifestyle' and reduce stressors wherever possible. This may help to improve the eating behaviours of workers and reduce the associated risks including non-communicable diseases and reduce productivity losses (211).

The study found that most FIFO workers engage in sufficient to high self-reported mild/moderate/vigorous physical activities per week. This reflects the findings from the extant literature, which suggests high levels of leisure-time physical activities among rotation workers (40). Furthermore, FIFO workers were found to engage in more MET-mins/week on on-shift days, but similar proportions of workers engaged in sufficient to high physical activities during both on-and off-shift days. This contradicts the finding of a previous daily diary study where FIFO workers reported less exercise time during on-shift days than off-shift days (13). The differences between the measurements and designs used in our study using one-off measures and the previous study using daily measures, which are less prone to recall errors, should be noted. The presence and accessibility of recreational facilities (149) such as gyms or wellness centres with health and well-being officers, basketball and tennis courts, swimming pools, and the organisation of sporting and other recreational activities including basketball, soccer and group fitness activities at worksites may have encouraged workers to engage in physical activities during on-shift days (212). Further, taking part in recreational activities on-site is indicated to promote social interactions and a sense of belonging (149) that support workers to manage separations from their families (15). The closeness of camps limits the commute to and from work sites, allowing for some free time, and on-site recreational facilities are maintained and promoted, which encourages physical activities (212).

The higher level of self-reported physical activities observed in the current study could reflect the high proportion of FIFO workers (91.2%) being classified as having good physical health status. This finding is in line with the extant evidence, where FIFO workers indicate having good to very good overall physical health status (40), and the use of medications for physical health impairments as unusual (13).

However, the study shows that 33.4% of FIFO workers reported a high to very high risk of psychological distress higher than reported in the Australian population (13.0%) (213). Similar previous studies have also reported a higher prevalence of high to very high psychological distress among FIFO workers than documented in the Australian general population (27,28,33). FIFO work arrangements mean workers may be absent from their families for a long period and may not be able to carry out their family duties and miss some important family events. In line with the work-family theory (41,180), the demands of being absent from home interfering with the accomplishment of family duties could result in stress-related outcomes at levels dependent on the significance of the unaccomplished task (41). It has been highlighted that the difficulties of balancing work and home life (15), not being able to attend to family emergencies and missing out on important family events (15), and worries about maintaining family and social relationships (15,39) are all potential sources of distress for FIFO workers. Again, FIFO work comes with high demands of long/compressed roster patterns and shift hours (typical of 12 hours), FIFO roles/workload, living away from families and dealing with loneliness and social isolation (emotional demands), and work-home interference (162), which have been highlighted in the extant literature to be associated with psychological distress among FIFO workers (40). Furthermore, workers travel long distances between worksites and home during their days off, which may take off some time spent at home (reducing the available time for recovery and to spend with families), particularly among drive-in drive-out (DIDO) workers and those who FIFO into the city but live a considerable distance from the airport or other states but need to drive or fly to their home/locations, which can potentially add to workers' distress levels (7,23). In line with the Job Demands-Resources Model (37), high job demands contribute to strain including psychological distress. Current regulations in Australia require FIFO organizations to provide support for workers experiencing distress (214). There are on-site support programs and services (39,151) such as counselling services (151). However, it has been indicated that some workers are reluctant to seek mental health support (15,39) for fear of losing their jobs, being regarded as weak (display of 'macho' culture) and lack of awareness of when to seek help (15). On-site support programs, such as on-site chaplaincy, have been suggested in a qualitative study to help workers overcome the fear of losing their jobs and workplace culture of masculinity associated with seeking help for mental health issues promoting the mental health and well-being of workers, with service provision related to *active outreach, trust-building, availability and confidentially* thought to be crucial in its effectiveness (151).

In the current study, FIFO workers who worked on shifts 12 hours or more were at increased risk of experiencing high to very high psychological distress. A similar finding has been documented among mining workers in Australia (29). Again, smoking could be propagated by increased stress (200) and was associated with the health status of workers in this study. Specifically, workers who were current smokers had a high risk of experiencing high to very high psychological distress and poorer physical health status compared to workers who were not current smokers. This finding aligns with that of a previous study among mining workers in Australia, where workers who were daily smokers were more likely to experience a high level of psychological distress (215). Other personal and work-related factors including gender, employment type, length of FIFO experience and shift patterns were found not to be associated with physical health and psychological distress, similar to the findings noted in a previous study (29). Contrary to previous studies in the mining industry (27,29,182), factors including age, marital status, educational status, alcohol use and days spent away at work and at home (roster length) were not associated with physical health and psychological distress in adjusted models. The differences in the sample sizes of the studies, where previous studies involved larger sample sizes compared to our study, should be noted. Our findings suggest the experience of poor physical health and psychological distress may be widespread across the different groups of the study sample. However, the demands of work-related factors are indicated to be significant determinants of the health of workers (40,162), and such factors have the potential to be modified within the work settings and could be the focus for interventions aimed at improving the health and well-being of FIFO workers (29,215). As such, studies with larger sample sizes and longitudinal designs may be needed to further examine the short and long-term impact of personal and work-related factors on health outcomes in FIFO workers. The findings of this study suggest that a change towards reducing the shift length, a key aspect of FIFO work, could reduce distress experienced by workers and in effect address a mirage of the sleep and health behaviour issues highlighted in the study, which as demonstrated above could mostly be linked to the experience of high stress.

The current COVID-19 pandemic and accompanying social/travel restrictions have been found to negatively influence lifestyle behaviours (216,217) including smoking, alcohol intake, physical activity and sleep (217) and given rise to an upsurge in psychological distress (218) in the general population. COVID-19 restrictions, border closures and quarantines across the states in Australia prompted prolonged FIFO rosters and restricted workers travelling back home and thus, further prolonging the separations and isolation of FIFO workers from their families and friends. Again, COVID-19 restrictions and quarantines/self-isolation on-site may limit socialization and other social activities on sites, causing further isolation and loneliness (219). Although the mental well-being levels of FIFO workers were found to be within normal limits during the pandemic (58), it has been documented that prolonged rosters, restrictions on travelling back home and prolonged separations from home and families necessitated by COVID-19 restrictions were concerns for high levels of psychological distress reported among FIFO workers (219). Increases in stress caused by COVID-19 and its associated restrictive measures could have fostered increases in risky lifestyle behaviours (216). During this study (data collected between July and December 2021), there were still COVID-19 restrictions, border closures and quarantines in place in Australia. This could also have contributed to the high prevalence of psychological distress and risky lifestyle behaviours reported in FIFO workers in this study.

3.5.2 Strengths and limitations of the study

The study contributes to evidence on the physical and mental health and their work-related predictors and has provided an overview of the lifestyle behaviours of FIFO workers during the on-and off-shift periods. The study employed multiple recruitment sources and validated scales to present "snapshot" differences in lifestyle behaviours across the two distinct components of the FIFO lifestyle – on-shift and off-shift periods – which could then be compared to the population norm data.

However, recruiting from multiple sources has the potential to present a diverse sample (possibly from different organizations) with differences in work arrangements and practices, which may need further study to explore the impact of such differences on the health and well-being of FIFO workers. The use of a cross-sectional design excludes any causal interpretation of findings. The non-random sampling technique to recruit participants may be an appropriate approach to recruiting from an unstable population such as FIFO workers is also acknowledged as a limitation. However, our sample profile reflects that of a previous large study, where the FIFO work population is mostly males, middle-aged, married/in a form relationship, with Technical and Further Education (TAFE)/college education, and spent 8 days at work (7). Due to a larger rate of incompletion than expected, our analytic sample was below the number we set out to achieve for estimating the rate of distress with the desired precision. However, the analytic sample was sufficient to test small on-shift versus off-shift differences, which was the primary aim of this study. Online surveys are indicated to have high dropout rates, where not being able to meet the researcher (anonymity) may lead to a higher risk of dropout (220). It should be noted that, besides the negative impact of COVID-19 on the lives of individuals, the pandemic has also brought several changes in work arrangements including lockdowns and restricted access to mining sites, further exacerbating the already existing problems of limited chance to meet workers which is characteristic of research at mining sites (27). However, recruitment was also done through the social media platform Facebook to recruit general FIFO mining workers in Australia. Additionally, while this study explored the difference in health behaviours during on-and off-shift days, further studies could consider examining the influence of workers' personal and work-related characteristics such as sex, age, and FIFO roles on their health behaviours across the FIFO roster cycle. Sleep and health behaviours were measured for two time-points (on-and off-shift periods) at the same time using a cross-sectional design, which is limited by recall biases as well as anchoring effects depending on the order with which questions are asked. This study considered number of days spent at home and on-site separately, which may only capture half of what makes a roster in each instance as could be done via roster types or roster ratio. Data on whether FIFO workers were engaged as full-time employees or as contractors were not collected. However, contractors compared to full-time employees may be treated differently by operating companies, such as having fewer statuary protections including sick or annual leave and compensation, and may face arbitrary dismissal without redress. With contractor employment on the rise, suggested further studies could explore the differences in the health and well-being of these two FIFO work groups.

3.6 Conclusion

FIFO workers participating in this study reported good physical health status but higher levels of psychological distress compared to the Australian normative data. Our results further highlighted more of the FIFO workers were overweight or obese, smoked more, drink more alcohol at risky levels than in the general Australian population, and consumed fewer fruits and vegetables as compared to recommended guidelines. More of the FIFO workers also engaged in sufficient physical activity. The study also indicated that, during on-shift periods, FIFO workers had shorter sleep duration and poorer sleep quality, lower consumption of vegetables, and higher levels of alcohol consumption, but spent spend more MET minutes per week in physical activities. No substantial differences in smoking or fruit intake between on-and off-shift days of the FIFO roster cycle were found. The study identified working long shifts of 12 or more hours and being a smoker to be associated with high to very high psychological distress. Interventions should attempt to alleviate psychological distress and support multiple health behaviour changes among FIFO workers. Such interventions could consider FIFO work-related characteristics including long shift hours. Additional studies exploring how behaviour change interventions could positively influence the health and well-being of FIFO workers are required. Furthermore, longitudinal research is also warranted to investigate how day-to-day variations in psychological and contextual variables change over time.

3.7 Summary and link to other chapters

This chapter summarised a cross-sectional study assessing psychological distress, physical health status and related behaviours, and their work-related determinants. The next Chapter 4 presents the productivity loss (arising from absenteeism, presenteeism and total work impairment), the cost associated with psychological distress, physical health status, and related behaviours using a cross-sectional study design. Subsequent Chapter 8 will describe the within-person variability of the psychological states and health-related behaviours tested using multilevel analysis and address the limitations associated with the cross-sectional design applied in this Chapter.

Chapter 4: Study Three

Preface

This chapter presents the third published study included in this thesis and is cited as;

> **Asare BY,** Makate M, Powell D, Kwasnicka D, Robinson S. Cost of Health-Related Work Productivity Loss among Fly-In Fly-Out Mining Workers in Australia. International Journal of Environmental Research and Public Health. 2022;19(16):10056.

The content of the paper presented here exactly appears as in print, but the formatting is consistent with the rest of this thesis. The high psychological distress, poor physical health and related behaviours including high alcohol intake identified in the previous chapters have been indicated to be associated with high work productivity losses in the general population, but evidence is limited in the FIFO context. This study addressed this research gap and evaluated the productivity loss (arising from absenteeism, presenteeism and total work impairment), the cost associated with psychological distress, physical health status and related behaviours in FIFO workers. This study is based on the same sample and data as in study 2.

Author contributions: B.YA., Conceptualization, methodology, investigation/data collection, software, validation, formal analysis, data curation, visualization, project administration, writing—original draft preparation. M.M., D.P., D.K. and S.R. assisted in conceptualization, funding acquisition and provided resources and supervision, and writing—review and editing. M.M. assisted in methodology and formal analysis. All authors have read and agreed to the published version of the manuscript.

Study Three: Cost of health-related work productivity loss among Fly-In Fly-Out mining workers in Australia.

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Acknowledgements

The authors are grateful to Mineral Resource Limited, Australia, for supporting the study and to all FIFO workers for participating and contributing to this study.

Funding

The study was funded by the Aberdeen-Curtin Alliance. Mineral Resources Limited, Australia also supported the study by providing an AUD 200 shopping voucher to the winner of a raffle draw as reimbursement for study participation. Mineral Resources Limited played no role in the design of the study, data collection and analysis, interpretation of study findings, preparation or decision to submit this manuscript for publication.

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of Curtin University (protocol code HRE2020-0693 and date of approval: 12 November 2020).

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Data availability statement

The data that support the findings of this study are not publicly available due to ethical and privacy restrictions but are available upon request from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no conflict of interest.

4.1 Abstract

Sufficient knowledge on the work productivity impact of the health of fly-in fly-out (FIFO) workers in the mining sector in Australia is lacking. This study examined the impact of health and lifestyle behaviours on the work productivity of FIFO workers in the mining industry in Australia. FIFO workers (*N*=216) completed an online questionnaire on health and work productivity loss measures. Linear regressions were used to model annual work productivity losses through absenteeism, presenteeism and total productivity loss. Workers with a high risk for health conditions were, on average, associated with 3.87% more productivity loss (absenteeism: 1.27% and presenteeism: 2.88%) than those with low risk. Workers who had multiple health risks classified as medium (3–4 health conditions) and high (5 or more health conditions) reported 1.75% and 7.46% more total productivity loss, respectively than those with fewer multiple health risks (0–2 health conditions). Health conditions were estimated to account for an annual additional productivity cost due to absenteeism of AUD 8.82 million, presenteeism of AUD 14.08 million and a total productivity loss of AUD 20.96 million per 1000 workers. FIFO workers with high health risks experience more absenteeism, presenteeism and overall productivity loss. These measures provide strong economic justifications that could support the need for targeted workplace health interventions.

Keywords: FIFO; health, absenteeism, presenteeism, productivity loss, mining.

4.2 Introduction

The mining industry is a significant contributor to the Australian economy and a significant proportion of the workforce work in fly-in fly-out (FIFO) work arrangements (46). Under FIFO work arrangements, workers travel to work at remote places for a period and travel back to spend leave periods at home (2). Workers generally work compressed day and/or night shifts and long hours of a standard 12 h (1), often separated from their families. They earn fairly higher wages than workers in other types of employment and/or industry (3). FIFO work arrangements are also practised in the offshore oil and gas industry around the world, notably in countries including Norway, the United Kingdom and Canada. The demands of FIFO work arrangements are indicated to contribute to a high prevalence of several health conditions and risky behaviours (40,162). Specifically, FIFO workers report higher levels of psychological distress, poorer sleep, and more fatigue, smoke more, consume more alcohol, and are more likely to be overweight and obese than the general population (40).

Productivity losses are indicated as major economic consequences of such health problems on employers and employees (221,222), besides the associated direct medical and pharmaceutical costs/claims (222,223). Productivity loss caused by health problems denotes output loss due to reduced labour input as a result of absenteeism (absences of a worker from work or the number of working times a worker is absent from work due to sickness) and presenteeism (present at work but limited by illness and not able to fully function) (224–226). Several studies have documented physical health problems such as musculoskeletal disorders (227–230) and mental health disorders such as psychological distress, depression and anxiety disorders (227–231) to have high absenteeism, presenteeism and/or productivity loss costs. For instance, a study in the United States has documented that workers with poor physical health reported 1.9% more productivity loss compared to those with good physical health

(232). Among employees in Australia, psychological distress has been found to be associated with a 22% increased risk of absenteeism and an over 300% increased risk of presenteeism (227), and it is estimated to account for AUD 5.9 billion (Australian dollars) in reduced productivity in a year (233). Fatigue and sleep-related problems have also been demonstrated to account for $15.3 billion and $21.5 billion, respectively, in productivity loss due to presenteeism per annum among workers in Japan (228). Several studies have identified health-related behaviours, including smoking, alcohol consumption, physical activity, eating behaviours, overweight and obesity and relaxation time, as significant predictors of work-related absenteeism and/or presenteeism (223,232,234–238). For instance, workers who are current smokers compared to non-smokers and physically inactive compared to physically active were found to report 2.8% and 1.9% reduced productivity, respectively, in the United States (232).

Furthermore, evidence suggests that the co-occurrence of health and risky behaviours are important contributors to productivity loss (50,223,232,239,240) and future medical claims, thereby imposing a high financial burden on employers (223). Individuals with more health behaviours experience higher levels of absenteeism and presenteeism than those with fewer risk behaviours (239,240). A study among workers in a large company in the United States has reported workers with five or more co-occurring health risks such as smoking, alcohol use, and physical inactivity were 12.2% less productive than workers with low (0 to 2) health-risky behaviours, and the occurrence of every extra health risk accounted for a 2.4% reduction in productivity (232). There is a limited number of studies that have evaluated the economic impact of the healthy and unhealthy behaviours of workers in the mining sector in Australia (46,47,49). A cross-sectional study of mining workers in Australia estimated an annual cost of AUD 22 million in lost productivity in every 1000 workers attributable to seven health conditions, including stress, depression, anxiety, sleep problems, alcohol use and poor nutrition (47). Similarly, Ling *et al.* established that psychological distress is associated with an annual cost of loss of work time of AUD 4.9 million in mining workers, with AUD 2.7 million due to absenteeism and AUD 2.3 million due to presenteeism (46). Studies examining health-related productivity in the mining industry tend to focus on the entire mining workforce rather than workers on FIFO work arrangements, which are increasingly becoming the standard form of employment in the mining industry in Australia (2). FIFO workers may differ in mental health and health-related behaviours from their counterpart mining workers who are not FIFO (30,32,48). For instance, local non-FIFO miners are indicated to experience worse mental distress compared to FIFO mining workers (32,40) and could be driving the attributed work productivity loss cost in the general mining population. Current studies have largely focused on a single health condition (e.g., psychological distress or stress) (46,49) and are limited in examining the economic impact of multiple health conditions (47) and their co-occurrence among workers. Additionally, the health risk profile of workers may change over time, which will require the regular evaluation of workers' health and accompanying economic impact. For instance, a study by Nielsen *et al.* found a decrease in the prevalence of psychological distress from 9% to 8% over a 6-month period among FIFO offshore oil and gas workers (145). Furthermore, limited studies have examined the health and FIFO job characteristics that predict productivity loss. The high prevalence of health problems and risk of unhealthy behaviours (40) reported among FIFO workers requires better workplace health and safety interventions and policies.

However, it has been suggested that employers may be reluctant to uptake or support such interventions unless an economic impact on the health and safety of workers has been demonstrated (47). Employers seek to regularly measure the financial gains workplace health interventions bring to their organizations (223) as they look to improve the health of workers and enhance work productivity. One way of demonstrating this financial benefit is to examine the impact of the health risk of workers on work productivity outcomes and/or the associated productivity cost (47,241). Furthermore, providing a comprehensive examination of the work-related factors that promote work productivity losses may be particularly beneficial to profiling which workers are at higher risk of experiencing productivity losses and where interventions could be targeted. For this, obtaining the essential information on the health and work-related predictors of productivity outcomes is of high economic and societal significance. This cross-sectional study aimed to examine the self-reported health and lifestyle behaviours of FIFO workers and the impact of this on work productivity in people working in FIFO work in the mining industry in Australia. Specifically, the study examined: (1) productivity losses attributable to the health and lifestyle behaviours of FIFO workers; (2) the relationship between health and lifestyle behaviours and productivity losses; (3) health and work-related predictors of productivity loss (absenteeism, presenteeism and total productivity loss); and (4) the annual cost of absenteeism, presenteeism and total productivity loss among FIFO workers.

4.3 Materials and methods

4.3.1 Study design and participants

A cross-sectional study was conducted among FIFO workers in the mining industry in Australia. The resources industry in Australia employed an average of 264,700 people in 2021 (242), and around 90,000 to 11,000 have been estimated to work in FIFO roles (243). FIFO work arrangements are predominant in Western Australia and Queensland (22), accounting for an estimated 17% of employment in the regional areas of Australia (13,14,25). Workers travel (commonly by plane) from the cities to regional, remote areas; for instance, in Western Australia, workers travel from Perth to work in the remote areas of Pilbara, Kimberly, Goldfields-Esperance and Central Midwest regions (3). FIFO workers in the mining sectors, including metal ore mining (such as gold, iron, lead, copper, etc.), coal mining and oil and gas) are predominately males (≈85%) and aged 25–44 years (58.6%) (25). Workers in the mining sector commonly work on a FIFO roster of 14 days on/7 days off or 8 days on/6 days off (5).

Data were collected via an online questionnaire through the Qualtrics XM online survey software (244). The study used a convenience (non-probability) sampling procedure to recruit a readily available FIFO sample interested in taking part in the study, which is suggested to be suitable to draw responses from a 'mobile population' like FIFO workers (6). Study participants aged 18 years and above and working on FIFO arrangements in the mining industry in Australia were recruited between July and December 2021 through a large mining company in Western Australia, where promotional materials were posted at various sites and through the company's weekly intranet communications. Study participants were also recruited through the periodic posts of promotional materials on Facebook pages of FIFO work support groups to increase diversity in the recruited study sample. The use of social media platforms in recruiting study participants has been demonstrated as an effective recruitment strategy in previous FIFO studies (13). Study participants provided informed consent and completed the questionnaire voluntarily and anonymously. Research promotional materials invited only FIFO workers in the mining sector, and each participant acknowledged that they did work FIFO. Qualtrics was not set up to record where participants were referred from to determine the proportion of study participants that were recruited through the mining company and/or from Facebook posts.

4.3.2 Survey instruments and measures

Given the novelty of this study, there was not a previously published questionnaire that could fully answer the question of interest. In the absence of a validated questionnaire, this study drew on previously published literature that had focused on a number of relevant areas relating to health and related behaviours and productivity losses. For each of the areas, we identified relevant sources questionnaires and established scales and national guidelines in supporting the development of a specific questionnaire (available on request to the first author). The final survey consisted of 57 questions across sociodemographic and work characteristics, health and related behaviours and work productivity measures (absenteeism and presenteeism) (see Appndix D).

4.3.2.1 Sociodemographic and work characteristics

Sociodemographic and work characteristics assessed included: age, sex, ethnicity, marital status, number of children, educational status, FIFO role, shift pattern, normal shift hours per day, number of consecutive days at work and at home, and the duration of working as a FIFO worker consistent with previous studies (7,29).

4.3.2.2 Health Conditions

Health and related behaviours commonly reported among rotation workers (40) and highlighted as significant contributors to work productivity loss (47,245) were assessed using established scales and national guidelines. The health conditions included: psychological distress, physical health status, sleep condition, risky use of alcohol, physical inactivity, smoking, weight problem (low and high body mass index (BMI)), and poor diet (insufficient fruit and vegetable intake). Psychological distress was assessed using the 10-item Kessler Psychological Distress Scale-K10 (183), which assesses the negative emotional states (e.g., feeling nervous, sad, depressed, worthless, or hopeless) over the previous 30 days on a 1 to 5 Likert scale. Based on the total score of 10–50, a high risk of psychological distress was classified as a score of 22–50 (183).

Physical health status was evaluated by the 4-item physical component summary (PCS) subscale of the SF-8 Health Questionnaire (185). Items assess the experiences of bodily pain, difficulty in doing daily work and limitation to physical activities due to physical health problems and perceived overall health status in the last 4 weeks on 5- or 6-point Likert scales. Of the potential scores of 0 to 100, a score less than 50 was indicative of poor physical health status (185).

Sleep condition was assessed using questions taken from the Pittsburgh Sleep Quality Index (PSQI); these include an item on sleep duration ("How many hours of actual sleep did you get at night during on-shift days?") and one on sleep quality ("During the past month, during on-shift days, how would you rate your sleep quality overall?") (186). Poor sleep condition was classified as participants who reported a sleep duration of less than 7 h and/or rated their sleep quality as fairly to very bad (47).

Risky use of alcohol was assessed using Alcohol Use Disorders Identification Test-Concise (AUDIT-C) (187). The 3-item (e.g., "How many standard drinks containing alcohol do you have on a typical day when drinking?") scale using a 0 to 4 scale assessed the frequency and quantity of standard alcohol drinks intake typical for on-shift days. Of a total score of 0–12, male participants with ≥4 and female participants with ≥3 scores were deemed to engage in risky alcohol-drinking behaviour (187).

On *smoking status*, participants were asked "Do you smoke?" and "Have you ever smoked?" and were classified as never smoked, previous smokers or current smokers.

Physical activity was assessed using the International Physical Activity Questionnaire-short form (IPAQ) (188). IPAQ assesses the number of days and minutes per week spent engaging in mild, moderate and/or vigorous physical activities. Each activity's weekly metabolic equivalent minutes (MET-minutes), given by the product of minutes, days and an established intensity (in METs), were computed and all added to give the total weekly physical activity (189). Participants not achieving a minimum of 600 MET minutes per week were classified as undertaking insufficient physical activity (189).

Weight problem was evaluated by estimating the body mass index (BMI) based on participants' self-reported weight and height. Participants recording BMI scores of <18.5

(underweight), 25–29.9 (overweight) and ≥ 30 (obese) were classified as having a weight problem. Diet was measured based on fruit and vegetable intake. Participants were asked "How many serves of vegetables do you usually eat each day?" and "How many serves of fruit do you usually eat each day?" during on-shift days (192). Per the Australian daily dietary guidelines on minimum daily-suggested servings, the intake of less than 2 servings of fruits and/or less than 5 servings of vegetables wasclassified as poor diet/nutrition (193). Table 5 presents the full risk classifications of health and lifestyle behaviours.

Table 5. High- and low-risk classification for health conditions

Health condition	High-risk criteria	Low-risk criteria
Psychological distress	K10 scores of 22–29 (high) and 30–50 (very high) levels	K10 scores of 10–15 (low) and 16-21 (medium) levels
Poor physical health	Scores of less than 50 on the PCS of SF-8 Health scale	Scores of less than 50 on the PCS of SF-8 Health scale
Poor sleep condition	Sleep duration less than 7 hours and/or poor sleep quality	Sleep duration of 7 or more hours and/or better sleep quality
Risky alcohol use	AUDIT-C score of ≥4 among men and ≥3 among women	AUDIT-C score of <4 among men and <3 among women
Smoking	Currently smoking	Non-or ex-smokers
Insufficient physical activity	Metabolic equivalent minutes (MET-minutes) of less than 600 per week	Metabolic equivalent minutes (MET-minutes) of ≥ 600 per week
Weight problem	BMI < 18.5(underweight), BMI=25–29.9 (overweight) and BMI ≥ 30 (obese)	BMI=18.5-24.9
Poor diet/nutrition	Intake of less than 2 serves of fruits and/or less than 5 serves of vegetables	Intake of more than 2 serves of fruits and/or 5 serves of vegetables

4.3.2.3 Work productivity loss measures

Work productivity was assessed using the Worker Productivity and Activity Impairment-General Health (WPAI-GH) tool (246). The WPAI-GH is a six-item validated tool that measures self-reported current employment status, work hours missed due to health problems in the last 7 days, the actual work hours in the last 7 days, and the extent of work impairment or reduced work productivity (or daily activities) due to health problems in the last 7 days (246). This tool has been used to study productivity loss cost in the resource sector based on its reliability, shortness and capacity to estimate productivity loss cost in monetary terms (47). Consistent with previous studies, this study adapted a measurement period of 4 weeks to limit the chance of influence of acute illnesses and workers' rosters arrangements on self-reported study parameters (47,245). Scoring on the items measured over a 4-week recall period was then divided by 4 to align to the 7 days of the original scoring metric (47) before computing the productivity loss measures, defined as the productivity lost at work in hours expressed in percentages and computed as per standard equations given by the WPAI-GH tool (246). The validity and reliability of the WPAI-GH scale (246) and its use in the resources industry (47) and general population (245,247) are well demonstrated. Absenteeism was defined as a percentage of work hours missed due to health problems and calculated as:

$$\frac{\textit{work hours missed due to health problems in the last 7 days}}{\textit{(work hours missed due to health problems+ actual hours worked in the last 7 days)}} \; x\ 100$$

Presenteeism, defined as the percentage of impairment/reduced productivity while working due to health problems, was estimated as:

$$\frac{\textit{extent of work impairment or reduced work productivity in the last 7 days, rated 0 to 10}}{10} \; x\ 100$$

The total productivity loss as a result of health problems measured as a combination of absenteeism and presenteeism was given as:

$$\textit{total prod loss (in \%)= absenteeism+[(1-absenteeism) x presenteeism]}$$

4.3.3 Data analysis and cost estimation plan

Data were processed and analysed using STATA version 13 software (StataCorp LP, College Station, Texas, USA). For descriptive purposes, are reported for categorical variables were presented in frequencies and percentages, and continuous variables in means and standard deviations. The risk of health conditions was classified into high risk and low risk for participants based on the measurement scales used (47,223) (see Table 5). Multiple health risks (having multiple health conditions) were determined for each participant and classified as low (0-2 health conditions), medium (3-4 health conditions) and high risk (5 or more health conditions) (240). Productivity losses due to absenteeism, presenteeism and the total productivity loss were estimated as high and low health risk for each participant, and the differences were calculated as the excess work productivity loss attributable to the health conditions (47); given as:

$$excess\ loss\ (\%) = productivity\ loss\ in\ high\ health\ risk - productivity\ loss\ in\ low\ health\ risk$$

In examining the relationships between health conditions and absenteeism, presenteeism and total productivity loss, the Mann-Whitney tests were used to examine differences in the absenteeism, presenteeism and total productivity loss between the workers with high and low risk for health conditions. Furthermore, the Kruskal-Wallis test was conducted to examine differences in absenteeism, presenteeism and total productivity loss between the workers with high, medium and low multiple health risks for health conditions.

To estimate the excess annual productivity loss cost attributable to the health conditions per worker, the percentage excess work productivity loss was multiplied by the average earnings per year for full-time mining workers in Australia (47), given as:

$$cost\ attributed\ per\ worker = \frac{excess\ loss}{100}\ x\ annual\ salary$$

The annual earning was estimated as AUD 134,323.20 based on the average weekly earnings as of May 2021 (for all workers in the mining industry taken from the Australian Bureau of Statistics) (248) multiplied by 48 working weeks per year (assumed for full-time workers: 52 weeks minus 4 weeks of annual leave) in the mining industry consistent with previous studies (46,47).

Consistent with previous studies (239,245), linear regressions, controlling for age, gender, and work characteristics, were also used to model excess annual work losses through absenteeism, presenteeism and total productivity loss, and annual indirect cost estimated per 1000 workers. Residuals were fairly normally distributed and the plots of standardized residuals against predictor variables showed linear relationships (249,250).

$$Y = \alpha + \beta_1 age + \beta_2 gender + \beta_3 fifo\ roles + \beta_4 shift\ patterns + \beta_5 shift\ hours + \beta_6 consecutive\ days\ at\ work + \beta_7 consecutive\ days\ at\ home + \beta_8\ years\ spent\ in\ FIFO + \beta_9 poor\ sleep\ condition + \beta_{10} smoking + \beta_{11} alcohol\ use + \beta_{12} poor\ diet + \beta_{13} bmi + \beta_{14} insufficient\ physical\ activity + \beta_{15} poor\ public\ health + \beta_{16} psychological\ distress + \beta_{17} multiple\ health\ risk + u,$$

Where; Y = productivity loss measure (absenteeism, presenteeism or total productivity loss)

To estimate the excess annual work productivity loss cost (due to absenteeism, presenteeism and total productivity loss) for each of the health conditions per 1000 workers, the coefficients (excess productivity loss for high risk) estimated from the regressions were multiplied by the prevalence for each health condition, the average annual salary (AUD 134,323.20) and by 1000 workers, consistent with previous studies (47,245). Simply, the cost attributed to a health condition was given as;

$$cost = \frac{prev\ of\ health\ condition}{100}\ x\ \frac{excess\ loss}{100}\ x\ annual\ salary\ x\ 1000\ workers,$$

Where;
prev = prevalence of a health condition,
excess loss =excess work productivity loss given by the regression coefficients (due to absenteeism or presenteeism or total productivity loss) attributable to an individual at high risk of a health condition,
annual salary = average annual salary for a full-time mining; AUD $134,323.20.

4.3.3.1 Sensitivity Analysis

The probabilistic sensitivity analyses (PSA) were done to examine the uncertainty of the study parameters and to test the robustness as well as validate the study model estimates. The PSA was done using Monte Carlo simulation to test for the uncertainty of parameter values in estimating the productivity loss costs. The estimation of the productivity loss costs was replicated with 1000 simulations, where the values for the parameters in PSA were based on the distributions and model estimates (point estimates and standard error) from the study sample data. There was no special rule for the selection of simulation trials (1000 samples) used in this study, but the selection and use of 1000 samples were made based on previous literature, which has been demonstrated to achieve convergence and accuracy for mean parameters (251,252). The results of the PSA are presented using the scatter plot graphs and the 95% certainty intervals reported.

4.3.3.2 Health- and Work-Related Predictors of Work Productivity Loss

The health- and work-related predictors of work productivity loss (absenteeism, presenteeism and total productivity loss) were examined using a two-part model approach (253). This was due to the data containing a large number of zeros, with several of the study participants reporting no productivity loss during the study period. This is consistent with similar studies (239). The first part of the model used multiple logistic regression to examine the health outcomes and work characteristics (job type, years working in FIFO arrangements, shift pattern, shift hours, consecutive days spent at home, consecutive days spent away from home) predictors of any reported productivity loss (i.e., reported productivity loss vs. no productivity loss) for the total study sample ($n = 216$). The second part of the model specified ordinary least square regressions to examine the relationships between health outcomes and work-related characteristics and productivity loss among the sample that reported positive productivity loss (253). Three logistic regression models (one each for absenteeism, presenteeism and total productivity loss) and three ordinary least square regression models (one each for absenteeism, presenteeism and total productivity loss) were conducted, with statistical significance set at $p < 0.05$. The estimated variance inflation factor (VIF) values, to test for multi-collinearity in the models, ranged from 1.16 to 6.31.

4.4 Results

4.4.1 Background characteristics of study participants

A total of 299 FIFO workers took part in the study: 83 of them did not provide sufficient data, particularly on health conditions and work productivity measures (absenteeism/presenteeism) and were excluded, leaving 216 who provided complete data to be included in the analysis. The excluded sample did not significantly differ in background characteristics from the included sample: e.g., age (mean age 39.9 ± 11.6 vs. 39.3 ± 12.2, p = 0.710), gender (male: 66.2% vs. 60.2%, p = 0.334), shift patterns (rotation shift: 56.0% vs. 56.7%, p = 0.920) and shift length (11.9 ± 1.7 vs. 11.8 ± 1.8 h, p = 0.599) (Appendix E: Supplementary Information S4). The background characteristics of the study participants are shown in Table 6. The mean age of the participants was 39.9 ± 11.6 years, and the majority of the participants were males (66.2%). Most of the participants worked on a rotating shift pattern (i.e., a mix of day/night shifts) (57.4%) for 12 h or more per day (86.1%) and have worked in FIFO work arrangements for 5 years or more (59.7%) (Table 6).

Table 6. Distribution of demographics and work-related characteristics of FIFO workers

Personal characteristics	Frequency (n)	Percent (%)
Age in year		
≤34	82	38.0
35-44	67	31.0
≥45	67	31.0
Gender		
Male	143	66.2
Female	73	33.8
Ethnicity		
Caucasian/White	183	84.7
Other	33	15.3
Relationship status		
Single/Never married	43	19.9
Married	93	43.1
Separated/Divorced/Widowed	25	11.6
De-facto/Co-habiting/Civil partnership	52	23.0
Other	3	1.4
Educational status		
Primary/Secondary education and equivalent	70	32.4
Trade/Apprentice	45	20.8
TAFE/College	60	27.8
Bachelor degree	30	13.9
Postgraduate degree	11	5.1
FIFO role		
Management/Administration/services	54	25.0
Professional	27	12.5
Maintenance/Technician	39	18.1
Production/Drilling/Construction/Labourer	45	20.8
Machinery operator and driver	35	16.2
Catering	10	4.6
Other	6	2.8
Shift patterns		
Rotation shift (mixture of day/night shift)	124	57.4
Regular shift (fixed day/night)	92	42.6

Shift length		
<12 hrs	30	13.9
≥12 hrs	186	86.1
Consecutive days spent at work		
<8 days	43	19.9
8-14 days	156	72.2
15+ days	17	7.9
Consecutive days spent at home		
<8 days	187	86.6
8-14 days	29	13.4
FIFO duration		
<5 yrs	87	40.3
5-9 yrs	46	21.3
10+ yrs	83	38.4

TAFE= Technical and Further Education

4.4.2 Prevalence of risk of health conditions

Table 7 presents the prevalence of health conditions among study participants. All participants reported at least 1 health condition. The study participants showed a high prevalence of poor diet (96.3%), weight problems (74.5%), and poor sleep conditions (64.4%). The majority of the participants (97.7%) reported having at least 2 health conditions (Table 7).

Table 7. Prevalence of risk of health conditions

Health condition	High-risk frequency (n)	Percent (%)
Poor sleep condition	139	64.4
Risky alcohol use	74	34.3
Currently smoking	57	26.4
Poor diet	208	96.3
Weight problem	161	74.5
Insufficient physical activity	58	26.9
Poor physical health	19	8.8
Psychological distress	72	33.3
How many health conditions reported		
1	5	2.3
2	39	18.1
3	67	31.0
4	53	24.5
5 and more	52	24.1

4.4.3 Productivity loss in individuals with high health risks

The proportions of study participants reporting any missed work hours and reduced productivity due to health problems were 20.4% (n = 44): average work hours missed of 16.07 ± 20.34 h (range 1–96) per 4 weeks and 53.7% (n = 116), respectively. On average, the study participants reported 1.70% absenteeism, 3.84% presenteeism and 7.48% total productivity loss rates per week during the study period (Table 8).

Table 8. Work productivity loss measures in study participants.

Measures	Frequency (n), mean±SD	Percent (%)
Absenteeism		
Yes	44	20.4
No	172	79.6
Work hours missed per 4 weeks	16.07±20.34hrs (range 1-96)	
Average absenteeism rate (per week)	1.70±5.36% (range 0-33.3)	
Presenteeism		
Yes	116	53.7
No	100	46.3
Reduced work productivity (ranked 0-10) per 4 weeks		
0	100	46.3
1-2	64	29.6
3-4	32	14.8
≥5	20	9.3
Average presenteeism rate (per week)	3.84±5.33% (range 0-22.5)	
Average total productivity loss rate (per week)	7.48±10.20% (range 0-40)	

Workers with a high risk of each of the health conditions reported excess (more) productivity loss compared with workers with low risk. For absenteeism, high-risk workers reported more productivity loss (on average 1.27%), ranging from 0.07% (risky alcohol use) to 2.77% (poor physical health). A Mann–Whitney test showed workers with high risk for insufficient physical activity ($z = -2.322$, $p = 0.020$), poor physical health ($z = -2.453$, $p = 0.014$) and high psychological distress ($z = -2.959$, $p = 0.003$) reported significantly higher percentage absenteeism than those with low risks (Appendix E: Supplementary Information S5; Table S4a).

Table 9. Average percentages of absenteeism, presenteeism and total productivity loss and annual excess cost attributed to health risks per worker

	Percent absenteeism due to health				Percent presenteeism due to health				Percent total productivity loss			
Health conditions	High risk	Low risk	Excess	Cost per year	High risk	Low risk	Excess	Cost per year	High risk	Low risk	Excess	Cost per year
Poor sleep condition	2.07	1.04	1.03	1383.53	4.64	2.40	2.24**	3008.84	6.43	3.36	3.07*	4123.72
Risky alcohol use	1.75	1.68	0.07	94.03	4.12	3.70	0.42	564.16	5.71	5.14	0.57	765.64
Current Smoking	1.99	1.60	0.39	523.86	5.70	3.18	2.52**	3384.94	7.37	4.61	2.77*	3720.75
Poor diet	1.77	0.07	1.70	2283.49	3.92	1.88	2.04	2740.19	5.47	1.94	3.53	4741.61
Weight problems	1.77	1.51	0.26	349.24	4.02	3.32	0.70	940.26	5.56	4.69	0.86	1155.18
Insufficient physical activity	2.73	1.32	1.41*	1893.96	5.13	3.37	1.76	2364.09	7.52	4.54	2.98*	4002.83
Poor physical health	4.23	1.46	2.77*	3720.75	11.71	3.08	8.63***	11,592.09	15.11	4.40	10.71***	14,386.01
Psychological distress	3.08	1.01	2.07**	2789.49	7.01	2.26	4.75***	6,380.35	9.64	3.19	6.45***	8663.85

*p<0.05; **p<0.01; ***p<0.001 from Mann-Whitney test
Australian dollar (AUD) 134,323.20 based on the average weekly earnings per worker as of May 2021

For presenteeism, high-risk workers reported more productivity loss (on average 2.88%), ranging from 0.42% (risky alcohol use) to 8.63% (poor physical health). A Mann–Whitney test showed workers with high risk for poor sleep conditions ($z = -2.390$, $p = 0.017$), smoking ($z = -2.609$, $p = 0.009$), poor physical health ($z = -5.000$, $p < 0.001$) and high psychological distress ($z = -6.069$, $p < 0.001$) reported significantly higher percentage presenteeism than workers with low risks (Appendix E: Supplementary Information S5; Table S4b). On total productivity loss, high-risk workers reported more productivity losses (on average 3.87%), ranging from 0.57% (risky alcohol use) to 10.71% (poor physical health). A Mann–Whitney test showed workers with high risk for poor sleep conditions ($z = -2.220$, $p = 0.026$), smoking status ($z = -2.183$, $p = 0.029$), insufficient physical activity ($z = -2.114$, $p = 0.035$), poor physical health ($z = -4.554$, $p < 0.001$) and high psychological distress ($z = -5.432$, $p < 0.001$) reported significantly higher percentage total work productivity losses than workers with low risks (Appendix E: Supplementary Information S5; Table S4c). The productivity loss was estimated for workers with multiple health risks, and the results showed the average percentage of absenteeism, presenteeism and total work productivity loss increased when health conditions accumulated in workers. The results are shown in Figure 3. The Kruskal–Wallis test showed there were significant differences in absenteeism ($\chi^2(2) = 10.643$, $p = 0.005$), presenteeism ($\chi^2(2) = 25.391$, $p < 0.001$) and total work productivity loss ($\chi^2(2) = 23.943$, $p < 0.001$) between the levels (low, medium and high) of accumulation of multiple health conditions (Appendix G: Supplementary Information S6). A Dunn's test of multiple comparisons with Bonferroni adjustment showed that the average percentage of productivity loss measures (absenteeism, presenteeism and total productivity loss) were significantly higher in workers with high multiple health risks (5 or more health conditions) compared to workers with low (0–2 health conditions) ($p < 0.001$) and medium (3–4 health conditions) multiple health risks ($p < 0.001$). For instance, total productivity loss increased from 2.57% in workers with low risk (0–2 health conditions) to 10.03% in workers with high risk (5 or more conditions), and compared to the low-risk workers (0–2 health conditions) ($p < 0.001$) and those with medium risk (3–4 health conditions) ($p < 0.001$), workers with high risk reported greater productivity loss of 7.46% and 5.71% respectively (Appendix G: Supplementary Information S6).

The cost of excess productivity loss due to absenteeism, presenteeism and total productivity loss was computed for individuals with higher levels of health risk by multiplying the percentage of excess productivity loss by the average annual wage (AUD 134, 323.20) (Table 9). The excess productivity loss due to absenteeism for the health conditions ac- counted for an additional average cost of AUD 1629.79 per year per worker, with the lowest of AUD 94.03 reported for risky alcohol use and the highest of AUD 3720.75 for poor physical health. The average additional cost of excess productivity loss due to presenteeism for the health conditions was AUD 3871.87 per year per worker, ranging from AUD 564.16 for risky alcohol use and AUD 11,592.09 for poor physical health. On average, excess total productivity loss (combination of absenteeism and presenteeism) for the health conditions accounted for an additional cost of AUD 5194.95 per year per worker, with the highest 3 contributors including poor physical health (AUD 14,386.01), psychological distress (AUD 8663.85), and poor diet (AUD 4741.61).

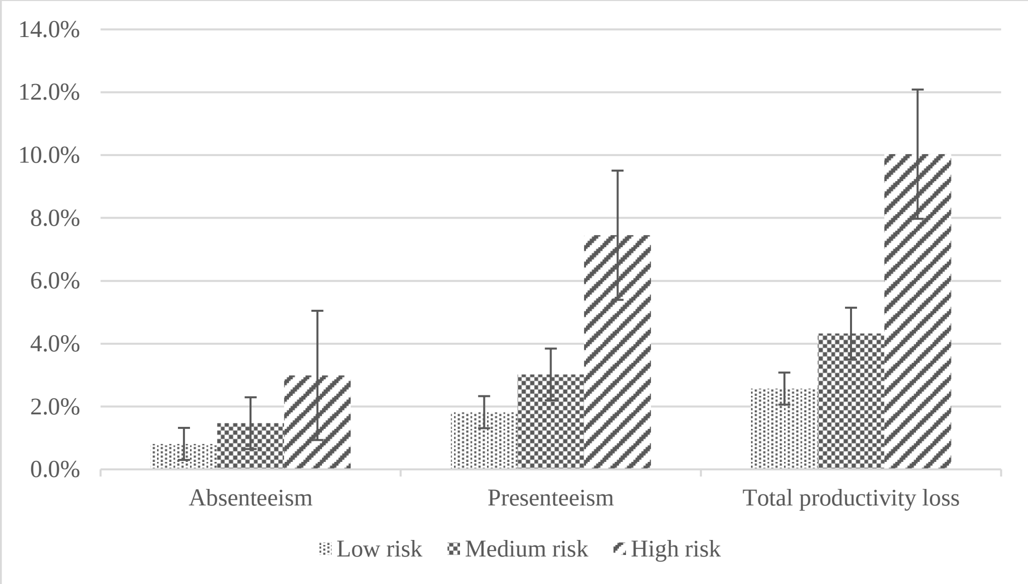

Figure 3. Average percentage productivity loss for each level of health risk

4.4.4 Productivity loss in individuals with high health risks

To estimate the independent contribution of each health condition to absenteeism, presenteeism and overall productivity loss, linear regression was used to estimate the unstandardized coefficients (excess productivity loss) for each health risk adjusting for age, gender, work-related characteristics, and co-occurrence of health risk factors (Table 10). The excess productivity loss was multiplied by the prevalence of each health condition and multiplied by the average annual salary (AUD 134,323.20) of a full-time mining worker in Australia and by 1000 workers to estimate the productivity loss cost (due to absenteeism, presenteeism and total productivity loss) for each of the health outcomes per 1000 workers per year. All health outcomes recording excess productivity loss in high-risk workers were included in estimating each of the productivity loss costs as they showed substantial costs. The F-test also showed a significant contribution of all health outcomes to the models estimating presenteeism, $F_{(8, 198)} = 10.66$, $p < 0.001$ and total productivity loss, $F_{(8,198)} = 6.30$, $p < 0.001$, except for the model estimating absenteeism, $F_{(8,198)} = 1.49$, $p = 0.164$ (Table 10).

Table 10. Estimates of loss in productivity per year by health indicators per 1000 FIFO workers

Health conditions	Prevalence of high risk (%)	Excess absenteeism (%)	Lost productivity cost per 1000 (AUD)	Excess presenteeism (%)	Lost productivity cost per 1000 (AUD)	Excess total productivity loss (%)	Lost productivity cost per 1000 (AUD)
Poor sleep condition	64.4	1.41	1,219,708.39	2.17*	1,877,139.86	3.28*	2,837,335.82
Risky alcohol use	34.3	0.93	428,477.58	1.48	681,878.29	2.26	1,041,246.58
Smoking	26.4	-0.07	-	1.26	446,812.69	1.03	365,251.65
Poor diet	96.3	3.20	4,139,303.73	4.26*	5,510,448.09	6.85*	8,860,697.05
Weight problems	74.5	1.00	1,000,707.84	1.50	1,501,061.76	2.21	2,211,564.33
Insufficient physical activity	26.9	1.64	592,580.23	2.54**	917,776.70	3.88**	1,401,958.10
Poor physical health	8.8	2.79	329,790.32	9.05***	1,069,749.96	11.10***	1,312,069.02
Psychological distress	33.3	2.47*	1,104,821.75	4.64***	2,075,454.63	6.56***	2,934,263.44

*p<0.05; ***p<0.001

Adjusted for age, sex, job type, years in FIFO, shift pattern, shift hours, consecutive days spent at home, consecutive days spent at home, co-occurrence of multiple health risks

The estimated average productivity loss cost due to absenteeism was AUD 1,259,341.41 per 1000 employees per year, ranging from AUD 329,790.32 for poor physical health to AUD 4,139,303.73 for poor diet. The total annual productivity loss cost attributed to absenteeism due to seven health conditions (excluding smoking, which recorded no excess productivity loss due to absenteeism in those at high risk of smoking) was AUD 8,815,389.84 per 1000 employees. On average, productivity loss cost due to presenteeism was AUD 1,760,040.25 per 1000 workers per year, ranging from AUD 446,812.69 for smoking to AUD 5,510,448.09 for poor diet. The total annual productivity loss cost attributed to presenteeism due to the 8 health-related risks was AUD 14,080,321.98 per 1000 workers. The overall productivity loss cost (combination of absenteeism and presenteeism) was, on average, AUD 2,620,548.25 per 1000 workers per year, ranging from AUD 365,251.65 for smoking to AUD 8,860,697.05 for poor diet. Annually, the 8 health risks accounted for an overall productivity loss cost of AUD 20,964,385.99 per 1000 employees. The risks of poor diet, psychological distress, poor physical health, poor sleep condition and insufficient physical activity contributed significantly to employees' excess productivity loss cost in the study sample ($p < 0.05$) (Table 10).

4.4.5 Sensitivity analysis

The results from the probabilistic sensitivity analysis to examine the uncertainty of parameters in estimating productivity loss cost using Monte Carlo simulation are presented in Figures 4-6. Replicating the estimated cost in 1000 samples indicated 95% certainty intervals for the cost of absenteeism (Figure 4): AUD 8.81 million to AUD 8.83 million, presenteeism (Figure 5): AUD 14.07 million to AUD 14.10 million and total productivity loss: AUD 20.95 million to AUD 20.99 million (Figure 6).

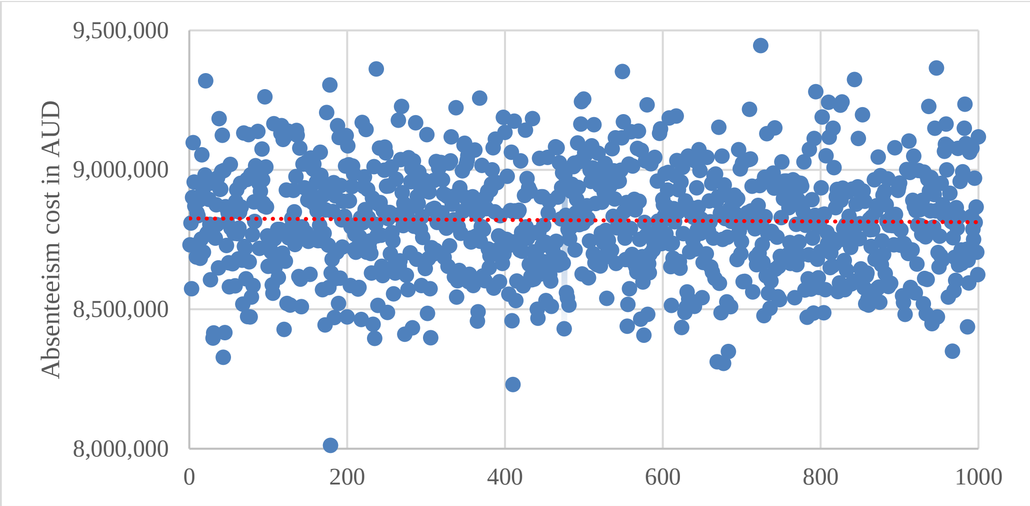

Figure 4. Scatter plot for probabilistic sensitivity analysis to examine the uncertainty of parameters in estimating absenteeism cost using Monte Carlo simulation to replicate the estimated cost in 1,000 samples. Average absenteeism cost was AUD 8.82 (95%CI: 8.83) million.

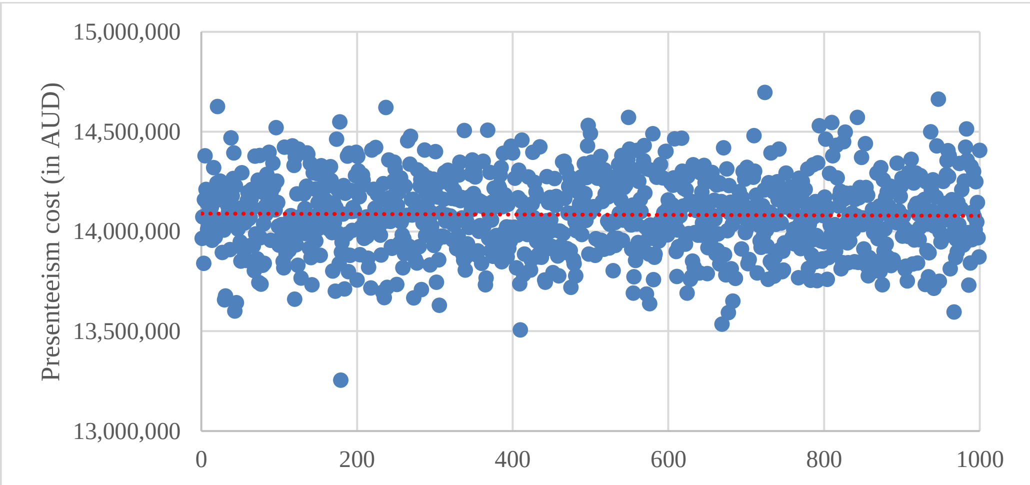

Figure 5. Scatter plot for probabilistic sensitivity analysis to examine the uncertainty of parameters in estimating presenteeism cost using Monte Carlo simulation to replicate the estimated cost in 1,000 samples. Average presenteeism cost was AUD14.08 (95%CI: 14.10-14.07) million.

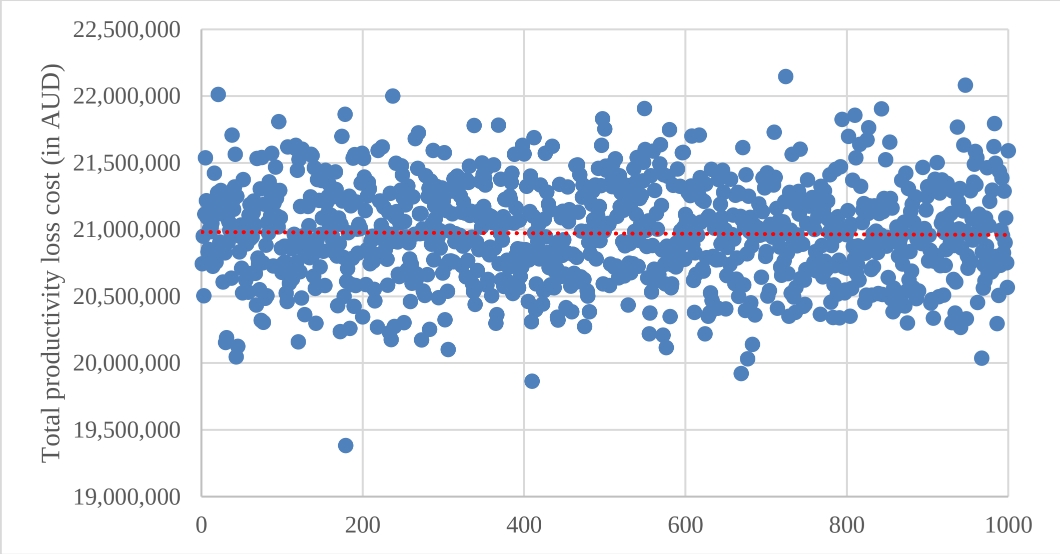

Figure 6. Scatter plot for probabilistic sensitivity analysis to examine the uncertainty of parameters in estimating total productivity cost using Monte Carlo simulation to replicate the estimated cost in 1,000 samples. Average total productivity loss cost was AUD 20.97 (95% CI: 20.95-20.99) million.

4.4.6 Health and work-related factors associated with productivity loss measures

The results of the two-part model analysis examining the health and work-related factors associated with productivity loss measures are shown in Appendix E: Supplementary Information S7. For absenteeism, results from the logistic regression model (−2 log-likelihood = −82.914, $p = 0.002$; pseudo $R^2 = 24.1\%$) showed that study participants with high risk for insufficient physical activity (OR = 2.94, 95%CI = 1.02, 8.48) and poor physical health (OR = 8.25, 95%CI = 1.88, 36.14) had higher odds of reporting any absenteeism than their counterparts with lower risk. Similarly, the odds of any absenteeism were higher among study participants who worked in production/drilling/construction/labouring roles (OR = 4.14, 95%CI = 1.09, 15.74) compared to their counterparts in management roles. Limiting the analysis to study participants who reported any absenteeism (n = 44), those with high risk for weight problems had low absenteeism ($\beta = -2.48$, 95% CI = −4.69, −0.26). However, the model was statistically not significant (($F_{(26,17)} = 0.90$, $p = 0.610$), with adjusted $R^2 = -6.8\%$).

For presenteeism, logistic regression model (−2 log-likelihood = −126.347, $p = 0.010$; pseudo $R^2 = 15.3\%$), results showed that study participants with high risks for poor physical health (OR = 5.17, 95% CI = 1.18, 22.54) and psychological distress (OR = 4.14, 95% CI = 1.55, 11.08) had higher odds of reporting any presenteeism than their counterparts with lower risk. Limiting the analysis to study participants who reported any presenteeism (n = 116) in an OLS model (($F_{(26,89)}$ = 1.99, p = 0.001), with adjusted R^2 = 18.4%), study participants with high risks for poor sleep conditions (β = 0.42, 95% CI = 0.06–0.78), poor physical health (β = 0.82, 95% CI = 0.38, 1.26) and psychological distress (β = 0.50, 95% CI = 0.12, 0.87) had high presenteeism.

For total productivity loss, logistic regression model (−2 log-likelihood = −126.048, p = 0.014; pseudo R^2 = 14.9%), results showed the odds of any total productivity loss was greater among study participants with high risk for psychological distress (OR = 2.85, 95% CI = 1.07, 7.57). Limiting the analysis to study participants who reported total productivity loss (n = 121) in an OLS model (($F_{(26,94)}$ = 1.62, p = 0.049), with adjusted R^2 = 11.8%), participants with insufficient physical activity (β = 0.48, 95% CI = 0.04, 0.89), poor physical health (β = 0.87, 95%CI = 0.32, 1.43) and psychological distress (β = 0.54, 95%CI = 0.08, 1.00) had high total productivity loss. No work-related factors such as FIFO roles, shift patterns and shift hours were found to be significantly associated with presenteeism and total productivity loss (Appendix E: Supplementary Information S7).

4.5 Discussion

4.5.1 Main findings

The aim of this study was to examine the impact of health and related behaviours on the work productivity of FIFO workers in the mining industry in Australia. The high prevalence of health conditions found in workers in our study reflects the extant literature, which reports high levels of poor sleep, risky alcohol use, current smoking, poor diet, high BMI, insufficient physical activity and psychological distress in FIFO workers in the resources industry (40). The proportion of workers reporting absenteeism (20.4%) and presenteeism (53.7%) due to health problems was higher than the rates (absenteeism: 18.7% and presenteeism: 26.9%) reported in a previous study in the mining industry (47). The differences in the measurements and the study periods could account for the observed differences in the findings. For instance, absenteeism in this current study was measured as reported hours of work missed, whereas the previous study measured absenteeism as days missed from work. However, our findings demonstrated the same trend of higher levels of presenteeism than absenteeism reported in the mining industry (46,47) and in the general working population, e.g., (239,245). Presenteeism in the mining sector has been associated with the mining work culture and lifestyle, long working hours and fatigue (221).

This study found excess productivity loss due to absenteeism, presenteeism and total productivity loss for health and related behaviours were highest for those reporting poor physical health and psychological distress. Not surprisingly, workers experiencing poor physical health reported excess absenteeism (2.77%) and presenteeism (8.63%) and were 10.71% less productive than workers reporting better physical health. A previous study found mining workers reporting poor physical health conditions such as musculoskeletal disorders (back, neck or spine injuries) to be 7.12% less productive than those who did not report such conditions (47). In this study, workers experiencing a high risk of psychological distress also reported high absenteeism (2.07%) and presenteeism (4.75%) and were 6.45% less productive than workers experiencing low risk. Similar findings were reported in a previous study, demonstrating that mining workers who experience a high risk of mental health conditions were significantly less productive than workers who did not experience such conditions (47). Another study reported psychological distress contributed to high levels of absenteeism and presenteeism among mining workers in Australia (46). Consistent with previous studies (232,239), we reported that health risk factors including poor sleep, smoking, and insufficient physical activity were significantly associated with lower productivity in high-risk workers than in low-risk workers.

The study found productivity loss increased with an increased number of health risks per worker. Workers with medium risk (3–4 health conditions) and high risk (5 or more conditions) compared to the low-risk workers reported lower productivity. Similar findings were also reported in the general working population in Australia (240) and the United States (232,234,239). The number and type of health risks that were independently associated with absenteeism, presenteeism and total productivity loss differed after controlling for other covariates.

A high risk of psychological distress was found to be associated with presenteeism and total productivity loss but not associated with absenteeism. Consistent with our findings, other studies reported that psychological distress was significantly associated with presenteeism and total productivity loss in the general working population (227,245,254). The negative impact of mental health disorders on work productivity has been well documented in the general working population (223,230,235,255,256). The severity of mental health symptoms such as impaired concentration, decision-making, communication, and social/mental interactions are indicated to drive productivity loss (254,257,258), and as such, the successful treatment of symptoms and mental health promotion interventions could substantially reduce productivity losses (256). It has been noted that workers experiencing high distress tend to be associated with higher presenteeism than absenteeism (259,260). Again, stigma and fear of job loss surrounding mental health disorders are suggested to prevent workers from making known and taking sickness absences due to their mental health status, thereby experiencing more presenteeism (260). High levels of psychological distress are reported in FIFO workers (40), and seeking help for mental health is suggested to be low in the mining sector, citing fears of bullying, stigmatisation and job losses (25), worsening the mental health problems. This could account for high levels of productivity losses. The findings of this study and the broader published literature (40) suggest the need for employers to promote mental health and well-being and to reduce the high levels of psychological distress, including by taking measures that promote/support mental health help-seeking behaviour among FIFO workers. Ebert and Strehlow suggest that active on-site counselling and support could reduce psychological distress (151).

Consistent with the findings of previous studies among the general working populations (259,261,262), the present study found poor physical health to be independently associated with absenteeism, presenteeism and total productivity loss. Poor physical health has been established as a significant contributor to high levels of absenteeism and presenteeism (232,262). Poor physical health is indicated to limit work, particularly for those whose tasks demand strength and manual skill (232), as is the case with some mining jobs. Poor physical health conditions may also require off-the-job time to seek regular medical care and treatment (239).

The present study, similar to the published literature (263,264), demonstrates that poor sleep impacts presenteeism, and it is associated with impaired concentration/attention, memory (264,265), fatigue (265), and worsened social/interpersonal interactions (264,266). With FIFO workers experiencing sleep problems and fatigue, particularly during on-shift days (40), the findings of this study suggest the need for employers to provide suitable environments that promote better sleep to enhance work productivity. However, poor sleep was found not to be associated with absenteeism and total work productivity loss, as has been documented in other studies (250,259). This study had a relatively small sample of participants reporting absenteeism, which could give rise to statistically insignificant relationships. Furthermore, it has been suggested that poor sleep is often associated with underlying poor physical health, which contributes to such individuals (poor sleepers) taking more sickness absence (259,267). As in the extant literature (40), a high proportion of the participants reported good physical health in our study, which could explain the insignificant association of poor sleep with absenteeism.

In line with the findings of this study, insufficient physical activity has also been reported to be associated with absenteeism and total productivity loss among the general working population (239,245). Physical inactivity is indicated to be a risk factor for poor physical health conditions, several of which contribute to absenteeism due to sickness (268) and the need to take time off to seek medical treatment and recover. Sufficient physical activity (269) is indicated to mitigate mental health and stress, which could help reduce work productivity losses (270).

The study findings point toward the need for suitable health and lifestyle workplace interventions to encourage and sustain physical activity among workers, which may reduce work productivity loss (271,272). This study found workers in production/construction/drilling/labouring roles were associated with higher odds of absenteeism. However, no work-related factors were significantly associated with presenteeism and total productivity loss. Supporting our study in part, a previous study in Australia has found mining job roles such as technicians, tradespeople, machinery drivers and operators, and duration spent working in mining to be significantly associated with both absenteeism and presenteeism due to psychological distress (46). The disparity in sample sizes and measurement tools between our study and the previous study could account for the observed differences. For instance, the previous study with a larger sample measured absenteeism and presenteeism in days using single items. Working in manual roles such as production/construction/drilling/labouring may come with high physical job demands, which are associated with sickness and absence from work (262). It has been noted that workers engaged in ‘physically demanding’ jobs tended to report more absenteeism than presenteeism as they may have fewer chances to adjust their tasks to their health status compared to those engaged in ‘mentally demanding’ jobs, who may have more chances to momentarily adjust their job or speed (262). The significant contributions of job-related characteristics to work productivity loss have been well documented (262,273). Additional studies may be required to further explore the work-related factors that significantly contribute to less productivity in FIFO workers.

In this study, seven of the health and related behaviours (excluding smoking) were estimated to account for an excess of AUD 8.82 million in productivity loss due to absenteeism per 1000 employees per year, whereas all 8 health and related behaviours accounted for an excess of AUD 14.08 million in productivity loss due to presenteeism per 1000 employees per year. Overall, the 8 health and related behaviours were estimated to account for an excess productivity cost of approximately AUD 20.96 million per 1000 employees per year. A previous study has also estimated an additional cost of AUD 22.1 million from 7 health risk factors, including sleep condition, short-term alcohol use, poor nutrition, anxiety and depression (47). Additional productivity costs associated with sleep problems (AUD 2.8 million) in this study were comparable to the AUD 2.7 million reported in previous study in mining workers (39). On the other hand, costs associated with alcohol intake (AUD 1.0 million) and poor diet (AUD 8.8 million) were higher than documented in previous studies in mining workers (39). Again, the productivity costs attributed to poor physical health (AUD 1.3 million) and psychological distress (AUD 2.9 million) were lower than reported in previous studies in a general mining workers (38,39). Previous study has reported that chronic health conditions including migraine and back, neck and spinal problems accounted for AUD 7.9 million and anxiety, depression and stress to account for a combined AUD 13.2 million per 1000 mining employees per year (39). The other study has also estimated psychological distress to account for an annual productivity loss cost of AUD

4.9 million in mining workers (38). Psychological distress has been documented to account for productivity costs of AUD 5.9 billion per year in the general working population in Australia (228). The probabilistic sensitivity analysis to examine the uncertainty of model parameters returned certainty intervals for the estimated productivity loss costs.

The findings of the study have provided a strong indication of the economic implications of high health risks in FIFO workers. Workplace interventions including integrated workplace-based health and wellness programs (266) and stress management programs (39, 41) could improve health and well-being among workers and may reduce work productivity loss (271,272). The workplace has been indicated as a significant environment for enhancing the reach and effectiveness of health promotion programmes (266). The findings have highlighted the financial basis for the significance of and decisions/justifications for workplace health interventions. The significant associations identified between a number of health risks and productivity loss measures provide the basis for targeted workplace health interventions and the basis for the evaluation of the impact of such interventions.

4.5.2 Study limitations

Some limitations to the study are acknowledged. The use of a cross-sectional design limits the causal interpretation of the study findings. Secondly, the study relied on self-reported data (health conditions, absenteeism and presenteeism) over a recall period of 4 weeks. As such, there could be issues with recall bias and the under- and/or overestimation of study parameters. Further, the estimation of productivity loss cost was based on the estimated average weekly wage for a full-time worker in the mining industry; however, wages may differ between job roles (e.g., management vs. machinery operator/driver) and employment type (e.g., full-time vs. part-time). This approach is consistent with previous studies in the resources industry (47) and general employment settings (223,245); however, obtaining original data on the health conditions, time (days/hours) missed from work and wages from organizations may present close to realistic estimates.

Limitations of the sampling technique used in this study are acknowledged. First, the non-probability or convenient sampling of the study participants may have the potential of sampling bias affecting the representativeness of the study sample. Secondly, the study recruited participants from two main sources, a mining company and posts on Facebook, which have the potential of sampling bias, particularly if sampling is mainly from the mining company, limiting the generalizability of the study findings. There was no system in place to track the number of participants in the study who were identified via Facebook posts or the mining company to observe any possible systematic differences in data sources. Again, recruiting through posts on Facebook have the potential to include non-FIFO workers in the study sample, though the use of social media platform in FIFO studies has been demonstrated (13).

The study also included a convenient small sample size. However, our study sample was reflective of the profile of the FIFO work population in Australia as mostly males, middle-aged and on a roster of 8 days at work, similar to that reported in a large sample study (7). We found no significant work-related characteristics associated with presenteeism and total productivity loss, and using a larger sample size may suggest otherwise (46). The study was conducted among FIFO workers in the mining sector whose work arrangements are unique with long shift patterns and leave periods between work periods and reported higher levels of health-related risks than the general population (40); as such, generalising the results of this study to other work settings may be limited.

4.6 Conclusions

The study contributes to evidence on how to measure the productivity loss cost of health outcomes to inform and justify the need for and evaluate workplace health interventions. The study provides information on the impact of multiple health risk factors on absenteeism, presenteeism and overall work productivity loss among FIFO workers in the mining industry. The study has also provided information on health-related productivity loss, adjusting for relevant work-related characteristics, which may significantly impact health and productivity. Our study also contributes to the growing evidence of the substantial contribution of presenteeism to productivity loss. The study found that levels of absenteeism and presenteeism in an assessed sample of FIFO workers were high. The study also suggested that FIFO workers with high-risk and multiple health conditions experienced higher absenteeism, presenteeism and overall productivity loss than those at lower risks and with fewer conditions.

Overall, FIFO workers with high health risks (poor sleep, poor diet, smoking, risky alcohol use, weight problems, insufficient physical activity, poor physical health and high psychological distress) were estimated to account for a total of AUD 20.96 million per 1000 workers per year in additional productivity cost. High risks for insufficient physical activity, poor physical health and working in production/drilling/construction/labouring roles were significantly associated with absenteeism, whereas high risks for poor sleep, poor physical health and psychological distress were significantly associated with presenteeism. Overall productivity loss was associated with insufficient physical activity, poor physical health and psychological distress.

There is a strong economic basis that could support the need for targeted/prioritised workplace health interventions and the basis for the evaluation of the impact of those interventions. Further studies exploring workplace health interventions could include prior and regular analysis of productivity loss cost to inform the effectiveness of such interventions in improving the health and well-being of FIFO workers and reducing work productivity and cost.

4.7 Summary and link to other chapters

This chapter has presented high productivity loss costs associated with psychological distress, physical health status and related behaviours. It evaluated high productivity loss arising from absenteeism, presenteeism, and total work impairment due to the common health outcomes identified in Chapters 2 and 3 to build a financial justification for the workplace health interventions that could be informed by the mechanisms identified and presented in Chapter 8, which details the within-person variability of the psychological states and health-related behaviours and the work condition predictors tested using multilevel analysis. The next part of the research examined the mental health and well-being, physical health and related behaviours of families of FIFO workers, with emphasis on the partners of workers.

PART TWO: Workers’ families

Chapter 5: Study Four

Preface

This chapter presents the fourth published study included in this thesis and cited as:

> Asare BYA, Powell D, Robinson S, Kwasnicka D. Rotation work in the resources sector: A systematic review of the impact on workers' families. Psychology and Health. 2023. 10.1080/08870446.2023.2190348.

The paper's content here is as it appears in print, however, it has been formatted to be in keeping with the rest of this thesis. This study was another important initial step in the thesis, to identify key mental health outcomes, physical health outcomes, and health-related behaviours relevant to families of FIFO workers. It also served to highlight relevant research gaps and limitations in the extant literature which could be addressed in later chapters within the thesis.

Author contributions: BYA, DK, SR and DP conceived and designed the study protocol. BYA developed the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment and drafted the initial manuscript. DK, SR and DP reviewed and contributed to the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment. BYA drafted the article and DK, SR and DP have reviewed and approved the final written manuscript.

Study Four: Rotation work in the resources sector: a systematic review of the impact on workers' families

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Acknowledgements

authors extend their sincere gratitude to Ms Diana Blackwood and Ms Vanessa Varis, Librarian for the Faculty of Health Sciences, at Curtin University for their professional assistance in developing the review search strategy.

Competing interests

None declared.

Funding

The study was funded by Aberdeen-Curtin Alliance.

5.1 Abstract

Objective: Rotation work involves travelling to work in remote areas for a block of time and alternating with spending another block of time at home; such work arrangements have become common in the resources sector. The intermittent absence of workers from the home may adversely affect the health of the families of workers. This study synthesises research on mental and physical health outcomes in partners and children of rotation workers in the resources sector.

Design: A systematic review was conducted. Quantitative, qualitative and mixed-method studies were retrieved from PubMed, Medline, EMBASE, CINAHL, PsycINFO, and Scopus. Nineteen studies were included and findings were summarised narratively.

Results: The impact of rotation work on the mental health and well-being of the partners and children of rotation workers remains unclear. However, on days when spouses are away, partners may experience greater loneliness and poorer sleep quality.

Conclusion: Partners may benefit from support, particularly when they have younger children and/or their spouses first begin rotation work jobs. Research is limited, particularly regarding the impact on health-related behaviours and physical health outcomes.

Registration: This review was registered on PROSPERO (ID: CRD42020167649).

Keywords: rotation work, FIFO, long-distance commute, families, systematic review.

5.2 Introduction

5.2.1 Definition of Rotation work and the impact on families

Rotation work, also known as *Fly-In Fly-Out* (FIFO) (1,11,66), involves travelling to work for a typical 12-hour day or night shift and staying for a specified number of days, ranging from 5 days to 6 weeks, after which the worker returns home to spend another specified period at home (1–3,7,21–23,162). Workers basically work on a rotational basis by alternating between a block of time at work and another at home. Rotation work arrangements initially developed for serving offshore oil and gas installations in the Gulf of Mexico (5) are nowadays increasingly used globally in the onshore mining and construction industry (1,2).

Rotation work arrangements present families with benefits including higher incomes, the maintenance of social networks and urban settlements, and the chance to spend blocks of time with family and friends during leave periods (3,20,23). Some authors referred to “independence for worker and partner” (22) and separation of work commitments from personal/family life (3,20,22) as potential benefits of rotation work. However, the rotation work lifestyle of alternating presence and absence from home over some time also has disadvantages for social and family life and workers' physical and psychological health. These include workers missing family and social events (67,274), potentially overburdening partners with their home obligations (20,67,275,276), and recurrently having to emotionally and functionally adjust to separations and reunions (20,22,276) often leading to disruption of family lives (5,7,276).

A review has suggested that the partners experience more stress, social isolation and loneliness and that the absence of the worker could negatively impact children’s development, well-being and family functioning (7). Another review has reported that children of rotation workers may experience more adverse emotions including anger, sadness, and hate; and more behavioural problems such as hyperactivity, conduct and peer problems due to the long absence of rotation work parents from home (22). Furthermore, children of rotation workers were more likely to suffer bullying at school, and are often under more stress to perform well at school compared to children of non-rotation workers (22). The review further noted the difficulties associated with partners of rotation workers having to intermittently switch from "solo parenting to co-parenting" and "providing for the physical, emotional and intellectual needs of children" (p. 1) when rotation workers are away on their rotation (22).

5.2.2 Theoretical frameworks

Little effort has been made to consider the effects of rotation work on families within the available theories and theoretical frameworks (7,36). Both *Work-Family Conflict Theory* (41) and the *Spillover-Crossover Model* (42) could explain how the pressures of rotation work demand impact the well-being of partners and children of workers. Studies have employed the *Work-Family Conflict Theory* and *Spillover Crossover Model* to expound in what ways the pressures of job demands and resources of spouses who both earn income influence the well-being of their partners (277–279) and children (280).

Furthermore, *Attachment Theory* (43) and *Social Ecological Theor*y (44) could also offer the means to understand the potential effects on partners and children of temporary separations due to rotation work. Several studies acknowledge the significance of Attachment Theory (281–286) and Social Ecological Theory (36,286,287) in explaining the effects of temporary parental and partner separations; for instance, due to military deployment on children and partners' well-being (282,287).

5.2.2.1 Work-Family Conflict Theory and Spillover-Crossover Model

Work-Family conflict is explained as, "a form of inter-role conflict in which the role pressures from the work and family domains are mutually incompatible in some respect. That is, participation in the work (family) role is made more difficult by virtue of participation in the family (work) role" (p. 77) (41). The *Work-Family Conflict Theory* suggests role conflicts arise when 1) the time demands of one role affect the undertaking of a different role *(time-based conflict)*, 2) strains caused by one role prevent/interfere with accomplishing the demands of another job *(strain-based conflict),* and 3) particular forms of behaviour within a role do not match with the expected behaviour in another role *(behaviour-based conflict).* The model suggests that the intensity of the role pressures and, therefore, *Work-Family conflict* corresponds to how significant the work and family roles are to the individual and the strong negative consequences associated with the inability to accomplish the demands of the roles (41). Studies have indicated increased Work-Family conflict to be connected to the experience of adverse consequences including problems caused by stress such as burnout, depression, substance abuse, psychological strain and somatic physical symptoms affecting the individual's general well-being and health (180,288–290).

The *Spillover-Crossover Model (SCM)* advances that "work-related experiences first spill over to the home domain, and then cross over to the partner through social interaction" (p. 58) (42). The SCM combines two processes; *spillover (or Work-Family conflict)*: involves one's job demands and the resultant strains being carried (within-person) along into the home space (42,291), and *crossover:* involves job demands and the resultant strains being transferred (between persons) from the worker to a close relation (42,291). The SCM suggests that strains caused by/from exposure to high job demands could *spill over* and be experienced at the home space, leading to *Work-Family conflict* which will impact negatively family interactions at home and incidentally affect the well-being of partners (42). On the other hand, high exposure to job resources may promote engagement and bring about *Work-Family enrichment* and sequentially foster positive interactions with their partners which will positively influence the well-being of partners (42).

Rotation work schedules of spending several days away from the home may mean the demands are often not met with performing one's roles as a spouse and parent, increasing the demands on the at-home partner by taking up extra domestic and parental roles (increasing the likelihood of work-family conflicts) leading to exhaustion. Rotation workers travel long distances to work on compressed shifts of a standard 12 hours and may return home tired and fatigued (spillover) and wanting to rest and recover (20), interfering with spending time and interacting with family members (may be unable to settle into family life creating work-family conflict) making the family feel neglected and unhappy and may at times results in arguments creating tension (crossover) (20). Furthermore, rotation work involves routine rigid schedules/structures of starting and ending work and eating at specified times, expectations and behaviour patterns which are often distinct from the family life (behaviour conflict) (15).

5.2.2.3 The Attachment Theory

The Attachment Theory proposed by Bowlby (43) addresses the formation, and maintenance of attachment or emotional bonds (292,293), such as the relationships between a parent and child and between adult romantic partners (281,294), where the one who provides support, comfort and relief becomes the 'attachment figure' (295). The theory argues *proximity maintenance* to and the *availability and responsiveness* of the relationship's attachment figure allow one to develop a sense of trust and security (43,292,293,295). In a parent-child relationship, the parent is the main attachment figure (292,293) whereas in the adult romantic partner's relationship, the spouse becomes the main "attachment figure" (296) and as such their principal *"safe haven"* and *"secure base"* (295,296). However, in the absence or separation or loss of the attachment figure, the emotional bonds become threatened and the experiences of anxiety and depression set in (43).

Rotation work arrangement means workers are frequently separated and absent from their families for several days; disrupting the partner/spousal and parent-child relationships and making them unavailable and responsive to the needs of their families. In line with the attachment theory, partners and children of rotation workers may become distressed and develop emotional and behavioural problems.

5.2.2.4 The Social Ecological Theory

The Social Ecological Theory, however, recognises that an individual's behaviours and health outcomes are influenced by the interaction between individuals and their environments (44). The Social Ecological model advances that the behaviour of an individual is shaped by factors at several levels including the *intrapersonal, interpersonal, organisational, community, and policy levels,* which interact and equally impact each other (297). This suggests that parent and child reactions to the separation and absence of a rotation worker/parent are also shaped by individual factors such as the child's age, sex, previous experiences of separations, disrupted parental and domestic roles, and individual weakness and strength including capacity and coping skills to deal with the challenges and demands of spousal/parental separations (36).

Furthermore, environmental factors and systems external to the family, including community factors such as the availability and provision of support from schools for children, social support networks in family and communities, and availability and accessibility to health services could influence how partners and children cope with the challenges and demands of rotation workers absence (36).

Partner and child response to separations could also be impacted by parental organisational-related arrangements such as the number of days spent at work and frequency of absence from home, high financial rewards, the risk profile of work (36), and supportive climate for families including the provision of health and mental health services, and one that connects workers to families such as the provision for reliable and regular communication infrastructure and to help family foster adaptation to separations and demands (287). Furthermore, governmental regulations and guidelines influence social institutions in which the individual functions, such as guidelines on employment arrangements and working conditions (20).

5.2.3 Aim of the present study

Rotation work in relation to family life differs from other work arrangements. The intermittent absence of workers from the home may adversely affect the health of the families of workers. As rotation work becomes more popular globally, particularly in the resource and related construction sectors, it is necessary to explore the impact of this work on the health and well-being of workers and their families in these sectors.

Previous systematic reviews have highlighted the impact of rotation work on partners and children. These reviews only focused on the impact on partners' mental health, children's emotional and behavioural problems, and family relationships and functioning (7,22), and were limited to a specific geographical setting; mainly focusing on the literature from Australia where rotation workers are predominately onshore mining workers (7,22). However, it is suggested that the impact of rotation work on families could be influenced by several contextual factors including rotation "workplace culture, rosters patterns and recruitment practices as well as community, home and personal factors" (p. 2) (22), which could differ from one sector to the other and from countries to countries (68). Furthermore, there are additional outcomes that are empirically related to the influence of rotation work on families such as sleep and health-related behavioural patterns of rotation workers' partners that were not included in these previous reviews. There is also a need to contextualise any impact on rotation work on families within available theories and theoretical frameworks (7,36).

A systematic review was conducted on studies examining the impact of rotation work on the health and well-being of workers' partners and children, including psychological health and well-being, physical health, sleep and health-related behavioural patterns, and emotional and behavioural patterns of children. The results are then discussed under the lens of the theories outlined above to explore which, if any, is most relevant: we expected to see evidence of conflict resulting from workplace demands spilling over into the home; and that the repeated absence of the spouse/parent may lead to more distress. Providing a comprehensive review of global resources and related construction sectors could provide clarity and highlight the consequences of rotation work arrangements on families.

5.3 Methods

This systematic review of the literature was conducted in line with the guidelines of the Joanna Briggs Institute (JBI) for quantitative and qualitative reviews (76), and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (77,298). This review was part of a broader review of which the protocol was pre-registered on PROSPERO (ID: CRD42020167649) assessing the overall mental and physical health of rotation workers, reported elsewhere (40) whereas the current review examines the mental and physical health of families of rotation workers.

5.3.1 Eligibility criteria

Original articles of quantitative, qualitative and/or mixed-method studies published in peer-reviewed journals and in English were included in the review. Qualitative findings can give in-depth insights into the health outcomes of rotation workers' partners and children, and support the understanding of quantitative findings. The study population were partners (with or without children) and/or children (of any age) of rotation workers who worked in the resource (offshore oil and gas, and mining) and related construction industry. Rotation workers were defined as workers who work on rotational schedules of travelling away from home to work for a block of time and alternate with spending another block of time at home.

Quantitative studies were included if they reported psychological health outcomes, children's behavioural and emotional problems, physical health outcomes, sleep problems or health-related behaviours. Qualitative studies that reported the perceptions of the impact of rotation work arrangement on the physical and mental well-being of partners and children of rotation workers were included. We also included studies that reported parents' perceptions about the impact of rotation work on children. The clearly defined quantitative and qualitative components of mixed-method studies were considered. Studies were excluded if they were reviews, letters, book chapters, study designs were not clearly defined, and only reported on family relationships and functioning, and parenting (but not on any health-related outcomes).

5.3.2 Data sources and search procedure

Searches were conducted in PubMed, Medline, EMBASE, CINAHL with Full Text, PsycINFO, and Scopus on 1st May 2020 for relevant articles as part of a bigger review (40) and updated on 21st April 2021, using search strategies presented in Appendix C: Supplement Information S1. Searches were not restricted by study design, publication dates and geographic location. The references of the included studies were also hand searched for other relevant studies.

5.3.3 Study screening and selection

Figure S2 (see Appendix F: Supplement Information S8) shows the PRISMA flow diagram for the selection of studies into the review. Studies identified were screened for inclusion/exclusion in the *Covidence* software (79). The titles and abstracts of articles and then full texts for all potentially eligible studies were retrieved and screened by two of the authors (BYAA and DK) for suitability. The agreement between raters (interrater reliability) for screening of studies at both the title and abstract and full-text stages were high with a

Cohen's Kappa statistic of 0.98 and 0.92 respectively. Disagreements at all stages of the screening were resolved through discussion until consensus between the two authors (BYAA and DK) and any that could not be agreed upon were referred to the other two authors (DP and SR) to resolve by consensus. Articles excluded at the full-text screening were recorded and the reasons that informed the exclusion of studies per the inclusion criteria were reported (Figure S2).

5.3.4 Assessment of methodological quality

Two of the authors (BYAA and DK) independently evaluated included studies for methodological quality using tools for appraisal of quantitative descriptive studies in the Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MASt ARI) and Qualitative Assessment and Review Instrument (JBI-QARI) (80,299), and rating discrepancies were deliberated on and resolved. Checklist items of the assessment tools were rated and scored 'Yes' (1), 'No' (0) and 'Not clear' (0), excluding not applicable items. Analytical cross-sectional and cohort studies were rated for methodological quality on 9 to 11 items such as the validity and reliability of exposure and outcome measurements, identifying and stating strategies for dealing with confounding factors, and appropriateness of statistical analysis used (80) with possible scores between 0 and 11. Qualitative studies were rated for methodological quality on 10 items such as research methodology agreement with data collection methods used, the representation and analysis of data, the interpretation of results, and the ample representation of participants and their voices (299) and a study potentially scored between 0 and 10. For mixed-method studies, each component of the method (quantitative and qualitative) was assessed separately as outlined above. Any inconsistencies in scores that arose were discussed and resolved through consensus. Studies scoring ≥ 7 were categorized as of high quality, scores 4-6 were considered medium quality and scores <4 were classified as low quality (300) and reported in the review. No study was excluded based on quality assessment (82,83) since there are few available studies examining the outcomes of interest (82), and strict exclusion based on quality assessment may exclude appropriate studies based on not following a particular reporting standard (83).

5.3.5 Data extraction

Using the templates from the JBI-MAStARI data extraction tool for quantitative data and JBI-QARI for the qualitative studies, a data extraction sheet (see Appendix C) was developed and piloted, and used for data extraction. The key information extracted included study authors, publication year, study design, aims/objectives, study setting (country and industry) and participants (number of study participants, gender, age), health outcomes and measurement tools used and the key findings. One reviewer (BYAA) conducted the data extraction and another reviewer (DK) double-checked 10% of the extracted data; all inconsistencies were discussed and resolved through consensus.

5.3.6 Strategy for data synthesis and analysis

Quantitative and qualitative data extracted in terms of the studies' characteristics and key findings were presented in tables and a narrative summary of the included studies was done. Based on previous literature (7,22,67) studies were categorized into four main themes: psychological health outcomes, physical health outcomes, sleep, and “lifestyle” behaviours. Studies were narratively reviewed within these themes, and based on study findings were further organised into subthemes. A quantitative summary of the study outcomes (meta-analysis) was not feasible due to the largely descriptive nature of studies that did not provide comparable quantitative data and the high heterogeneity of included studies and study outcomes. The effect sizes, where available, and further statistical details were extracted and are presented in Table S7-S10 (Appendix F: Supplement Information S9).

5.4 Results

5.4.1 Characteristics of studies

A total of 19 studies, 9 quantitative studies and 7 qualitative and 3 mixed-method studies were included in the review; 12 of the studies were conducted in Australia, 4 in the UK, and one each in Iran, Chile and Canada. Twelve studies examined outcome data among partners; all 12 studies (5 quantitative, 5 qualitative and 2 mixed method studies) examined psychological health and well-being (13,15,34,131,132,301–307), 3 quantitative studies investigated sleep (13,34,304), 3 quantitative studies assessed perceived physical health status (13,303,304), and 4 quantitative studies examined health-related behaviours (13,131,132,304). Among the studies, the overwhelming majority of the partners in the sample were females (average 99.4%). The age of the partners ranged between 18 and 59 years (mean age 35.9 years).

Ten studies investigated outcomes data among children; seven of the studies (4 quantitative and 3 qualitative) investigated children's psychological health and well-being (33,275,307–311) and seven studies (4 quantitative and 3 qualitative) examined children's behavioural and emotional outcomes (33,132,305,307,308,310,312). Five studies (3 quantitative and 2 qualitative) (33,132,305,307,312) included data from parents rating the behavioural and emotional impact of partners' rotation work on children. The summaries of study characteristics and key findings are presented in Tables S7-S10 (Appendix F: Supplement Information S9).

Out of the 11 quantitative studies (including 2 quantitative clearly defined components of mixed-method studies), seven (13,34,131,132,275,308,311) were rated as high quality, 1 medium (33), and 3 low (303,304,312). Of the 9 qualitative studies (including 2 qualitative clearly defined components of mixed-method studies), 4 were rated high quality (15,301,307,309), 4 medium (302,305,306,310) and 1 rated low (303). Overall, the majority of studies (84.2%) were of medium to high methodological quality. Almost all of the quantitative studies used and reported common validated scales/scoring for measuring outcomes and showed a psychometric analysis of the validity and reliability of scales (131,132,275,305,308,311) or pointed to original or previous studies (33,34,303,304,312) where the validity and reliability of scales had been confirmed. The suspected risk of selective outcome reporting bias was low, as studies reported all outcomes measured. However, a number of studies included smaller sample sizes, which may affect their statistical power; hence, the findings of this study should be interpreted with caution. Nine (47.4%) out of the nineteen included studies received external funding; 3 from university/research institutions (132,303,304,310), 2 each from a governmental agency (33,301) and non-for-profit organization (13,15) and industry regulator (305), but were not involved in the study designs and processes. No study was funded by the industry itself.

5.4.2 Psychological health and well-being of partners

5.4.2.1 Psychological distress and well-being

Quantitative studies showed inconsistent findings on the mental health of partners. Studies' findings on partners' psychological distress compared to the general population were mixed. Two cross-sectional studies examined the prevalence of distress symptoms using cut-off points (33) and symptoms checklists (304) on validated scales. One of the studies reported a higher prevalence of psychological distress (32.0% vs 2.6%) among partners of on-shore rotation workers compared to a secondary data source of the general population (33). But the other study reported comparable proportions of partners of offshore rotation workers to other married women in the general population from a secondary data source (18% vs 16%) showed 'nervy', 'tension' and 'depressed' symptoms (304). Two other cross-sectional studies examined the levels of distress using symptom checklist scores and recruiting comparison groups. One of the studies showed significantly higher levels of depression, anxiety, and stress among partners of rotation workers compared to partners of non-rotation workers (132) whereas the other study found no significant differences in levels of depression, anxiety, and stress between partners of rotation workers and partners of non-rotation workers (131).

Quantitative evidence was also not clear on partners' experience of psychological distress, depression and anxiety in the absence of their partner. Out of three studies, two cross-sectional studies using symptoms checklist scores on a validated scale reported higher levels of anxiety among partners in the absence of rotation workers than when at home (303,304): in one study, 10% were classified as having 'Intermittent Husband Syndrome' characterised by changes in mood and behaviour in the partner in the absence of workers (303). One other daily study using a self-reported diagnosis of mental health problems reported the daily use of medications for mental health problems among partners was not common, and the finding was not significantly different in the absence and presence of rotation workers (13).

Quantitative evidence show partners can experience loneliness in the absence of rotation workers. One cross-sectional study examined the levels of social isolation and/or loneliness among partners using symptom checklist scores on a validated scale and reported significantly higher loneliness in the absence of workers than in the presence of workers and when compared to the general population (34). Another cross-sectional study using self-reported measures on a validated scale reported a high proportion of partners (66.4%) indicating loneliness in the absence of workers (305).

Qualitative evidence showed both a negative and positive impact of rotation work on the mental health and well-being of partners. Qualitative studies emphasise the enhanced emotional strain, anxiety, and burden felt among partners in the absence of workers. The burden highlighted was generally around having to bring up children and do domestic chores alone (15,303,305,307). Partners also reported feeling anxious and frustrated about workers' physical and psychological health (15,305), safety (305), job insecurity (305,307), infidelity (301), and long roster patterns (306) particularly whilst workers were away on rotation. Again, partners reported feeling anxious about the physical and psychological distance created by rotation work arrangements, which leads to disconnect and tension in relationships (15) and were frustrated by poor communication networks with partners when at work (306). Improved and maintained communication between partner and workers during off-shift periods were highlighted to help partners adjust to the intermittent absence and help alleviate the anxiety about worker's safety (305). There was also evidence to suggest high anxiety among partners who are new to the rotation work lifestyle about becoming too independent as they cope with the rotation work lifestyle (306).

Qualitative evidence showed partners of rotation workers also indicated experiencing emotions of sadness, loneliness and hopelessness when rotation workers are away from home (302,303,305–307), and that tended to be magnified in partners with younger children (306). Partners reported a lack of sympathy from community members and even other FIFO families, and a lack of support from organizations toward negotiating the health of FIFO families (15).

Evidence also showed partners experience emotional strains and distress during reunions and prior to separations. Four qualitative studies discussed partners are faced with difficulties in adjusting to this lifestyle of presence and absence of workers, some studies referred to '*living two lives',* causing role conflicts and disruption to life leading to tension and irritation (15,301–303,305). Some partners expressed experiencing tensions between the showing of and the need to play down their developed emotional capability when the FIFO worker returns home (306). Some partners indicated experiencing emotional strain due to the disruption of family life as partners feel separated from workers when at home (303,305), citing the need for workers to recover from fatigue (305) or catch up with lost social events (303). Partners also consistently expressed stress and anxiety in the periods prior to workers going away from home to work (303,305).

Despite the concerns and strains expatiated, there was evidence to show rotation work lifestyle could have positive effects on partners' personal and emotional development, particularly among those without children/younger children or of long-serving rotation workers. Three of the qualitative studies also showed rotation partners, particularly those of long-serving rotation workers, can become more independent and resourceful (developing coping abilities and skills) and overcome emotions as they adapt to the rotation work lifestyle (303,305,306). Furthermore, studies indicated that some partners in the absence of workers develop their capabilities (303), personal confidence (305) and a sense of control and empowerment in making decisions regarding the family (307) over time. Other studies indicated that some partners particularly those without children in the absence of the workers get free time to socialise with others and increase their social networks (302,303,306). Some partners indicated the sense of high financial rewards of rotation work helps them to cope with rough patches in the absence of workers (307).

5.4.2.2 Sleep problems among partners

Three studies examined various indicators of sleep problems among partners in the absence of rotation workers. Two of the studies examined sleep quality, specifically, and both indicated poorer sleep quality in the absence of workers. One cross-sectional study using scores on the Pittsburgh Sleep Quality Index showed significantly poorer sleep quality among partners in the absence of workers than in their presence at home (34). Similarly, a daily diary study examining within-person differences in the sleep quality of partners when workers were present or absent found significantly poorer sleep quality among partners when workers were on-shift away from home (13).

One of the studies examined partners' sleep duration and reported sleep duration was not significantly longer in the presence of workers than in the absence of workers (34). One of the studies using a symptoms checklist examined general sleep difficulties and found more partners of offshore rotation workers experience sleep difficulties when workers were away at work (20%) than when at home (14%) (304).

Evidence on partners' sleep compared to the general population was unclear. Of two cross-sectional studies, one study using cut-off points on validated scales reported statistically significantly shorter sleep duration, excessive sleepiness and poor sleep quality among partners of onshore rotation workers compared to the general population from secondary data sources, in the presence or absence of rotation workers (34). The other study using a symptoms checklist scale found similar proportions of partners (20%) in the absences of workers and less proportion of partners (14%) in the presence of workers compared to a secondary data source of the general population (20%) experience sleep difficulties (304).

5.4.2.3 Physical health

Three quantitative studies that investigated the physical health of partners of rotation workers found perceived good physical health status. Of the studies, two cross-sectional studies reported comparable proportions of partners of rotation workers perceived to have good physical health status as measured by self-rating of general health to that of the comparing group of partners of onshore non-rotation workers (303,304). Another daily study reported partners' daily intake of medication for physical impairments (as a self-reported measure of physical health) was not common, but significantly higher during workers' on-shift than off-shift days (13).

5.4.2.4 Health-related lifestyle behaviours (alcohol intake, smoking, exercise and relaxation)

Limited studies investigated health-related lifestyle behaviours of partners of rotation workers.

Alcohol intake. Three quantitative studies examined alcohol intake, and the results suggested some partners may consume more alcohol in the presence than the absence of rotation workers, but that alcohol intake or alcohol-related problems were similar to partners of other workgroups and women in the general population. Of the three studies, two examined alcohol intake using checklists scales; one of the studies found no statistically significant difference in the proportions of alcohol intake problems between partners and comparison groups of partners of non-rotation workers (131). Similarly, the other study also found levels of alcohol intake were not statistically significantly different between partners and comparison groups of women in the general population of women (132). The third study using self-reported measures examined within-person differences between presence and absence of workers and found alcohol consumption was significantly higher in the presence of workers (13).

Smoking, diet, exercise and relaxation. One daily study examined within-person differences between the presence and absence of workers and found partners were more likely to consume foods with poorer nutrition quality, carry out fewer exercises, and have less time to relax in the absence of rotation workers (13). The study also reported partners smoke significantly more in the absence of onshore rotation workers (13).

5.4.3 Mental health and well-being of children

5.4.3.1 Psychological distress and well-being

Evidence of the impact of rotation work on the mental health and well-being of children was unclear. Two quantitative studies found high symptoms of mental health outcomes whereas two other studies did not. Three cross-sectional studies using cut-off points on validated scales examined the prevalence of mental health outcomes. One of the studies reported a significantly higher prevalence of symptoms of anxiety among children of offshore rotation workers than a comparison group of children of onshore-based workers (56.2% vs 32.3%, p=0.03) (311). Children were more likely to report anxiety symptoms when their parents worked offshore rotation work (311). Another study established prevalence of symptoms of moderate (9.1% vs 6.9%, p=0.02) and severe (3.0% vs 2.8%, p=0.03) depression significantly higher in adolescents of onshore rotation parents than in a comparison group of adolescents from non-rotation-work families (308). The other study established lower proportions of adolescents of onshore rotation parents (2%) show mental health level of clinical significance compared to a secondary data source of the general population (10%) and their mental health level was not related to rotation worker's roster (33). Similarly, one cross-sectional study using symptoms checklist scores on validated scales reported children of onshore rotation workers had depression and anxiety levels within healthy functioning and found no significant difference between them and the children of military and community families (275).

Qualitative evidence was also unclear. Studies revealed many children enjoy the rotation work lifestyle as it provides enough free days to spend and socialise with parents during the leave period (305,309), expressed feeling relaxed and less stressed when rotation parent was away as they can have friends come over (309) and feel happy being able to avoid parents taking out their frustration on them or punishment (310). Furthermore, children of offshore rotation workers indicated seeing their fathers more (during leave days) than children of onshore office workers (310). However, some children were also reported to experience incidences of sadness or loneliness when their fathers started working on long-distance commuting job arrangements or rotation jobs in a qualitative study (307). Some children also indicated feeling hurt by their parents' absence and expressed worries/anxieties about the safety of their father when away at work (310).

5.4.3.2 Behavioural and emotional problems

Studies investigated the rotation work impact on children's behavioural and emotional issues, and findings were unclear. Three quantitative studies examined behaviours and emotions using checklist scores on validated scales. Out of the three studies, one cross-sectional study showed significantly higher levels of emotional and behavioural difficulties including conduct problems, hyperactivity, and peer problems were found among adolescents of onshore rotation parents than in a comparison group of adolescents from non-rotation families (308). However, other two cross-sectional studies reported parents rated their adolescent children as not suffering from emotional difficulties (33), and that levels of behaviour and emotional difficulties were statistically similar among children in rotation families and a recruited comparison group of non-rotation families (132).

However, three cross-sectional studies found parental rotation work characteristics and associated well-being were related to children's behaviour and emotional difficulties. Rotation parents working excessive working hours and being too emotional and exhausted were related to emotional and peer problems in children; working excessive hours was also related to worse hyperactivity in children whereas parental tiredness and sleep disruption were associated with conduct and emotional problems among children (312). Similarly, poor parental emotional adaptation, parental weekly working hours and perceived effect of rotation work lifestyle on family were found to predict children's behaviour and emotional problems (132). Parental presence (which is limited by rotation work intermittent presence and absence) was established to be related to adolescents' behavioural and emotional problems (132) and mediated the negative effect of working rotation on adolescents' emotional and behavioural problems (308).

Qualitative evidence on emotional and behavioural outcomes also remains unclear. Evidence from two qualitative studies suggested some children of offshore rotation workers develop emotional strain and rejection behaviours towards workers as a result of missing parents and feeling upset about the absence of a parent (305,310) and parent missing special family events (310); tended to perceive their mother as being bad towards them (305); and get annoyed seeing their mothers carry out their father's house chores (310). However, two qualitative studies reported partners of rotation workers indicated some children become independent and well-adjusted (305) and do not exhibit any serious behavioural and emotional problems (307).

5.5 Discussion

This systematic review summarises studies investigating the impact of rotation work on the psychological and physical health of the partners and children of rotation workers in the resources sector.

5.5.1 Impact of rotation work arrangement on mental health and well-being of partners

Evidence on the mental health and well-being of partners though mixed, shows a tendency towards negative impact. The inconsistencies in the findings of quantitative studies could be attributed to the methodological differences between the included studies, including differences in measurement tools used. However, several qualitative studies suggested some partners of rotation workers experience emotional strains/distress and anxiety, and social isolation and/or loneliness, particularly in the absence of workers and among young and new rotation work families. Other literature reviews have found similar results highlighting the negative impact of rotation work on the mental health of partners (7,36).

Evidence from our review is in line with the Work-Family Conflict Theory, and its focus on inter-role conflicts and the associated stress outcomes (41,180). For instance, studies in the review reported that in the absences of workers, due to their work schedules of being away from home making it incompatible to carry out their family roles, at-home partners take up new and additional domestic and parental roles increasing their demands/burden and the likelihood of work-family conflicts (41). The increases in burden in in-home demands may give rise to role pressures that interfere with the discharge of other jobs of partners and also demands/pressures from the other job may interfere with discharge of new and additional domestic and parental roles (41) and could result in stress-related outcomes such as psychological strains and depressive symptoms (180).

Evidence from our review also showed a spillover of workers' strains from work into the home domain and in turn cross over to the partner in line with the Spillover Crossover Model. For instance, studies in the current review identified that workers' job demands make workers tired and exhausted upon their return home (increasing their spillover or work-family conflict), and that impact negatively on their interaction with the family (affecting relationship quality) resulting in feelings of isolation and emotion strains among the at-home partners. It has been demonstrated that workers' high job demands increased work-family conflicts and poor relationship quality which in turn resulted in increased depressive symptoms and physical complaints among their partners (278).

The findings in the current review are also consistent with the Attachment Theory; in the absence or separation of a romantic partner, at-home partners' sense of safety may be threatened due to the unavailability of their "secure base" and "safe haven", and their need for "proximity maintenance" is diminished (281,295); causing them to experience anxiety and depression (43). The intermittent absence of partners due to rotation work suggests constant disruptions to the accustomed pattern of family life including "changes in parenting roles and responsibilities, family dynamics, and day-to-day interactions among family members" (p. 528) (36) which could cause insure attachments. Evidence suggests positive affect decreases while negative affect increases among at-home partners with insecure attachment relationships and less contact with outbound partners during temporary separations (283). Similar temporary work-related separations from romantic partners in military families are found to be associated with emotional distress, including increased anxiety, depression, loneliness, and anger in at-home partners (281,282). Furthermore, consistent separations over a long period suggesting workers may consistently not be responsive to their partners' needs and seem neglectful when away, which could make at-home partners develop *insecure-avoidant attachment* where partners exhibit emotional detachment and seem unaffected by separations or reunion (292,313). As reflected in our review, some partners particularly those with long experience of rotation work lifestyle of intermittent separations, expressed overcoming emotions, developing their capabilities, personal confidence and sense of control and empowerment in decision making and becoming more resourceful over time.

The current review findings can also be considered within the framework offered by Social Ecological Theory. At the individual level, the partner's history/long experience of rotation lifestyle and coping abilities (306) were notably highlighted to shape the experience of emotional distress. Rotation work families are often a self-selected group as those who can adapt to the lifestyle remain in the rotation employment (305). Rotation work is regarded as temporary employment for many families but those who decide to stay on may actively develop and engage in strategies that help them deal with the associated stressors (20). Interpersonal level factors such as having children and disruptions to routine and parental roles were also noted. Having children could keep at-home partners companions thus mitigating issues of social isolation and loneliness (305,306), but could also be stressful in helping them (particularly younger children) understand and deal with the rotation lifestyle of an intermittent absence of a parent (305). It can also be stressful raising children alone and taking on new parental roles such as ensuring discipline (305) and with an increased workload in the absence of the worker (307). Evidence in our review suggests that potential strategies could include the offering of training and mentoring programs on coping skills, personal development and family strengthening strategies and the provision of child care services (287) particularly to new/young rotation work families to help them adapt quickly to the demands and challenges of rotation work lifestyle.

Notable at the community level, there was a general lack of appropriate social support. Support from extended families, the community and other rotation work families are suggested to help mitigate negative stressors of rotation work (15). There are now, for example in Australia, several online support networks such as *FIFO families* that have been indicated to provide support on mental health and family issues (15,22,33). Encouraging strong social networks could provide suitable support during separations to reduce the high psychological distress among partners.

At the organisational level, work schedule, communication infrastructure (306), and the level of job risk and security (15,305) were highlighted to influence the development of psychological distress among at-home partners. Work schedules allowing for more days for recovery and reducing commuting time could allow workers to spend more time with their families (20). Improvement in communication infrastructure allows for families to regularly interact, which fosters family relationships (15,307) and alleviates the worries about partners' safety at work (305). Organisations could promote a supportive climate for families such as healthcare services, (287) and reliable and quality communication infrastructure to aid and/or improve regular communication with families to foster family connectedness when workers are away. Studies have demonstrated that the nature of partners' everyday interactions and affect see fewer changes when partners engage in longer daily conversations particularly telephone conversations during separations and suggested remote communication could enable partners' accessibility to each other and foster positive interactions (283).

There was evidence in the current review to suggest that some partners may experience poor sleep quality in the absence of rotation workers, consistent with the finding of a study among cohabitating romantic partners separated by the travelling of one partner that reported at-home partners to experience sleep problems on separation (283). Sleep is a 'shared behaviour' in which sleeping together with a partner could provide one with a sense of security, comfort and the sharing of assurances (314), and as such, the absence of rotation workers could impact negatively the sleep of their partners. According to the Attachment Theory, inconsistent or neglectful caregiving, which could result from the intermittent absence of rotation workers from home, creates insecure attachment (292,293). Studies have demonstrated partners with insecure attachment (particularly highly anxious partners) tend to have poorer sleep quality (283,313,315) as they worry over the emotional inaccessibility and responsiveness of attachment figures (315). Furthermore, in the absence of rotation workers, partners are also engaged in multiple roles and the stresses from these roles could contribute to sleep disturbances: Wilson *et al* (34) reported partners indicated 'stress of work and children prevented them from taking a nap or getting enough sleep. This is in line with the Work-Family Conflict Theory, where high demands increase the likelihood of partners' work-family conflict which has been demonstrated to be associated with poor sleep outcomes (290,316–318).

The review findings also suggest perceived good physical health among at-home partners of rotation workers. However, there are too few studies (which relied on self-rated physical health on single items) to justify overall conclusions about the physical health of partners of rotation workers. This emphasises the necessity for more robust research to explore the physical health of partners of rotation workers as, in the absence of workers partners' job demands increase and in turn experience work-family conflict which has been indicated to be associated with poor physical health (180).

The review suggests the level of alcohol consumption among partners of rotation workers is similar to partners of non-rotation workers, and some partners may consume more alcohol when workers are at home (13), however studies examining alcohol consumption were few. Drinking alcohol is often a shared experience influenced by family, friends and social groups (319,320). Evidence suggests having a spouse who consumes a high level of alcohol is associated with high alcohol consumption in their partners (321,322) and rotation workers are reported to consume high levels of alcohol during off-shift days (40,171). The Attachment Theory stipulates persons are more likely to engage in exploration or 'novelty seeking' when in environments they feel safe due to the availability and responsiveness of their attachment figures (293). Further, negative emotions/distress due to the high job demands of rotation workers (40,51,114) could spillover and crossover to their partners during reunions and that could promote the high intake of alcohol as studies have demonstrated crossover negative emotions during reunions to be associated with binge drinking behaviour (323).

Limited studies examined partners' smoking, exercise and relaxation, and nutrition behaviours and again evidence is scarce to make definite conclusions. These findings suggest a need for more research looking at the effects of rotation work arrangements and workers' presence and absence, and well-being on the health-related behaviours of partners owing to their known long-term health consequences. As speculated by Rebar *et al* (13), partners in the absence of workers may have additional responsibilities limiting their time to engage in exercises or relaxation in line with the Work-Family Conflict Theory, and the increased stress in the absence of workers may increase the urges for smoking and influence eating behaviour.

5.5.2 Impact of rotation work arrangement on mental health and well-being of children

The findings regarding rotation work's impact on the mental health of the children of rotation workers remain unclear. Children form emotional bonds with their parents, and separations from them are indicated to threaten these bonds which may lead to the experience of anxiety and depressive symptoms (43). Furthermore, parental job demands through spillover (work-family conflict) and reduced quality of relationship (crossover) could affect the well-being of their children (324). More research is therefore required to examine the influence of rotation workers' job demands and absence on the mental health of children of rotation workers and the mechanisms employed by at-home parents to mitigate the effects of workers' absence on children.

The impact of rotation work on the emotions and behaviours of children in rotation workers' families remains unclear. However, evidence from the current review supports the Spillover Crossover Model; in that rotation work demands and their consequential strains were reported to be related to the emotional and behavioural problems of children. As has been suggested, parental work demands could lead to work-family conflict which sequentially could affect parental behaviour (e.g., negative parenting), impart emotions, and family functioning (e.g., poor relationship quality), which potentially affect the well-being of children (280). For instance, parental workaholism has been found to be positively related to work-to-family conflict, which, sequentially was negatively related to their happiness, which was also negatively related to the emotional and behavioural problems of their children (280).

Evidence also supports the Attachment Theory and its focus on the impact of distressing separations and reunions. For example, studies in the current review suggest that a rotation work lifestyle can result in insecure attachment relationships between parents and children, as rotation parents may be inconsistent in responding to the needs of their children, whereby children may "show signs of emotional disengagement and withdrawal, and engage in behaviours that keep them distracted from the distress they are feeling" (p.6) (292). Children with parents working non-standard work schedules have been found to have emotional and behavioural problems at high levels (325,326), and as a result of 'worse family functioning, more parent distress and ineffective parenting' (p.403) (326).

Strategies to reduce the impact of rotation work on the emotions and behaviours of children could include decreasing parental job demands and improving their job resources to promote work-family facilitation and in turn improve parental happiness which may in turn reduce the emotional and behavioural problems of their children (280). Secondly, supporting at-home partners where there are challenges with the emotions and behaviours of their children. Positive strategies include specifying and reinforcing boundaries, regular open and significant communication; spending quality family time together during leave periods; and maintenance of family routines even in the absence of the rotation parent (33). Social support networks have also been identified to assist in the nurturing of adolescent children of rotation workers (33). These may be in line with ways of maintaining and reassuring children of the secure attachment relationships between rotation parents and children where children trust parents to be responsive to their needs when required (292). Additional studies are essential, particularly longitudinal studies to determine the long-term effect of rotation work on parental absence and presence, parental mental health and well-being and parenting strategies that influence children's behavioural and emotional problems and well-being.

5.5.3 Strength and limitations of the study

The inclusion of qualitative findings alongside quantitative studies is a strength of the current review and can support the understanding of quantitative findings by giving in-depth insights into the health outcomes of rotation workers' partners and children. This was the first review that investigated the impact of rotation work on workers' families in the global resource and related construction sectors. As rotation work becomes more popular globally, it is necessary to explore the impact of this work on the health and well-being of workers and their families.

Due to the nature of the data collected and the heterogeneity of the included studies, we could not produce a funnel plot to demonstrate the potential risk of publication bias. The findings of the review could be limited by publication bias, as only peer-review publications published in English were included; however, their quality is potentially higher than the quality of non-peer-reviewed studies. The review excluded studies focusing on family relationships, functioning or parenting, which may help explain the health of the families of workers. There were several research limitations noted in the research field. There were generally few studies examining the health outcomes and lifestyle behaviours of partners and children of rotation workers in relation to rotation work. The available cross-sectional studies were limited in making causal interpretations of the findings. There is a particularly limited number of longitudinal studies investigating health impacts in partners and children of rotation workers to understand the short-term changes and long-term health impact of rotation work and the factors that influence health outcomes. Longitudinal studies are required to give insights into how partners and children experience the health impact of intermittent absence and presence of rotation workers and how their predictors change over time.

Other limitations were small sample sizes in a number of included studies (13,33,275) which affect their statistical power and studies have generally recruited study samples through convenience sampling, which may affect the representativeness of recruited samples. A few of the included studies (15.8%) had low methodological quality which may limit the accuracy of the study findings, but such studies are relevant for inclusion into narrative reviews (82,83), particularly with fewer studies examining the outcomes of interest (82). Again, few of the studies had comparison groups and those studies were largely descriptive and did not provide standardized quantitative data required to carry out any quantitative synthesis. Further, the available data did not allow for subgroup analysis such as comparing the rotation work impact on partners with and without children, and children with different age groups. Some of the studies, particularly those that examined the impact of rotation work arrangement on the children of workers (132,307,312), obtained information based on the perceptions of rotation workers and partners which may not be reflective of the actual experiences of the children. Studies were largely from Australia where rotation work is common. This may limit the generalisation of evidence on parental work separations to other parts of the world due to contextual country-specific differences and as such more studies from other countries are required particularly from the UK, Norway, and Canada where rotation work practices are common in the resources sector.

5.5.4 Implications for policy and research

The current review identified a number of key areas for organisations employing rotation work arrangements and research to consider. Organisations wishing to promote the mental health and well-being of workers should also extend the support mechanisms to the families of the workers, as evidence suggests at-home partners and children can be negatively impacted by the intermittent presence and absence of the rotation workers, and this, in turn, can impact negatively on workers. Interventions could include the development of training and mentoring programs aimed at increasing the capacity to understand and manage the demands and challenges of rotation work lifestyles (306), and to deal with the family demands (305). Programs could also include developing partners' stress management skills and their ability to cope with the associated emotions around the intermittent presence and absence of spouses (305,306). Such programs could target partners of new/young rotation work families to support their balancing domestic and family demands in the absence of their spouses, in order to help minimise any distress among partners.

Furthermore, organisations should help facilitate improved communication strategies between workers and their partners to help in reducing the associated sense of loneliness and isolation, and the anxieties of at-home partners in dealing with family demands in the absence of rotation workers (15,305). The findings suggest that interventions could also include approaches to support at-home parents where there are challenges with the emotions and behaviours of children because of the demands of the rotation work lifestyle. Research suggests that, in general, enhancing positive parenting skills reduces child behavioural problems (327). Programs including the *"Triple P-positive parenting program"* which enhances "the knowledge, skills, and confidence of parents" "to prevent and treat social, emotional, and behavioural problems in children" (p. 339) (327) could be exploited in the rotation work parents.

Additional research is needed particularly in examining the absence and presence of workers and family demands on the mental health, physical health, sleep problems and health-related behaviours among partners of rotation workers as limited studies and mixed findings exist to understand the impact of rotation work on the families of workers. Future studies are also required in examining the parental presence and separation, and parental well-being influence on mental health and the behaviours and emotional functioning of children, and the parenting strategies that assist to alleviate the effects of workers' absence on children. Particularly, longitudinal studies with large samples are essential to explore the short and long-term health effects of rotation work on the health outcomes of partners and children of rotation workers to give insight into how partners and children of rotation workers experience health and to determine the factors that influence the health outcomes over time.

5.6 Conclusion

The impact of rotation work on the mental health and well-being of the partners and children of rotation workers though mixed, there is a tendency towards negative impacts. On days when spouses are away, partners may experience greater loneliness and poorer sleep quality. Partners may benefit from support in balancing the increased domestic and family demands, particularly when they have younger children and/or their spouses first begin rotation work jobs. Research is limited, particularly in regard to the impact on health-related behaviours and physical health outcomes.

5.7 Summary and link to other chapters

This chapter summarised the key mental and physical health outcomes and related behaviours that arose from the systematic review of the health and well-being of the families of FIFO workers. The subsequent chapters offer empirical studies to test further the inconsistencies and research gaps in the evidence among partners of FIFO workers. In the next chapter, we examined further the inconsistencies in psychological well-being and evidence on physical health status and related behaviours of partners of FIFO workers using a cross-sectional study. In the subsequent part of the thesis (Chapter 9), the within-person variability of short-term health outcomes (affective states and health behaviours), and their work-related/psychosocial factors among partners are tested using multilevel analysis. Applying multiple methods, the health (psychological well-being, physical health and related health behaviours) and their associated economic impacts among partners of FIFO workers are explored.

Chapter 6: Study five

Preface

This chapter presents the fifth study included in this thesis, published in *Community, Work & Family* and cited as:

> **Asare BY,** Kwasnicka D, Robinson S, Powell D. Health and related behaviours of partners of fly-in fly-out workers in Australia: a cross-sectional study. *Community, Work & Family.* 2022:1-20. doi: 10.1080/13668803.2022.2100741.

The content of the article presented here exactly appears as in print, but the formatting is consistent with the rest of this thesis. Having identified potential research gaps including limited rigorous studies that examined psychological well-being, physical health and related behaviours in partners of FIFO workers in the systematic review, this article assessed the psychological distress, physical health status and related behaviours, and their work-related determinants. The study highlights cross-sectional/between-persons differences in health behaviours across on and off-shift FIFO work periods and is limited in assessing the within-person differences which could be addressed in later chapters within the thesis.

Author contributions: BYA: conceptualization; methodology; investigation; data curation; formal analysis; visualization; project administration; writing—original draft preparation. SR, DP and DK assisted in conceptualization; funding acquisition; resources; supervision; writing—review & editing. The final manuscript was read and approved by all authors.

Study Five: Health and Related Behaviours of Partners of Fly-in Fly-out Workers in Australia: A Cross-sectional Study.

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Acknowledgement

We express our sincere gratitude to all partners of FIFO workers who took the time to participate and contribute to this study.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [BYA]. The data are not publicly available due to ethical restrictions and privacy issues.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethical approval and consent

The Curtin University Human Research Ethics committee provided the ethical approval for the study (Approval reference number: HRE2020-0693). All study participants provided informed consent online before taking part in the study.

Funding

The study was funded by the Aberdeen-Curtin Alliance.

6.1 Abstract

The recurrent absence of workers from home associated with Fly-In Fly-Out (FIFO) work practice, has the potential to affect the partners of the workers. This study aimed to examine the mental and physical health of partners of FIFO workers and to compare their health-related behaviours during on-and off-shift periods. A cross-sectional study was conducted among 248 partners of FIFO workers in Australia who completed an online survey between July and December 2021. Partners reported higher sleep duration (7.3±1.4hrs vs 6.4±1.3hrs, $p<.001$) and better sleep quality during off-shift nights compared to on-shift nights. About 17% of the partners were current smokers; smoking more cigarettes per day during on-shift periods than off-shift (13.1±8.2 vs 11.6±7.6, $p=.034$). A high proportion of partners (83.9%) reported alcohol consumption, with similar proportions consuming alcohol at risky levels during on-and off-shift days (69.8% vs 70.6%, $p=.500$). Partners also consumed similar and low amounts of fruits (1.6±1.1 vs 1.6±1.1 serves per day) and vegetables (2.5±1.4 vs 2.4±1.3 serves, $p=.123$) during the workers' on-and off-shift days. About two-thirds of partners (65.7%) were identified as overweight/obese and 4 in 9 of them (44.3%) engaged in less than 30 minutes of moderate to vigorous physical exercise per day during on-and off-shift days. In general, the majority of partners were classified as having good physical health status (85.1%), but 50.4% reported a high/very high risk of psychological distress. Interventions could be aimed at assisting multiple health behaviour changes and reducing psychological distress by assisting partners to adapt to and cope with the demands/stressors of FIFO lifestyles particularly in the absence of workers.

Keywords: Psychological distress, Physical health, FIFO, Rotation work, Health behaviours, Partners, Australia.

6.2 Introduction

In the last couple of decades, the mineral resources industry, particularly the mining sector, has contributed significantly to the Australian economy; bringing substantial revenue to both the government and private enterprises (11). The recent 'resource boom' in Australia has been driven by demands from Asia, notably China (5), and as a result of the upsurge in demand, the adoption of rotational work arrangements, also noted as *Fly-In Fly-Out* (FIFO), has increased (5,22). FIFO work arrangements are also common in the resources industry in other parts of the world including Scotland, Norway and Canada (40).

FIFO is a long-distance commuting arrangement (11), where workers travel to remote work areas to stay in company-provided accommodation. They work compressed shifts of extended hours (typically 12 hours) for a designated continuous number of days, before travelling back home for designated leave periods (1,21). Simply put, workers rotate between the worksites in remote/isolated locations and their homes (1,302). For example, a worker may be required to spend 14 days at a worksite followed by 14 days at home or 14 days at worksites followed by 7 days at home (or 8 days on /6 days off) (5,68).

The upsurge in the use of FIFO work schedules in the mineral resource industry has been attributed to efficiency gains and cost savings for companies. It is also seen to be an effective way to recruit staff during initial mine site construction and maintenance phases, during peak demands and for short-medium term operations in remote areas. Other reasons include the preference of workers and their families for urban residence and the inadequate social amenities in remote resource-based communities (1,11).

Besides the considerable high financial benefits associated with FIFO work (1), workers' preference for FIFO work could also be attributed to the opportunity given to expend significant periods with family and friends during days off and to separate work from domestic obligations (20,22). The efficiency and operational advantages of FIFO arrangement as a mode of employment for several companies in Australia, suggest the use of FIFO work arrangements will continue to increase in the near future (11,131). This escalating use and preference for FIFO work arrangements have raised concerns, with governmental calls for more investigations into the effect of such work arrangements on workers and their families and the design of measures to promote the health and well-being of such populations (25).

FIFO work lifestyle involves frequent separations of workers from their families over a period. Such recurrent absence of workers from home may suggest constant interruptions to the routine family life such as the domestic roles and obligations, and everyday interactions between family members (132,305). In the absence of workers, partners may have to take up extra domestic and parental obligations increasing the demands on them, and according to the *Work-Family Conflict Theory* (41), *inter-role conflict*: the demands of work and family roles interfering with the discharge of one another, can arise leading to stress-associated problems (41,180) such as psychological strains and substance abuse (180). A FIFO work lifestyle of recurrent presence and absence of workers is indicated to be synonymous to 'living two lives' (15,305) with schedules that require partners to take up diverse social responsibilities and forms of behaviours (15).

Furthermore, spending long periods apart from the family home could impact partner relationships. In line with the Attachment Theory, partner relationships require the continuing presence, accessibility, and awareness of one another to build trust and security (43,293). As such, in the absence or separation of one, the emotional bonds become vulnerable causing one or both to experience distress (43).

Several studies have examined the effects of FIFO employment on workers' health and well-being (40), and have demonstrated some negative consequences on workers. These included: a higher prevalence of psychological distress (27–29) and a higher risk of suicide

(32) among onshore FIFO workers than reported in the general populations. FIFO work can also be associated with risky lifestyle behaviours such as excessive alcohol intake, smoking and being overweight/obese (99). However, studies examining the influence of FIFO employment arrangements on the health and related lifestyle behaviours of families and FIFO partners are limited (22,63).

Available quantitative studies have reported that partners of FIFO workers have a higher prevalence of psychological distress than the overall population (7,33), higher levels of depression, anxiety and stress as compared to partners of non-FIFO workers (132), and higher levels of loneliness in the absence of workers as compared to the general population (34). In contrast, other studies found no significant differences in levels of depression, anxiety, and stress between partners of FIFO workers and partners of non-FIFO workers (131) and reported healthy psychological well-being among partners which were not influenced by rotation employee's presence or absence (328).

Some studies have reported higher levels of alcohol drinking and smoking in partners of FIFO workers than in the normal population in Australia (7,35). However, other studies suggest there is no statistical difference in alcohol intake between partners of rotation workers and partners of other types of employment and the normal population (131,132).
A systematic review of the health and well-being of partners of FIFO workers (63) indicated that available quantitative studies present inconsistent findings to understand the effects of FIFO work schedules on the health and well-being of partners of workers. Thus, more research is needed to examine the effects of FIFO work schedules on the health and well-being of partners of workers. Furthermore, there are limited studies (131,132) that have examined factors that predict the health and well-being of partners of FIFO workers. Assessing the factors that contribute to the health and well-being of families of FIFO workers could help to identify concerns for targeted interventions to support FIFO families and inform

interventions aimed at improving the health and well-being of FIFO workers and their families. The present study is a cross-sectional study that was aimed at examining the mental and physical health and lifestyle behaviours of partners of FIFO workers and identifying the sociodemographic characters and FIFO work-related characteristics that are associated with their mental and physical health outcomes.

6.3 Methods

6.3.1 Participants and recruitment

Partners of FIFO workers aged 18 years and above in Australia were recruited to take part in the study. A sample size of 199 was estimated to detect, in paired samples t-tests, a small difference (d= 0.2) between on-and off-shift days with 80% power. Also, we determine the sample likely to detect the prevalence of health outcomes based on the estimates of psychological distress. The estimate for psychological distress in the Australian population is 13% (213), but we assumed a slightly higher prevalence as we expected there may be higher distress levels in this population (132); therefore, we used an estimate of at least 21%. Cochran's sample size formula, estimating a 21% rate with 95% confidence intervals (z = 1.96) and 5% precision, generated a required sample of 255. Assuming a 10% dropout, we aimed to recruit 280 participants. Three hundred and fifteen (315) partners of FIFO workers consented to take part in the survey; 67 were excluded due to incomplete data and 248 completed the full questionnaire and their data formed part of the analysis in this study.

Recruitment into the study was done by posting the study's advertising materials in FIFO work and/or partners' support groups on the social media platform Facebook periodically from July to December 2021. Advertising materials directed interested individuals to an online participants' information sheet and consent form. Participants were asked to complete a 10-15 minute online questionnaire developed and hosted on Qualtrics XM online survey platform *(www.qualtrics.com/au/)*.

6.3.2 Data collection instrument and measures

The online questionnaire consisted of adapted measures from validated instruments and replicated previous studies (see Appendix D). Data were collected on the socio-demographic characteristics of participants (*age, sex, ethnicity, relationship status and duration, number of children, age of the youngest child, educational status, and employment status and job type*), and their partner's FIFO work characteristics (*FIFO occupational role, usual FIFO shift pattern, normal shift hours per day, number of consecutive days at work and at home, and the duration as a FIFO worker)*.

The psychological distress of participants was assessed using the validated *Kessler Psychological Distress Scale-K10* (183). K10 assesses the current level of psychological distress in the last 30 days using 10 items scored on a 5-point Likert scale of 1 *(none of the time)* to 5 *(all of the time),* with high internal consistency (α=0.93) (183). The total scores (range 0 to 50) were computed and the level of psychological distress was classified as *low (10–15), moderate (16–21), high (22–29) and very high (30–50)* (183).

The physical component (PCS) scale of the validated SF-8 Health Questionnaire (185) was used to measure the physical health status of participants in the last 4 weeks. The subscale of 4 items rated on a 5 and/or 6-point Likert scale, with retest reliability high (Cronbach's alpha =0.73), was analysed in line with the recommendations by the authors to compute a total score (0-100): with a score of 50 and above suggesting better physical quality of life (185).

Sleep duration and sleep quality were assessed using an item each adapted from the *Pittsburgh Sleep Quality Index (PSQI)* (186) and replicated in a previous study (34). Participants self-reported the hours of actual sleep they usually get at night (sleep duration) during on-and off-shift days separately using the item: *'How many hours of actual sleep do you usually get at night during your partner's on-shift days (off-shift days)?'* Sleep duration was categorised into short sleep (< 7 hrs of sleep) and long sleep (≥7 hrs of sleep) (195). Participants also self-rated their overall sleep quality typical of on-and off-shift periods separately using the item: *'How would you rate your overall sleep quality during your partner's on-shift days (off-shift days)?'* on a 4 Likert scale of *0=very good to 3=very bad* (186).

The risky use of alcohol during on-and off-shift days was assessed by completing the 3-item *Alcohol Use Disorders Identification Test-Concise (AUDIT-C)* (187). The AUDIT-C, a short validated tool, enquires about the frequency of drinking, usual quantity per day, and frequency of heavy drinking on an occasion in the past 12 months and scored on a 5-point scale (0 to 4). Participants were asked separate AUDIT-C questions for on-and off-shift days *(e.g., 'During your partner's on-shift days (off-shift days), how many standard drinks containing alcohol do you have on a typical day when drinking?'*) and total scores (range 0 to 12) was generated separately for each period. Risky alcohol use was defined as a score of ≥4 among males *(sensitivity 0.86, specificity 0.89)* and ≥3 among females *(sensitivity 0.73, specificity 0.91)* (187).

On smoking status, participants responded to whether they smoked and/or had ever smoked and were grouped into *never smoked, ex-smokers and current smokers*. Participants who were current smokers then reported the number of cigarettes usually smoked each day, separately for on-and off-shift periods using the item: *'How many cigarettes do you usually smoke per day during your partner's on-shift days (off-shift days)?'*

Physical activity during on-and off-shift days was assessed separately using the item: *'How many minutes per day do you usually do vigorous or moderate physical activities outside of work for at least 10 minutes at a time during your partner's on-shift days (off-shift days)?*' adapted from the *International Physical Activity Questionnaire-short form* (188). Engaging in at least 30 minutes of moderate-intensity or 20 minutes of vigorous-intensity physical activity per day is deemed adequate physical activity for health benefits (329). Thus, in this study, participants reporting at least 30 minutes of moderate to vigorous physical activity were classified as engaging in adequate physical activity for health benefits.

Participants reported on the typical servings of vegetable and fruit intake each day, separately for on-and off-shift days using the item: *How many servings of vegetables (fruits) do you usually eat each day during your partner's on-shift days (off-shift days)?* on an 8-point response scale *(1 serve, 2 serves, 3 serves, 4 serves, 5 serves, 6 serves or more, 7 less than one serve, 8 Don't eat fruit/vegetable)* (192). Participants' daily intake of fruits and vegetables was classified as adequate (2 or more servings of fruits and 5 or more vegetable) and inadequate (less than 2 servings of fruits and 5 vegetables) (193).

Participants' Body Mass Index (BMI) was calculated using their self-reported weight (kg) and height(m) and categorised into *underweight (BMI < 18.5)*, *normal weight (18.5–24.9)*, *overweight (25–29.9)* and *obese (BMI ≥ 30)* (194).

6.3.3 Data analysis

Descriptive statistics including means, frequencies, and proportions were done to explore the sociodemographic, FIFO-related characteristics, psychological distress, physical health, and lifestyle behaviours *(sleep, alcohol consumption, smoking, physical activity, BMI, and fruit and vegetable intake).* Appropriately, paired t-tests and McNemar's test of proportions were done to examine the difference in lifestyle behaviours during on-and off-shift days. Using multiple logistic regressions, the sociodemographic and FIFO-related characteristics factors associated with the mental and physical health status of partners were examined. Reference groups for categorical variables in the model were chosen based on the largest category for age, ethnicity, marital status, education, job, shift pattern, days spent at work and home, and FIFO duration; and the normative category for the age of the youngest child, employment status, alcohol, smoking, physical activity, BMI and shift hours (330).

$p<.05$ was set as the level of significance. The tolerance test was done to test the assumption of multi-collinearity and the Variance Inflation Factor (VIF) suggested no multi-collinearity (VIF ranging from 1.07 to 2.10). Data were analyzed using STATA version 13 (StataCorp LP, College Station, Texas, USA).

6.4 Results

6.4.1 Socio-demographic and partner's FIFO work characteristics

A total of 248 participants were included in this study. The participants were on average 36.8±8.7 years (range 19-59), with approximately 57% aged 35 years or more. Most of the participants were females (98.8%), with a Caucasian/White ethnic background (87.9%). Most of them were married (70.6%), in a relationship with FIFO workers for 5 years and more (85.4%) and had children (83.1%). The youngest child was on average 6.6±6.6 years. More of the participants had attained a bachelor's or postgraduate degree (38.3%) and had a part-time job (28.2%) or solely undertook house duties (27.8%) (Table 11).

Most of the participants indicated their partners had worked in FIFO work for 5 years and more (55.7%), worked in the maintenance/technician roles (31.9%), on rotation-mixture of day and night shifts (56.5%) or regular fixed day shifts (41.9%), and for 12 hours on average (70.1%). Additionally, most of the participants indicated workers usually spend 8-14 consecutive days at work (62.9%) and less than 8 consecutive days at home (70.2%). Table 11 presents the socio-demographic characteristics of participants and their partners' FIFO work characteristics.

Table 11. Multiple logistic regression of personal and FIFO work-related characteristics associated with psychological distress and physical health status

Parameters	Total	Very high/high psychological distress	Poor physical health
	n(%)	OR (95%CI)	OR (95%CI)
Personal characteristics			
Age in years			
<35	180(43.6)	1	1
35-44	97(39.1)	0.61(0.27-1.36)	1.14(0.34-3.80)
45+	43(17.3)	0.88(0.27-2.85)	0.93(0.14-6.03)
Ethnicity			
Caucasian/White	218(87.9)	1	1
Other	30(12.1)	0.77(0.30-1.94)	3.57(0.96-13.22)
Relationship status			
Married	175(70.6)	1	1
Civil partnership	6(2.4)	0.80(0.13-5.12)	0.42(0.01-12.02)
De-facto/co-habiting	67(27.0)	0.95(0.42-2.17)	1.80(0.56-5.73)
Relationship duration (in years)			
10+	146(58.9)	1	1
5-9	66(26.6)	0.58(0.24-1.41)	2.33(0.56-9.73)
1-4	36(14.5)	1.30(0.40-4.19)	1.16(0.19-7.16)
Age of youngest child (years)			
None	42(16.9)	1	1
<1	37(14.9)	0.20(0.06-0.68)*	2.01(0.36-11.23)
1-5	76(30.7)	0.63(0.22-1.86)	0.29(0.05-1.64)
6-11	46(18.6)	0.48(0.15-1.54)	1.72(0.33-9.05)
12-17	35(14.1)	1.05(0.32-3.51)	0.40(0.06-2.61)
18+	12(4.8)	0.45(0.08-2.39)	0.45(0.03-6.65)
Educational status			
TAFE/College	86(34.7)	1	1
Secondary education	51(20.6)	1.04(0.45-2.42)	1.37(0.44-4.28)
Bachelor degree	68(27.4)	0.48(0.21-1.10)	0.36(0.09-1.47)
Postgraduate degree	27(10.9)	0.83(0.28-2.42)	0.44(0.06-2.98)
Trade/Apprentice/Other	16(6.4)	0.76(0.28-2.52)	0.23(0.03-1.88)
Employment status			

Undertaking house duties	69(27.8)	1	1
Working full-time	59(23.8)	0.60(0.23-1.54)	0.26(0.06-1.07)
Working part-time	70(28.2)	0.66(0.28-1.55)	0.32(0.08-1.47)
Self-employed	15(6.1)	1.23(0.31-4.82)	1.40(0.20-9.81)
Student	15(6.1)	0.12(0.03-0.53)**	0.54(0.05-5.28)
Other	20(8.1)	0.34(0.10-1.22)	0.87(0.15-4.84)
Smoking status			
Non-smokers	124(50.0)	1	1
Ex-smoker	82(33.1)	1.19(0.60-2.38)	0.99(0.33-2.96)
Current smoker	42(16.9)	1.60(0.65-3.90)	2.98(0.82-10.88)
Alcohol intake			
No	40(16.1)	1	1
Yes	208(83.9)	1.12(0.50-2.53)	0.61(0.19-1.98)
Body mass index			
Normal weight	85(34.3)	1	1
Overweight	78(31.4)	1.69(0.78-3.64)	2.55(0.76-8.53)
Obese	85(34.3)	1.16(0.56-2.39)	2.57(0.79-8.32)
Physical activity			
Adequate	138(55.7)	1	1
Inadequate	110(44.3)	1.82(0.97-3.39)	0.77(0.29-2.04)
FIFO worker's work characteristics			
Partner's FIFO role			
Maintenance/Technician	79(31.9)	1	1
Management/Administration/services	17(6.9)	0.70(0.19-2.63)	0.25(0.02-3.21)
Professional	36(14.5)	1.02(0.41-2.54)	0.52(0.13-2.14)
Production	15(6.1)	1.46(0.39-5.51)	0.65(0.08-5.39)
Machinery operator and driver	46(18.6)	1.25(0.51-3.10)	0.86(0.25-2.96)
Drilling/Construction/Labourer	34(13.7)	2.26(0.81-6.32)	0.17(0.03-0.85)*
Other	21(8.5)	2.46(0.76-7.97)	0.14(0.02-1.12)
Shift pattern			
Rotation shift (mixture of day/night shift)/other	142(57.3)	1	1
Regular shift (fixed day/fixed night)	106(42.7)	0.75(0.39-1.45)	0.82(0.29-2.32)
Shift hours			
<12 hrs	18(7.3)	1	1
12+ hrs	230(92.7)	0.68(0.20-2.30)	0.60(0.09-4.11)

Consecutive days spent at work			
<8 days	25(10.1)	0.71(0.26-1.91)	0.47(0.08-2.88)
8-14 days	156(62.9)	1	1
15+ days	67(27.0)	1.39(0.59-3.25)	2.92(0.86-9.85)
Consecutive days spent at home			
<8 days	174(70.2)	1	1
8-14 days	54(21.8)	1.08(0.49-2.37)	0.74(0.22-2.50)
15+ days	20(8.0)	1.30(0.33-5.19)	0.25(0.02-3.34)
FIFO lifetime duration			
<3 yrs	84(33.9)	1	1
3-4 yrs	54(21.8)	0.85(0.35-2.09)	0.13(0.03-0.60)**
5-9 yrs	56(22.5)	1.09(0.41-2.93)	0.20(0.04-0.99)*
10+ yrs	54(21.8)	1.24(0.42-3.66)	0.20(0.03-1.25)

*p<0.05; **p<0.01

Reference category: used largest category for age, ethnicity, marital status, education, job, shift pattern, days spent at work and at home, and FIFO duration; and normative category for the age of the youngest child, employment status, alcohol, smoking, physical activity, BMI and shift hours; TAFE= Technical and Further Education

6.4.2 Lifestyle behaviours of partners during on-and off-shift FIFO work periods

Table 12 presents the lifestyle behaviours of partners during on and off-shift FIFO work periods.

Sleep duration and quality

The participants reported an average sleep duration significantly higher during off-shift days compared to on-shift days (7.3±1.4hrs vs 6.4±1.3hrs, p<.001). A significantly higher proportion of the participants reported 7 or more hours of sleep duration during off-shift than on-shift days (69.3% vs 45.6%, p<.001). Likewise, a significantly higher proportion of partners indicated their sleep quality as fairly good or very good during off-shift as compared to on-shift days (73.0% vs 54.8%, p<.001).

Smoking and alcohol intake

Seventeen per cent of the participants indicated to be current smokers; smoking on average more cigarettes per day during on-shift days than on off-shift days (13.1±8.2 vs 11.6±7.6, p=.034). A high proportion of participants (83.9%) reported consuming alcohol in the last month before the survey. Similar proportions of participants were found to consume alcohol at risky levels during on- and off-shift days (69.8% vs 70.6%, p=.500).

Fruits and vegetable intake

With regards to fruits and vegetable consumption, partners indicated consuming 2.5±1.4 serves of vegetables per day during on-shift periods and 2.4±1.3 serves during off-shift days (p=0.123). Similar proportions of them reported consuming the recommended 5 or more serves per day during on-and off-shift days (7.3% vs 4.4%, p=.167). Likewise, at-home partners reported consuming similar amounts of fruits during the workers' on-and off-shift days (1.6±1.1 serves per day); with similar proportions consuming 2 or more serves per day during the on-and off-shift days (46.4% vs 42.7%, p=.272).

Physical activity and Body Mass Index

The same proportion of partners undertook moderate-to-vigorous physical activity of at least 30 minutes (55.7%) or less (44.3%) per day during the on-and off-shift days. The overall average BMI reported by partners was 28.8±6.5Kg/m^2 and 31.4% classified as overweight and 34.3% as obese.

Table 12. Health status and lifestyle behaviours of partners of FIFO workers

Health indicators	On-shift days	Off-shift days	Test statistics	*p*-value
Sleep duration	6.4±1.3hrs	7.3±1.4hrs	-7.8614	**<0.001**[ᵑ]
<7 hrs	135(54.4)	76(30.7)	33.80	**<0.001**[¥]
7+ hrs	113(45.6)	172(69.3)		
Sleep quality				**<0.001**[¥]
Fairly good/very good	136(54.8)	181(73.0)	21.32	
Fairly bad/very bad	112(45.2)	67(27.0)		
Alcohol intake				
Non-risky	75(30.2)	73(29.4)	2.00	0.500[¥]
Risky	173(69.8)	175(70.6)		
Smoking	*n(%)*			
Non-smokers	124(50.0)			
Current smokers	42(16.9)			
Ex-smokers	82(33.1)			
Number of cigarettes smoked per day	13.1±8.2	11.6±7.6	2.2000	**0.034**[ᵑ]
Vegetable intake (serves per day)	2.5±1.4	2.4±1.3	1.5463	0.123[ᵑ]
<5 serves	230(92.7)	237(95.6)	2.58	0.167[¥]
5+ serves	18(7.3)	11(4.4)		
Fruits intake (serves per day)	1.6±1.1	1.6±1.1	0.8111	0.418[ᵑ]
<2 serves	133(53.6)	142(57.3)	1.53	0.272[¥]
2+ serves	115(46.4)	106(42.7)		
Moderate/vigorous physical activities (mins)	32.6±33.9	32.2±31.6		0.869[ᵑ]
Inadequate	110(44.3)	110(44.3)	0.00	1.000[¥]
Adequate	138(55.7)	138(55.7)		
Body mass index	*n(%)*			
Underweight	2(0.8)			
Normal/healthy weight	83(33.5)			
Overweight	78(31.4)			
Obese	85(34.3)			
Physical health status				
Poor	37(14.9)			
Good	211(85.1)			
Psychological distress				
Low risk	71(28.6)			
Moderate risk	52(21.0)			
High risk	76(30.6)			
Very high risk	49(19.8)			

[ᵑ]p value from paired t-test; [¥]Exact McNemar significance probability; Bold significant at p<0.05

6.4.3 Physical health and psychological distress

The physical health and psychological distress of partners are outlined in Table 12. The majority of the partners were classified as having good physical health (85.1%). A combined 50.4% of partners reported a high (30.6%) or very high (19.8%) risk of psychological distress.

6.4.4 Personal and FIFO work-related characteristics associated with physical health and psychological distress

The results of multiple logistic regression are outlined in Table 11. The results showed participants whose partners worked in drilling/construction/labourer roles compared to working in maintenance/technician roles (OR= 0.17, 95%CI= 0.03-0.85) and had worked in FIFO arrangements for 3 to 5 years (OR= 0.13, 95%CI= 0.03-0.60) and 5-9 years (OR= 0.20, 95%CI= 0.04-0.99) compared to less than 3 years had reduced odds of experiencing poor physical health.

The odds of experiencing high to very high psychological distress were lower among partners who had children aged less than 1 year compared to those without children (OR= 0.20; 95%CI= 0.06-0.68) and those who were students compared to partners who solely undertake housework (OR= 0.12; 95%CI= 0.03-0.53). There were no significant associations between FIFO work-related characteristics and psychological distress (Table 11).

6.5 Discussion

6.5.1 Main findings

This study aimed to examine the mental and physical health and lifestyle behaviours of partners of FIFO workers in Australia. Partners of FIFO workers reported shorter sleep duration, poorer sleep quality and smoking more cigarettes during workers' on-shift days. Partners of FIFO workers consumed fewer fruits and vegetables, engaged in inadequate moderate-to-vigorous physical activities and drank alcohol at risky levels across on-and off-shift periods. A high proportion of partners reported good physical health status, but the risk of psychological distress was high among partners.

6.5.2 Sleep and lifestyle behaviours

The study found sleep duration during off-shift days to be higher than during on-shift days. Furthermore, study results found that sleep duration during on-shift days (6.4±1.3hrs) was shorter than the suggested 7 or more hours a night (195). These findings are in contrast to an earlier study, which reported no differences in partners' sleep durations during on-and off-shift days but reported an average sleep duration of 6.9±1.6 hrs among partners when workers are away at work so comparably low as reported in our study (34).

The study found more partners during on-shift days experienced poorer sleep quality than during off-shift days. This finding is consistent with the findings of prior research, which found that sleep quality was poorer during workers' on-shift periods (13,34). In the absence of workers, partners take up additional and multiple household roles (15,305) increasing the demands on them, leading to inter-role conflicts (41), which is indicated to be associated with short sleep duration and poorer sleep quality (318,331). Additionally, the absence of workers from home may impact the partners' sense of security, comfort and shared assurances that could be provided by sleeping together with the partner (314).

The study found about 17% of partners were current smokers, this is similar to another study (35). This rate is higher than the 10.4% reported among females and 11.2% reported among adults in the Australian overall populace (332). Again, partners smoked more cigarettes per day during FIFO workers' on-shift days than on off-shift days, which is in line with the findings of a daily study in Australia (13). High stress is indicated to be an important factor contributing to smoking (200,333), particularly in females (333). The partners of FIFO workers, most of whom were female in our study, are indicated to experience increased stress (profound in the absence of workers), for instance, from the recurrent adjustment to the presence and absence of workers, which comes with changes to roles and disruption to lifestyles (15,302,305). These stressors could potentially increase the urge to smoke cigarettes among partners (13) and may explain why smoking prevalence is higher in partners of FIFO workers than in the overall populace and partners smoke more during on-shift days. The daily cigarettes smoked during on-and off-shift days were on average comparable to the rates reported for adult females and the general smoking population in Australia (12.9 cigarettes per day) (332).

Our study also found high proportions of partners (83.9%) consume alcohol in the last month, and that is comparable to the 85.9% previously documented among partners of FIFO workers (35). The use of alcohol is reportedly high in the general Australian population, where about 77% of the population aged 14 and above report drinking at least a serving of alcohol in the last 1 year (201). Furthermore, a high proportion of partners consumed alcohol at risky levels during on-shift days (69.8%) and off-shift days (70.6%), higher than rates reported for drinking at long-term risk (16.8%) and short-term risk (25%) in the overall Australian populace (201). A previous study has documented similar findings of higher proportions of partners of FIFO workers consuming alcohol at long-term (37.8% vs 10.3%) and short-term (32.9% vs 17.5%) risk levels compared to population norm (7). FIFO workers also consume alcohol at higher levels than the general population (7,132) and other workgroups (99). With alcohol drinking often indicated as a social experience (319), and the level of alcohol consumption in partners documented to be associated with that of their spouses (322), may account for the high levels of alcohol consumption observed among partners in our study.

Furthermore, the levels of consumption of alcohol during on- and off-shift days were similar. This contradicts the findings of a daily study, which found that partners consume more alcohol when workers are at home (13). The observed differences could be attributed to the difference in measurements and study designs where the previous study employed longitudinal daily assessments as compared to the snapshot assessment employed in our study. The findings of high levels of smoking and alcohol consumption in our study suggest the need for interventions aimed at addressing smoking and alcohol consumption in workers to be extended to their families who are also affected by the stressors of FIFO lifestyles.

Our study found the average serves of fruit and vegetable intake among at-home partners were below the recommended daily requirements of 2 or more serves of fruits and 5 or more serves of vegetable intake per day (193). The proportions of partners found to meet the daily requirement of fruit intake during on-shift (46.4%) and off-shift (42.7%) days were lesser than the 51.3% found in the overall adult Australian population (193). Concerning vegetable intake, a lower proportion of partners during off-shift days (4.4%) met daily requirements than the reported 7.5% in the overall Australian populace (193). A previous daily study has found FIFO families (workers and partners) to consume food of limited nutritional quality (13). It has been suggested that increased stress from the demands of the FIFO lifestyle may limit the choices and prioritisation of healthy food among FIFO families (13), as an increase in stress promotes the intake of unhealthy foods while reducing the intake of healthy foods (207). Future studies could also explore unhealthy eating and the quality/regularity of meal during worker's on-and off-shift periods.

The study also found partners to engage in physical activity for on average more than 30 minutes per day, but 4 in 9 partners engaged in moderate-to-vigorous physical activity lasting for less than 30 minutes per day during the on-and off-shift days. A previous daily study has also found FIFO families engage in an average of more than 30 minutes of exercise per day with very much day-to-day variation (13). The increase in demands of FIFO lifestyles on partners (15) has been suggested to limit the time needed for leisure-time physical activities, particularly when workers are away at work (13). However, we found no difference in the average minutes spent or the proportion of partners who participate in moderate-to-vigorous physical activity for not less than 30 minutes per day during the on-and off-shift days. Likewise, the intake of fruit and vegetable was similar during on-and off-shift days. These findings contradict the findings of a previous daily study where partners reported less exercise time and poorer nutrition quality during on-shift days than off-shift days (13). The differences seen may well be ascribed to the variances in measurements and designs between the previous longitudinal daily assessments and our snapshot cross-sectional study.

This study found about two-thirds of participating partners (65.7%) were overweight or obese. Comparable findings have been reported among the general adult Australian population where 67% of the population were overweight or obese (194). The rates of overweight and obesity are generally increasingly high in the adult population in Australia (334,335). In Australia, high BMI is indicated as the second prominent contributing factor of disease burden (336) and is associated with increased risk of non-infectious diseases, such as cardiovascular diseases (211) and productivity losses (337). Our study findings, therefore, emphasise the need for continuous efforts in addressing the high overweight and obesity rates in FIFO workers' partners and the overall Australian populace. Particularly in FIFO partners, efforts could be geared toward assisting them to adapt to and cope well with the demands/stressors of FIFO lifestyles to reduce stress and encourage increased consumption of fruits and vegetables and uptake of regular physical activity (211).

6.5.3 Physical Health and Psychological Distress

The study found a high proportion of partners (85.1%) were classified as having good physical health status. Similarly, a previous daily study has found the daily intake of medication for physical health impairments among partners as rare (13). Another study has also found partners of rotation off-shore workers to report similar physical health status as partners of non-rotation on-shore workers (304). Most FIFO families are suggested to be self-selected people who choose and remain in FIFO work, and as such tend to develop resilience and strive to deal with the stresses and challenges of FIFO work (131,305).

However, this study has showed that more partners experience psychological distress (50.4%) at levels higher than reported among females (14.5%) and the general (13.0%) population in Australia (213). This finding is comparable to that of a previous study, which found a higher prevalence of high psychological distress among partners than in the general population (33). Another study has also documented higher levels of depression, anxiety, and stress among partners than in partners of non-FIFO workers (132). Qualitative studies have highlighted the increased demands from the additional and multiples roles in the absence of the FIFO workers (15,305) and the emotional demands of and the difficulty adjusting to recurrent ‘partings and reunions’ (305) as some of the stressors that increase distress among partners. The increasing demands on partners may result in *inter-role conflicts* (41), which are indicated to give rise to stress-related outcomes (41,180) including psychological strains and depressive symptoms (180). Again, partners are frequently separated from their romantic partners over a period and in line with the Attachment Theory, such separations threaten the attachments or the emotional bonds between the partners, which foster trust and a sense of security, leading to the experiences of distress (43).

It should also be noted that the ongoing COVID-19 pandemic and associated social/travel restrictions have impacted negatively lifestyle behaviours (217,338) and contributed to a widespread increase in psychological distress in the general population (218,339). This could also contribute to the observed high prevalence of psychological distress and risky lifestyle behaviours in at-home partners. In Australia, several FIFO workers travel interstate and abroad for work (33) and COVID-19 restrictions, border closures and quarantines across the states have resulted in some FIFO workers being separated from their families for a prolonged period.

The study found partners who worked in construction/labourer roles compared to those working in maintenance/technician roles were less likely to report poor physical health. A study has found construction workers in Australia to have better physical health and suggested this to be attributed to their younger age (340). It has been indicated that the strains experienced by FIFO workers could also affect the physical well-being of their spouses (305). The study results also revealed poor physical health was less likely in participants whose partners had worked in FIFO arrangements for 3 to 9 years compared to those working for less than 3 years. It has been established the longer the duration workers spend in FIFO work arrangements the more their partners develop strategies to adapt to the physical and emotional demands of the FIFO lifestyle (305).

Partners who were students were less likely to report higher psychological distress compared to partners who solely undertook house duties. Strategies including being in employment and increasing social interactions have been highlighted to help partners cope with loneliness and distress in the absence of the worker (305). Being employed outside of the home and/or being a student may promote positive social interactions and help partners, particularly those without much domestic roles like demands of childcare, mitigate the experiences of stress in the absence of the worker, thus, helping promote their health and well-being. The odds of experiencing high psychological distress were lower among partners who had children aged less than 1 year compared to those without children. Having children at home has been indicated to keep partners occupied and assist to overcome loneliness and distress in the absence of their worker partners (305,306). However, qualitative studies have highlighted the difficulties and distress of childcare and having to raise children alone in the absence of workers (15,307). Another study has indicated that some partners without children get the chance to engage in increased social interactions in the absence of the workers (302).

Further studies are needed to explore the impact of children on the health and well-being of partners of FIFO workers.

The study found no significant associations between FIFO work characteristics and psychological distress. Another study has also found work-related characteristics such as FIFO job roles not to be associated with perceived stress in partners (131). However, other studies highlighted FIFO work-related factors including job type, roster/shift pattern, shift length and work hours per week to influence the well-being of partners (328) and determine the behavioural problems of their children (132). Additional studies are needed with larger sample sizes to further examine the influence of FIFO work characteristics on the health and well-being of partners of FIFO workers.

6.5.4 Strength and limitations

This study contributes to the limited literature examining the health and lifestyle behaviours of partners of FIFO workers during the on-and off-shift periods and factors associated with these health outcomes.

The study's limitations include the use of a cross-sectional design and self-reported health outcomes and related behaviours data, which could be under-or over-estimated. The study is also limited by the larger incompletion (dropout) rate than was expected. This reduced the precision of our estimated rates of health outcomes. Nonetheless, the sample size estimated to detect small differences between on- and off-shift at a power of 80% was exceeded. There are usually higher dropout rates with online surveys, where participants have indicated they may be more easily distracted and the relative anonymity of the researcher may lead to a higher risk of dropout (220). Furthermore, the study used snowballing procedures in engaging study participants, which may present samples not typical of the FIFO partners' population and self-selection bias where the partners who were either positively or negatively affected by the FIFO lifestyle may select to take part or not to take part in the study. The study sample of more Caucasian/White, female and being educated reflects that of previous studies (7,33). The study involved only partners with comparisons of health outcomes and related behaviours made to Australian norms secondary data; assessing partners of workers on standard work schedules may enable for more direct evaluations of the differences in the groups. The measure of roster as number of days spent at home and on-site separately is limited in capturing what makes a roster in each instance as could be done via roster types or roster ratio.

6.6 Conclusions

The partners of FIFO workers showed short sleep duration and poorer sleep quality when workers were on-shift. The study also found that partners of FIFO workers smoked more, drank more alcohol and at risky levels, consumed fewer fruits and vegetables, and engaged in less than 30 minutes of moderate-to-vigorous physical activity as compared to recommended guidelines and the general Australian population. Apart from sleep and smoking, there were no significant differences in partners' lifestyle behaviours found during the on-and off-shift days of the workers' roster cycle. This study has found that a high proportion of partners had good physical health status, but levels of psychological distress were significantly higher than the Australian population norms. Higher drinking and smoking in partners could be a potential coping mechanism connected with the higher psychological distress. No FIFO work-related characteristics were found to be associated with the partners' physical health and psychological distress.

Interventions could be aimed at assisting multiple health behaviour changes and reducing psychological distress by assisting partners to adapt to and cope with the demands/stressors of FIFO lifestyles, particularly in the absence of workers. Further studies should explore how behaviour change interventions can positively impact on health and well-being of partners of FIFO workers and their families. To understand the changing nature of

FIFO work, further studies also need to investigate how day-to-day fluctuations in psychological and contextual variables change over time and how to best implement just-in-time adaptive interventions that can support FIFO workers and their partners. Just-in-time adaptive interventions give the appropriate (kind and amount) support at the right moment by responding to changing conditions and context of an individual (341).

6.7 Summary and link to other chapters

This chapter has presented a snapshot of the psychological distress, physical health status and related behaviours of partners of FIFO workers over the on-and off-shift days, and their work-related determinants. The next part of the research involved the use of Ecological Momentary Assessment (EMA) design (longitudinal studies) to examine the within-persons processes in FIFO health outcomes; addressing the limitations associated with the cross-sectional study design. The subsequent chapters summarise the common EMA methods in FIFO health research (Chapter 7) and detail the within-person variability of the psychological states and health-related behaviours over the on-and off-shift days tested using multilevel analysis among workers (Chapter 8) and partners (Chapter 9).

PART THREE: EMA/daily studies

Chapter 7: Study Six

Preface

This chapter presents a published study in *Safety and Health at Work* and the sixth study included in this thesis and cited as follows:

> **Asare BY**, Robinson S, Kwasnicka D, Powell D. Application of Ecological Momentary Assessment in studies with rotation workers in the resources and related construction sectors: A systematic review. Safety and Health at Work. 2023;14(1):10-16. doi: 10.1016/j.shaw.2022.10.004.

The paper's content here is as it appears in print, however, it has been formatted to be in keeping with the rest of this thesis. This was an important step in informing the subsequent chapters 8 and 9 of the thesis, to identify key EMA methods employed in assessing the health outcomes and related behaviours in the FIFO work population. It also served to highlight relevant EMA designs and recommendations on reporting EMA studies that could be explored in the FIFO context and in the subsequent chapters.

Author contributions: BYA, DK, SR and DP conceived and designed the study protocol. BA developed the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment and drafted the initial manuscript. DK, SR and DP reviewed and contributed to the initial question development, search strategy, study selection criteria, study reviewing, summary and assessment. BYA drafted the article and DK, SR and DP have reviewed and approved the final written manuscript.

Study Six: Application of Ecological Momentary Assessment in studies with Rotation workers in the resources and related construction sectors: a systematic review

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Acknowledgements

The authors extend their sincere gratitude to Ms Diana Blackwood and Ms Vanessa Varis, Librarian for Faculty of Health Sciences, at Curtin University for their professional assistance in developing the review search strategy.

Competing interests

None declared

Funding

The study was funded by Aberdeen- Curtin Alliance.

7.1 Abstract

Whilst Ecological Momentary Assessment (EMA) can provide important insights over time and across contexts among rotation workers whose work periods alternate with leave at home, it can also be challenging to implement in the resources and construction sectors. This review aimed to provide a summary of the methodological characteristics of EMA studies assessing health outcomes and related behaviours in rotation workers. Systematic searches in PubMed, Medline, EMBASE, CINAHL, PsycINFO, and Scopus were done to include 23 studies using EMA methods in assessing health-related outcomes and behaviours. EMA designs included daily diary: assessments once per day typically fixed at the end of the day (47.8%), within day fixed interval time-based design: assessments on multiple times per day at certain times of day (17.4%), and a combination of both designs (34.8%). Studies employed paper and pencil diaries (73.9%) and one or more electronic methods (60.9%): wrist-worn Actigraphy device (52.2%) and online-based diaries (26.1%) for data collection. Most of the studies (91.3%) did not report prompting EMAs by schedule alerts or compliance. Daily diary and within-day fixed interval dairies designs are common, with increasing use of electronic EMA delivery techniques. It is unclear how well participants adhere to assessment schedules, as these are inadequately reported. Researchers should report compliance-related information.

Keywords: ecological momentary assessment, rotation work, FIFO, offshore oil and gas, mining, systematic review.

7.2 Introduction

Rotation work arrangements have become the standard model in the resources sector (21). Rotation work, also known commonly as *Fly-In Fly-Out* (FIFO), involves workers travelling to remote areas, being accommodated and provided with food to work for a specified number of days and to return home to spend another fixed number of days (21).

Rotation work has some benefits both for the companies (e.g., by reducing the cost of establishing and operating mine sites) and workers (e.g., higher wages and extensive leave periods to spend time with family and friends) (21). However, there are some concerns that rotation work may be associated with poorer health outcomes, such as higher psychological distress (29), sleep and fatigue problems (40), and health-related behavioural problems such as higher alcohol consumption and smoking (99).

Rotation workers' lifestyles are characterised by distinct contexts and routines during on-shift and off-shift days (15). For instance, during on-shift days, rotation workers work long hours, live and work in remote areas far away from their families and social networks, usually without their domestic or family obligations (15). On off-shift days, workers are free from work commitments but take up their family roles (15). Requirements of this distinct lifestyle make workers take up "different social roles and patterns of behaviour" (p3) (15). Studies that employ methods that examine within-person processes across time and everyday life contexts of rotation workers are needed. Ecological Momentary Assessment (EMA) studies can demonstrate important insight into the daily life of rotation workers, how they experience various health variables day-to-day, and what features of their working lives predict such variability. EMA provides the opportunity to examine how outcomes and predictors vary and covary within-persons, over time and across contexts, as people go about their usual daily activities (13,342) and has the potential to assess the health outcomes and experiences of rotation workers with precision. The advantages of EMA methods over the traditional research methods include reduced self-report bias as recent/current states are assessed, greater ecological validity as assessments are done in subjects' natural environment, and the repeated assessments assist in understanding variations of experiences and behaviours over time and across settings (342). With the advancement in mobile technologies, EMA has become a flexible research design with various options for the scheduling of assessments, including assessments that are event-contingent (e.g., individuals reporting as and when they experience an event such as pain), time-contingent (fixed, random, or quasi-random) (e.g., individuals signalled at particular time intervals in the day to report on the number of standard drinks consumed) (342,343) or, in the case of wearable sensors (e.g., accelerometry), assessments may be continuous and reliant only on wear time.

As technological capabilities increase to observe behaviours and other phenomena in daily life, opportunities to carry out EMA studies with rotation workers are also likely to increase. Available EMA studies provide a useful insight into rotation workers' lives (e.g., (13,87,98,165,344)), as the suitability of the EMA methodology allows us to monitor the workers as they are on and off shifts in their 'natural work settings'. Despite the advantages of EMA methods, there are some challenges; including the burden on participants (345), participants' compliance to study protocol and missing data (346), low sample sizes (347), and can be expensive (347), all of which may make it difficult to implement in some populations. As such, considerations about the suitability of different EMA study design choices become necessary (342) to make informed decisions.

In many ways, rotation work in the resources sector is unique and may present challenges for the application of EMA methods, such as multiple and randomised time-based assessments. Rotation workers typically have a routine day of daily alcohol and random drug testing, working compressed day and night shifts of a standard of continuous 12 hours starting and ending at pre-specified times, with short snacks and fatigue breaks: a work schedule that interferes with regular behaviours/activities including eating, sleeping, and social interactions (7). Rotation workers also may operate heavy machinery, and work in noisy and critical safety environments, which require specified or prescribed and standardized safety apparel (personal protective equipment) all the time, with full attention on tasks and potentially limited access to personal or other mobile devices with internet connections to which EMA studies may be deployed (348).

There is therefore the need to understand how to best utilise this method to learn about this population, design comprehensive studies that allow us to make conclusions about health, and design just-in-time adaptive interventions that support workers' health when they are at work and home. EMA approaches to assessing the health outcomes in rotation workers have not been comprehensively assessed. Considering that the use of EMA is comparatively a new approach for examining the health outcomes among shift and rotation workers, concerted efforts are required to improve the key aspects of EMA studies and methods so that their use could be consistent and replicated in rotation work and other settings. In this review we aim, to provide a summary of the methodological characteristics of EMA studies [e.g., EMA design/strategy and assessment schedules (design, monitoring period, study duration), sampling and measures, EMA delivery method - technology and administration (data collection methods), response and protocol compliance, and data analysis plan] assessing health outcomes and related health behaviours in resource and construction industry rotation workers. These methodological characteristics are critical considerations in the implementation of EMA studies and the documentation of such features will permit better evaluation of EMA studies and their findings, and the appropriateness of the different methods/procedures applied in assessing particular phenomena and study populations (349). For instance, a previous review found the use of paper-and-pencil and fixed-schedule designs as most common in assessing the psychological and behavioural experiences in older adult populations (350). Another systematic review also found a wide variability in EMA designs employed in assessing diet and physical activity among a youth population, with studies employing both paper-and-pencil and electronic EMA designs and mostly interval-contingent prompting strategy (351).

Furthermore, a previous review assessing the compliance to mobile-EMA protocols has suggested that the EMA study design use may affect compliance in a youth population in different settings (352). It is also suggested that the findings of EMA studies could be misinterpreted if the key aspects of the EMA design employed and participant compliance are not provided, and as such recommended for a more consistent EMA reporting (351). The learnings from this review about the implementation of EMA in rotation workers in the resource and construction industry will guide future EMA studies and are potentially transferable to other worker populations engaging in shift and rotation work.

7.3 Method

7.3.1 Eligibility criteria

Studies were included if 1) original articles were published in peer-reviewed journals and in English; 2) participants were rotation workers and worked in the resource (offshore oil and gas, and mining) and construction industry; 3) studies employed EMA designs, including event-or signal-time based sampling, continuous assessment, and daily surveys; 4) used EMA-based techniques including any electronic, wearable, or mobile technology (such as cell/smart-phones, handheld devices, PDAs); website/online diaries/surveys and paper-based diaries/surveys for data collection; and 5) assessed mental health and physical health outcomes, sleep problems (sleep duration and quality, sleepiness and fatigue), or health-related behaviours including alcohol intake, smoking and drug use, diet and physical activity, measured via EMAs and continuous assessments.

Studies were excluded if 1) they were reviews, letters, or editorials; 2) EMA designs and strategies were not clearly defined; 3) there were no repeated measures and/or variable collected momentary or diary data once in less intensive frequency than weekly intervals during the study period; 4) data collection was done in a laboratory setting or not in participants' real-life natural living environment; and 5) they reported on adaption and re-adaption of circadian rhythm to shift patterns measured by cortisol concentration and *6-sulphatoxymelatonin acrophase*.

7.3.2 Literature sources and search strategy

Literature searches were conducted in the databases: PubMed, Medline, EMBASE, CINAHL with Full Text, PsycINFO, PsycArticles, and Scopus for relevant articles on 1st May 2020 as part of a bigger review (40) assessing rotation workers' health in the resource industry [pre-registered on PROSPERO (ID=CRD42020167649)] and updated on 21st April 2021. The search strategy comprised terms linked to health and FIFO work, with no restrictions on study design, publication dates and geographic location but restricted to peer-reviewed articles and those published in English language set (40). An additional hand search of the references of the included studies was also done for other relevant studies.

7.3.3 Study screening and selection process

Two reviewers, BYAA and DK, independently screened the titles/abstracts and later full text of articles for eligibility and inclusion into the review, and any inconsistencies in the selection were discussed and resolved by consensus. The systematic review of the literature was reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (298); the detailed study selection process is presented in Figure S3 (Appendix G: Supplementary Information S10).

7.3.4 Data extraction and data items

Data were extracted using a data extraction sheet developed according to the Checklist for Reporting EMA Studies (CREMAS) (351) and other reporting guidelines (349). The key information extracted included study authors, publication year, study design, aims/objectives, study setting (country and industry) and participants (sample size, age), and health outcomes. We also extracted the main EMA methodological characteristics including EMA design/prompting strategies (event-or signal-based contingent), method/technology used for data collection, monitoring period (number of data collection waves), study duration, prompt frequency, protocol compliance, measures used to assess outcome under study (number of items used and validity), and data analysis (model type). Data extraction was done by one reviewer (BYAA) and another (DK) double-checked 10% of the data, and the cases of inconsistencies were resolved through the discussions.

7.3.5 Data synthesis

Data extracted were descriptive and were presented in tables based on study characteristics (author/year, setting/country, sample size, analytical sample, age, study type, outcomes, predictors) and EMA methods features (EMA design/approach, method for EMAs delivery, monitoring periods/Study duration, compliance rate/compliance enhancer, assessment frequency, assessment period, outcomes measures and analysis method). Data were narratively synthesized under the following areas: characteristics of studies, sampling and measures, EMA design/strategy and assessment schedules, EMA delivery method-technology and administration, response and compliance, and analytical methods.

7.4 Results

7.4.1 Study selection

The searches retrieved 6978 records and after removing duplicates, 86 studies were screened at full text for eligibility. Twenty-three (23) studies were included in the review (Figure S3).

7.4.2 Characteristics of studies

The included studies were published between 1998 and 2021 and conducted in the United Kingdom (n=6; 26.1%), Australia (n=6; 26.1%), Norway (n=5; 21.7%), the Netherlands (n=4; 17.4%), Thailand (n=1; 4.3%) and Iran (n=1; 4.3%). The majority of studies (*n* = 17) recruited participants from the oil and gas workers, 4 from mining workers and 1 each with FIFO workers (predominately mining workers) and construction rotation workers. The characteristics of the included studies are summarised in Table S11 (Appendix G: Supplementary Information S11).

7.4.3 Sampling and measures

The average number of participants recruited per study was 54.0±31.7 (range 7-111) and included an average analytical sample of 34.7±17.6 (range 6-64). The mean age of study participants was 41.2±3.0 years (range 35.9-47.5). One of the studies did not report the mean age of participants (51).

Of the 23 studies, 19 (82.6%) studies assessed sleep and fatigue (13,52,53,85–87,98,140–144,146,156,165,344,353–355), three (13%) assessed mental health outcomes (13,51,144) including emotional exhaustion and engagement (51), depression and anxiety (144); five (21.7%) assessed health-related behaviours including exercise/physical activity and relaxation (13,98,139,344), alcohol intake (13,98,356), smoking (13,356) and eating behaviour (13); and one (4.3%) measured physical health status (13). All included studies used self-reported measures to assess outcomes; 14 studies (52,53,85–87,140–

142,156,165,344,355) combined self-reported EMAs with additional objective measurements. The number of self-reported items used was dependent on the outcome being measured; for instance, sleepiness or fatigue were mostly assessed using a single item whereas sleep outcomes were mostly assessed using questionnaires with multiple items.

7.4.4 EMA design/strategy and assessment schedules

All included studies used a regular timed-based approach: daily diary design *(assessment once per day typically at the end of the day)* (n=11; 47.8%) (13,51,52,139–144,146,356), within day fixed-interval diaries design *(assessments on multiple times per day at certain times of day)* (n=4;17.4%) (85–87,344), and eight (34.8%) studies combined daily diary design with within day fixed interval diaries design (53,98,156,165,353–355,357) (Table S12) (Appendix G: Supplementary Information S11).

All of the included studies assessed an outcome at regular interval schedules; 19 (82.6%) studies assessed an outcome once per day (morning or evening) (13,51–53,98,139–144,146,156,354,355,357), eight (34.8%) of the studies (53,85–87,98,353) collected data twice daily (before and after work shifts or morning and evening), three (13%) studies (51,353,356) collected data once or twice daily in every 3 days, four (17.4%) studies carried out hourly assessments for one of the main study outcomes measure (sleepiness) (156,354,355,357), and 12 (52.2%) studies also combined regular interval dairy assessments with continuous monitoring for assessing sleep outcomes and physical activity (53,85–87,140–143,165,344,355).

The majority of studies (n=21; 91.3%) did not report whether or not the participants were in any way prompted (reminded) to complete assessments. Only two studies reported prompting participants using alerts via smartphones; one study sent text messages once daily to remind participants to complete their diary assessments (51) and another sent prompts but did not report their frequency (86).

The majority of studies (n=18;78.3%) monitored study participants and collected data over one monitoring period (i.e., one wave of data collection) (51–53,85–87,98,139,140,142,143,146,165,344,353,355–357). Four studies (13,141,156,354) collected data over 2 monitoring periods whereas one study (144) had 6 data collection periods/waves. Data were collected for an average of 18.1±7.5 consecutive days (range 7-28) per single wave of data collection: 7 days (3 studies), 11 days (1 study), 14 days (8 studies), 21 days (2 studies), 22 days (2 study), 28 days (6 studies). Studies with burst designs with more than one monitoring period collected data for an average of 50.4±25.4 total days (range 14-84 days). Data collection was undertaken during both on- and off-shift rotation periods in 11 studies (47.8%), on-shift only in nine studies (39.1%) and off-shift only in three studies (13%).

7.4.5 EMA delivery method - technology and administration

The majority of studies (n=17; 73.9%) used paper and pencil diaries and 14 (60.9%) studies used electronic methods: website/online based diaries (n=6; 26.1%) (13,51,85–87,344), wrist-worn device (Actigraphy) (n=12; 52.2%) (52,53,85–87,140–143,165,344,355) and hand-held device (n=4; 17.4%) (86,156,353,355). Eight of the studies used both paper and pencil diary and electronic methods: wrist-worn device (Actigraphy) (52,140–143,165) for assessing sleep outcomes and hand-held computer for assessing sleepiness/fatigue (156,165,355). Four of the studies combined two electronic methods: website/online-based diaries alongside a wrist-worn device (Actigraphy) (85–87,344) for assessing daily sleep outcomes and *reaction time tasks* delivered through an iPad to assess cognitive fatigue (86). Studies that used website/online-based diaries were delivered to participants through emails containing links to surveys (13,51,85–87).

7.4.6 Response and compliance

Compliance is defined as the percentage of scheduled assessments to which participants responded by completing the measurement (349). Participation or response rate is defined as the percentage of participants who completed the predetermined number of assessments (i.e., all scheduled assessment days) (352). Only two of the studies reported compliance rates; among these, compliance was 80.3% (139) and 87% (98) of total assessments. All the studies reported the sample size they had included in their analysis, and the response rate based on that, as a proportion of the recruited sample, ranged from 31.5-100.0% (mean = 70.3%). Three studies explicitly reported response rates of 67.8% (141), 95% (98) and a range of 66-78% across 6 waves of data collection (144). Studies that reported a response rate of less than 50% were of either daily diary design (52) or combined both daily diary and interval diary designs (165,355) and collected data over 1 monitoring period and for an average of 18 days (range 14-22 days) (52,165,355). Likewise, studies reporting a response rate of greater than 80% were either a daily diary design (13,140,142) or combined both daily diary and interval diary designs (98,353,354,357), and data collection was done over one monitoring period (98,140,142,353,357) or two waves (13,354) and for an average of 23.3 days (range 7-42 days) (13,98,140,142,353,354,357).

Sometimes, research using EMA may specify a compliance threshold (level of data completion) for inclusion in the study analysis. Most of the studies (n=18; 78.3%) did not explicitly report compliance threshold (13,52,85–87,139,140,142–144,146,165,344,353–357), while five studies reported level for data completion required for data inclusion: 100% compliance (53), at least three daily surveys (51), at least complete data for 1 week or more (141,156), and at least one day or night shift period (98). Authors in most of the studies (n=14; 60.9%) cited work arrangements, lost to follow-up, incomplete assessments, withdrawal, and personal reasons of participants such as sick/annual leaves and transfers for either non-compliance or dropout (participation) or exclusion from analysis.

Most of the studies (n=19; 82.6%) did not report on any incentives or reimbursements to study participants in return for participation that might have been given; three studies explicitly reported not giving any incentives (354,355,357) and one (5%) study (13) reported giving personalised feedback on health outcomes to interested participants as an incentive. Few studies explicitly reported the use of any other compliance-enhancing strategy, with only daily remote monitoring for completion by investigators (n=2; 10%) (85,156) and collection of paper diaries at the end of each day (n=1; 4.3%) (156) stated as methods incorporated to encourage compliance.

7.4.7 Analytical methods

Most of the studies (n=13;56.5%) aggregated data to the person-level to create a summary metric and analysed using analysis of variance (ANOVA) and/or correlation or standardised parametric regression (53,98,140–144,156,353–357). Some studies (n = 8; 34.8%) used linear mixed models or generalised linear mixed models (13,51,52,85–87,165,344) and 2 (8.7%) used generalised estimating equations (139,146).

7.5 Discussion

The main aim of this study was to systematically review and summarise EMA studies assessing several health outcomes and related behaviours in rotation workers to describe the common EMA methodological characteristics and discuss other methods that could be explored in this workgroup.

7.5.1 Sampling, EMA design/strategy, and assessment schedules

Included studies had varied and relatively low sample sizes, with an average of 54.0±31.7 (range 7-111) participants recruited per study. The power to detect within-person effects is higher in EMA studies due to a large number of repetitive data points (347), which allows studies to typically recruit fewer participants (345). Sample size is also a function of assessments, days of monitoring, etc., where studies with many assessments and longer monitoring periods may typically have low sample sizes. For instance, in the current review studies that carried out hourly assessments per day and over an average of 33 days, reported an average sample size of 20 (range 7-38). However, consequential of the burden on participants associated with EMA studies, fewer participants may also want to participate in the EMA studies, often resulting in low sample sizes compared to field surveys (347). The burden of commitment required to complete repeated/several surveys (51,355) was stipulated to affect participation and attrition of rotation workers in the included EMA studies.

All studies included in this review employed regular-interval time-based designs; daily diaries and within-day fixed interval contingent diaries. Daily diaries which are a special type of time-based design (342), involve assessments once per day typically fixed at the end of the day (345,358), whereas within-day fixed interval contingent designs involve assessments on multiple times per day at certain, usually pre-specified, times of day (345,358). The daily diary approach is easy to administer and less demanding on study participants (342,345), and within-day fixed interval signal-contingent designs are also considered less intrusive on study participants (345) than the other EMA designs; *random interval assessments*: involve multiple assessments per day at random schedules, and *event-based design*: involves assessments that are initiated by the occurrence of a predefined event of interest (342,343,345,358). Daily diary and within-day fixed time-based designs seem more appropriate for rotation workers compared to variable time schedules of random assessments and event-based assessments (342); as rotation workers in the resources sector work compressed day and night shifts of a standard of 12 hours and work schedule may not allow for multiple random assessments; workers could only be available to respond to assessments at fixed times which may coincide with their break times and/or after shift periods. Again, a daily diary design is deemed most appropriate for assessing outcomes that show no significant variation within the day (345,358), such as sleep.

Evidence from this review showed most of the studies (≈83%) employing daily diary designs examined sleep outcomes. However, daily diary designs are subjected to recall bias as they rely on recalls to capture experiences over the day and may not be representative of the subject experiences (345,358). Within-day fixed interval designs, although lessens the biasing effect of end-of-day or bed-time assessments as in daily diaries due to the short recall periods (345), could also be susceptible to measurement reactivity where participants may alter their behaviours or experiences in anticipation of assessments (345).

Evidence in this review has suggested multiple assessments within a day among offshore rotation workers could be done during work periods (at every other hour) using single-item measures (156,354,355,357) and the involvement of the participant's organisation (344). These more-intensive study designs recorded response rates of between 44.7-85.7%. Other design choices such as *random interval assessments* and *event-based design* have not yet been used in rotation workers, and it is unclear whether this is due to being unsuitable for the population in general or for the research questions selected.

Evidence from this review showed participants tended to be monitored over one wave. Possibly due to the demand of EMAs on study participants (359) coupled with the demanding nature of rotation work arrangements. However, some studies demonstrated that data collection over 2 or more waves (141,144,156,355) could be applied among rotation workers and across the on-and off-shift phases (13,85,98,143,156) of the rotation work roster. Studies in our review assessed most of the outcomes once per day but those assessing sleepiness/fatigue reported an assessment frequency of 2 or more times per day. Choosing the frequency of assessments in an EMA is guided by the level of variability of the phenomenon under study, the theoretical basis of the study and the burden on study participants (342,349).

A higher frequency of assessments per day affords better 'temporal resolution' of the phenomenon whereas assessment for several days may increase generalisability (349). However, a higher assessment frequency could increase the invasiveness of the study (359), and burden on study participants (349). Mechanisms suggested to reduce participants' burden includes the use of electronic devices in EMA (360), and/or the brevity of items of measures (349). Evidence from this review showed studies indicated using single and/or reduced items to reduce participants' burden (13,51); studies with a higher frequency of assessments within a day employed single-item measures (156,354,355,357).

Evidence in this review suggests studies' prompting schemes were generally inadequately reported. Prompting schemes are usually used in EMA studies using time-based assessment schedules to alert study participants when assessments are to be completed (342), and evidence suggests prompting participants enhances compliance even with a paper diary protocol (361). Future EMA studies among rotation workers should report on the prompting schemes used, to guide the design of subsequent studies in rotation workers.

7.5.2 EMA delivery method - technology and administration

The use of paper and pencil diaries to deploy assessments was the most common in this review. Paper and pencil dairies may be easy to implement (362). But due to the lack of time-stamped entries (362), paper and pencil diaries are limited by "hoarding" *(failure to complete assessments at the specified time but later backfills the missed data*) (345,349); and highly falsified compliance to scheduled assessments *(difference between participant's reported compliance and their objectively measured actual compliance to scheduled assessments)* (349,361). Recent studies included in the review suggested the increasing use of electronic diaries (13,51,85–87,344). Evidence in this review suggested study participants' preference for online diaries over paper and pencil diaries in onshore rotation workers (51). Compliance with using paper and pencil diaries and electronic diaries in our review was inadequately reported. However, electronic diaries have been demonstrated to produce higher participants' compliance (363) than paper and pencil diaries. The use of mobile device-assisted EMA has also been suggested to have the potential of reducing participant burden and recall bias (360).

This review found daily diaries were combined with wrist-worn ActiGraph for assessing sleep outcomes. This is consistent with a previous review that established subjective sleep ratings are most generally measured using sleep diaries, and objective sleep parameters were measured using Actigraphy (364). This finding suggests the feasibility of using wearable devices in EMA studies among the rotation work population; as ActiGraphs were worn during both working hours and off-shift periods throughout study periods.

Studies assessing sleep and sleepiness/fatigue combined both subjective and objective measurements, where in one study (85) subjective measures were used to confirm and complement missing objective assessments and in another (53) assessments were combined to determine sleep outcomes. Objective measurements could support removing the information bias associated with self-reported measurements (365). However, evidence in the current review (85) and broader literature (366) have suggested subjective measurements of sleep and sleepiness may be correlated with objective measurements.

7.5.3 Protocol compliance and analytical methods

Compliance rates were generally inadequately reported; a compliance rate of 80.3-87% (98,139) was reported for paper and pencil diaries, consistent with the rate of 80% considered to be representative of the daily lives of participants (349). Compliance with pen and paper diaries is reportedly high but limited by participants reporting high false compliance to scheduled assessments (349,363). The participation or response rate based on the included analytical sample size was high in our review; suggesting that more of the rotation workers are able to complete the minimum number of assessments set by studies to be included in their analysis. Ensuring high compliance to study protocols is regarded as important in EMA studies (349); and strategies including participatory design techniques, prompting/signalling and the training of study participants, employing inconspicuous objective assessments using electronic devices, monitoring and feedback, and providing incentives have been stated to help enhance compliance among participants (346,349). In this review, compliance strategies were inconsistent and inadequately reported. Compliance rates are required and essential for evaluating the quality of data collected and the validity of findings reported by a study (349,351). Compliance rates are also important in informing and enhancing prospective EMA study designs (349,351). We recommend subsequent EMA studies in rotation workers report response and compliance rates.

EMA datasets are large and complex, and analysing such data could be challenging (349,367). The use of common analytical methods including aggregation strategies, repeated measures analysis of variance, and multiple regressions have been indicated to be generally suboptimal and could lead to incorrect inferences as they assume the same number of assessments available per individual (equal variance), and ignore the hierarchical nature of EMA data and treat all the assessments as if they were independent (367). Evidence from this review showed varied analytical methods used in EMA studies. Though analytical approaches employed in studies are directed by the hypothesis being tested (349), mixed or multilevel models have been indicated to have considerable advantages for analysing EMA data (367) including having the ability to handle 'correlated data and unequal variances'(368).

7.5.4 Lessons/good practices for EMA in rotation work setting

The review has highlighted some practices, in conjunction with broader existing guidelines, to guide EMA in rotation work setting and that include;

- The design and intensity of assessments should be guided by schedules/demands of rotation work to reduce burden and promote participation
- Using single-and/or reduced item measures to reduce participants burden
- Involving rotation work organisations in more intensive assessment designs to enhance compliance

- The use of online/electronic diaries and automated devices are increasingly feasible and preferable in rotation work setting
- Adequately reporting prompting schemes and protocol compliance is required to guide future study designs

7.5.4 Strengths and limitations

The key strength of this review is that it is the first to systematically review the literature and employed standardized guidelines for reporting EMA studies (such as CREMAS) to characterise the methodology of EMA studies assessing health outcomes among rotation workers in the resources and construction sector.

However, the limitations of this review need to be acknowledged. The review included only peer-reviewed publications and those in English, as such perhaps limited in scope and by publication bias. Some aspects of the included studies (e.g., compliance rates) were inadequately reported. Studies were mostly done among offshore oil and gas workers and in the offshore setting. This may limit the generalisation of evidence on EMA methods and procedures to other onshore rotation work settings due to contextual working environment-specific differences. As such, more EMA studies among onshore rotation workers (e.g., mining and construction sectors) and settings are needed. Most of the studies assessed sleep and fatigue, which may employ EMA techniques that may not be generalizable to other study outcomes, as such more EMA studies assessing other outcomes such as mental health outcomes and lifestyle behaviours are needed. Studies examined diverse outcomes and reporting strategies, as such quantitative synthesis was limited.

7.6 Conclusion

The review revealed the common use of both daily diaries and within-day fixed interval contingent designs with continuous assessments, increasing use of electronic EMA delivery techniques (website/online-based diaries and wearable devices), and suggested data collection could be done over more than 1 monitoring periods and across the on-and off-shift phases of the rotation work roster with high participation/response rate.

Nonetheless, there were inconsistent or inadequate reports of prompting strategies and compliance-related information among the reviewed studies. This suggests the need for future EMA studies assessing the health outcomes of rotation workers to adequately report prompting strategies and compliance-related information. This will help in the understanding of the feasible prompting strategies and rotation workers' compliance with EMA protocols and to help plan subsequent EMA study designs. More EMA studies particularly within-day interval contingent designs are needed to further investigate psychological states and lifestyle behaviours and to clarify the achievability of EMA methods in assessing such outcomes among rotation workers in the resources industry. The most common assessment methods are one-off daily assessments due to the nature of rotation work; however, further studies are required to demonstrate the feasibility of methods such as event-based and random multiple prompts/assessments during working hours in the rotation work environment such as the mining environment.

7.7 Summary and link to other chapters

This chapter summarised and presented the methodological characteristics of EMA studies assessing health outcomes and related behaviours in rotation workers. The findings of this chapter informed the methods/design of the studies in the next chapters, which include the assessment of the within-person variability of the psychological states and health-related behaviours among FIFO workers (Chapter 8) and their partners (Chapter 9) tested using multilevel analysis.

Chapter 8: Study Seven

Preface

This chapter presents the seventh study included in this thesis and submitted for publication to *Stress and Health* in January 2023 and is now under the second round of peer review. The article's content here is as it appears in the manuscript submitted to the journal; however, it has been formatted to align with the rest of this thesis. The systematic reviews identified potential research gaps including limited longitudinal studies that examined within-person health and their potential job-related determinants in FIFO workers, and daily diary studies as common designs. This article assessed the affective states, related behaviours, and job demands and control determinants. The study highlights the within-person effects of job demand and control on affective states and health behaviours across on and off-shift FIFO work periods.

Author contributions: BYA: conceptualization; methodology; investigation; data curation; formal analysis; visualization; project administration; writing—original draft preparation. DK assisted in formal analysis. SR, DP and DK assisted in conceptualization; funding acquisition; resources; supervision; writing—review & editing. The final manuscript was read and approved by all authors.

Study Seven: Impact of fly-in fly-out work on health behaviours and affective states: a daily diary study

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Acknowledgement

We thank Mineral Resources Limited, Australia for supporting the study and advertising the study to their employees. We also extend our sincere thanks to all FIFO workers for taking part and contributing to this study.

Funding

The study was funded by the Aberdeen-Curtin Alliance.

Data availability statement

The data that support the findings of this study are not publicly available due to ethical and privacy restrictions.

Conflict of interest statement:

The authors declare no conflict of interest.

8.1 Abstract

Our knowledge about the role of fly-in fly-out (FIFO) work-related factors on the well-being of workers across the FIFO work cycle is limited. This study examined the within-person effects of job demand and control on psychological states and health behaviours. The study employed a daily diary design (Ecological Momentary Assessment), with 23 FIFO workers in the Australian mining industry completing a daily diary survey for 28 consecutive days across on-shift and off-shift periods. Multilevel analyses showed FIFO workers experienced higher positive affect and enjoyed better sleep quality, but consumed more alcohol, during off-shift days as compared to on-shift days. Within-person variability in daily demand (workload) was associated with higher anxious affect, whereas job control predicted lower anxious and depressed affects, higher positive affect, more alcohol consumption and more physical activity. The within-person effect of demand on anxious affect was moderated by job control such that those who generally had more control over their jobs had a smaller demand effect on anxiety than those with less control. Results suggest potentially modifiable aspects of FIFO work – particularly job control – may help alleviate the impact of workload on poorer health behaviours and mood.

Keywords: FIFO, job demand, job control, affect, health behaviours, daily diary

8.2 Introduction

Fly-in Fly-out (FIFO), which entails travelling a long distance to work in remote areas and rotating between a continuous specified number of days working at the site and a specified leave period at home, is commonly practised in the natural resources industry, particularly onshore mining and offshore oil and gas (21) in several countries around the world. Workers typically work 12-hour day and/or night shifts and could work, for example, 8 or 14 days with a corresponding 6 or 7 days leave period (7).

Previous research has explored the impact of FIFO work on the health and well-being of workers (7,40), with evidence of a higher prevalence of psychological distress and alcohol consumption among FIFO workers than among the general Australian population (7). Work and leave periods of the FIFO lifestyle are distinct, with diverse conditions and schedules for the FIFO workers as compared to other occupations (15). Such contextual differences warrant consideration in assessing the health of FIFO workers.

Whilst current research tends to compare differences between FIFO workers and other professions/general populations, there is little available evidence relating to within-person variations over time (40,65). A small number of within-person design studies have provided some insights into how FIFO workers experience health outcomes over time and by context (13,53,98,369). For instance, a study by Rebar *et al.* used a daily diary study to establish day-to-day variation in behaviours, including less physical activity, poorer nutrition, poorer sleep quality, and more cigarette smoking during on-shift days, and more alcohol drinking during off-shift days among FIFO workers in Australia (13).

Furthermore, studies examining within-person effects have found FIFO work-related predictors of health that are mainly concentrated on the influence of roster and/or shift patterns of rotation on health issues, e.g., (53,98). Studies providing insight into the impact of job demands and resources of FIFO work on the health and well-being of workers are uncommon and mainly used cross-sectional designs (40). A recent daily diary study established that on days with higher workloads and emotional demands, there was higher emotional exhaustion (51). However, the study was limited to on-shift work periods of construction FIFO workers in Australia, and it is known that psychosocial work characteristics may differ between different occupations (370). The present research focused on examining the job demand and control determinants of FIFO mining workers' psychological health and behaviours.

The Job Demands and Resources (JD-R) Model and FIFO Work

The Job Demands and Resources (JD-R) model suggests that job-related strains are caused by factors broadly classified as job demands and job resources (37,38). Job demands are described as the aspects of work that "require sustained physical and/or psychological effort or skills and are therefore associated with certain physiological and/or psychological costs"(p. 312) (37). Such aspects of work, including workload, work pressures and emotional demands, are deemed to initiate health impairment processes (38). On the other hand, job resources are described as the "aspects of the job that are either functional in achieving work goals, reduced job demands and the associated physiological and psychological costs, or stimulate personal growth, learning, and development" (p. 312) (37). Examples of job resources include autonomy, job clarity and social support, and are indicated to initiate motivational processes (38). These two underlying psychological processes directly and interactively influence the health and well-being of workers (37,38).

According to the JD-R model, excessive job demands will need more effort in attaining job-related goals, which lead to exhaustion (or burnout) and health issues (37). The presence of high job resources nurtures the "growth, learning and development" of workers or contributes to accomplishing job-related goals and assists workers to cope with the negative impact of job demands (37). Also, the motivational roles of high job resources are said to help buffer the negative health consequences of high job demands, whereas the availability of low job resources exposes individuals to the negative consequences of high job demands (37).

Very few studies have employed the JD-R model to explain the impact of FIFO work-related characteristics on the health of FIFO workers (40). Studies have highlighted some favourable and unfavourable FIFO work characteristics that are pertinent to the JD-R model. For instance, the emotional demands of dealing with living away from families, loneliness and social isolation, concerns about keeping family and social relationships, and absence from significant family occasions during extended work periods (15,39). The workload inherent within FIFO roles with high demands of compressed rosters, and long shift hours, are indicated as important stressors among FIFO workers (40). On the other hand, FIFO workers often earn higher wages relative to similar occupations (2) and, during work periods, are not involved in domestic commitments (15).

Affects, Health Behaviours and Job Demands and Resources

Work activities and experiences potentially have significant ramifications for people's mental well-being, such as their emotional states and health-related behaviours on- and off-shifts (371). The existing literature demonstrates that workers' experiences of high perceived job stressors (e.g., workload) are related to negative emotions, e.g., (371–373). Within-persons study designs have also well documented that affects show substantial within-and day-to-day variations, e.g., (374) and which can be influenced by job stressors over time, e.g., (371,372). For instance, daily diary studies have reported that perceived high workload is positively associated with daily variability in negative affect (371). On the other hand, job resources (e.g., job control) are noted to be connected to positive mental well-being, e.g., (375). Studies have also documented the effect of job demands and job resources on health-related behaviours, e.g., (376–378), including those associated with problematic alcohol use (376).

The Present Study

A daily diary study, using Ecological Momentary Assessment (EMA method) aimed at examining the within-person variability in health outcomes of FIFO workers over the course of a roster cycle, focusing primarily on within-person fluctuations in job demand and control as determinants, was conducted. The first aim was to examine within-person differences in affects and health behaviours between on-shift and off-shift periods. It was hypothesised that, during on-shift periods: negative affects would be higher, positive affect would be lower, sleep quality would be poorer, leisure-time physical activity would be lower, fruit and vegetable consumption would be lower, smoking would be higher, and alcohol consumption would be lower. The second aim was to test the JD-R model, and it was hypothesised that, within individuals, higher-than-usual daily demand (workload) would be associated with a higher daily negative affect, and higher-than-usual daily job control would be associated with a higher daily positive affect. It was also hypothesised that higher-than-usual levels of daily demand would be associated with poorer daily health behaviours, whereas high-than-usual levels of daily job control will be associated with better health behaviours. Lastly, it was hypothesised that a moderation effect based on the JD-R model that job control (both typical level and within-person variability) would moderate (attenuate) any relationship between daily demand and affect and behaviour.

8.3 Methods

8.3.1 Study design and participants

This was a daily diary study conducted among FIFO workers in the mining industry in Australia. All participants that took part in a larger cross-sectional study of FIFO workers, reported elsewhere; (61), were invited to take part in the present study. The participants were invited to take part between July and December 2021. All were FIFO mining workers, aged 18 years and above, and worked on more than 3 days of on-and off-shift roster during the study period. Figure 7 outlines the flow of participants in the present study. Of the 216 workers that completed the cross-sectional study (61), 52 (24.1%) agreed to take part in the present study. Of the 52 participants included in the study, 8 (15.4%) could not be reached to schedule the daily surveys and 21 (40.4%) did not respond to at least 3 daily diaries each in both the on-shift and off-shift phases, which was set as a minimum threshold for data provided for statistical modelling (Figure 7).

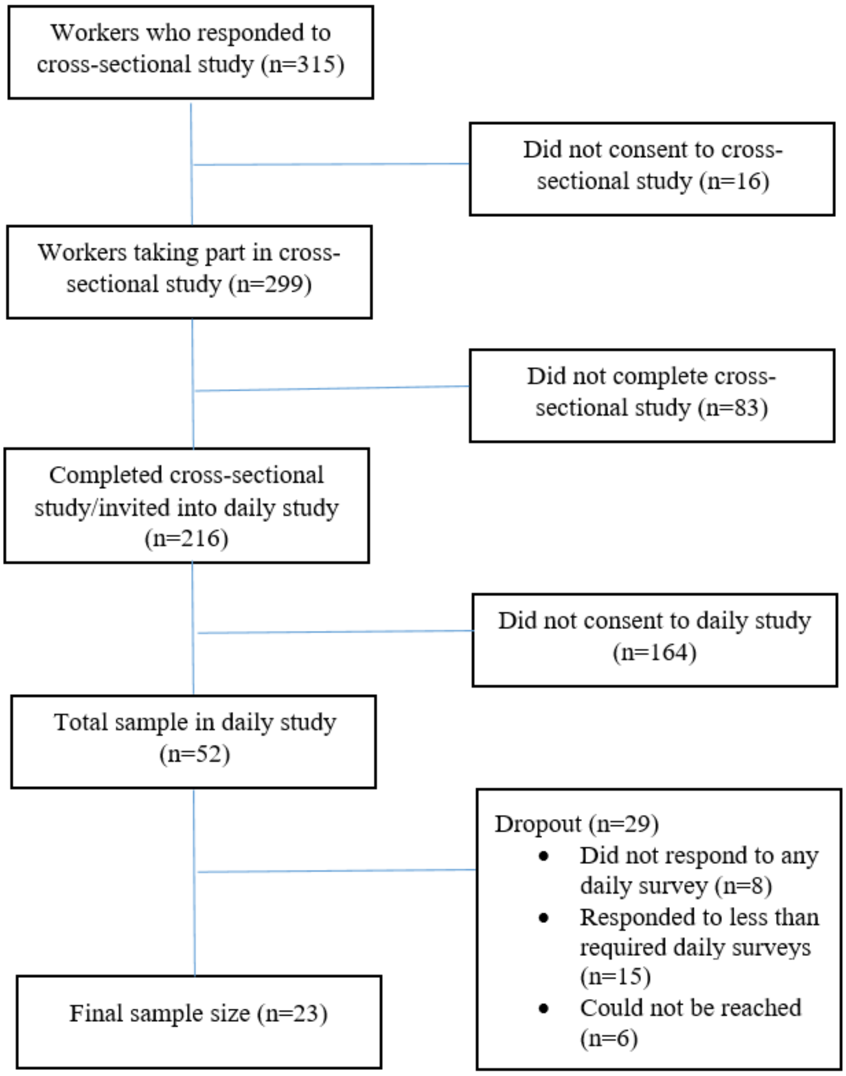

Figure 7. Flow of participants into the present study (workers)

A pragmatically-derived final sample of 23 was included in the analysis. Comparable study sample sizes have been demonstrated in previous similar studies (53,146,156). Participant demographics are reported in Table 13.

Table 13. Background characteristics of study participants (FIFO workers)

Characteristics	n(%)
Age (years)	M=43.04(SD=9.97)
Sex	
Male	16(69.6)
Female	7(30.4)
Ethnicity	
Caucasian/White	18(78.3)
Other	5(21.7)
Marital status	
Married	13(56.5)
De-facto/co-habiting	6(26.1)
Single/divorced	4(17.4)
Have children	
Yes	18(78.3)
No	5(21.7)
Educational level	
Secondary education	7(30.4)
Trade/Apprentice	6(26.1)
TAFE/College/Diploma	6(26.1)
Bachelor/postgraduate degree	4(17.4)
Years worked in a FIFO role	M=10.52(SD=6.53)
FIFO role	
Management	3(13.0)
Professional	3(13.0)
Maintenance/technician	8(34.8)
Production/Drilling/construction/labourer	5(21.7)
Machinery operator and driver	4(17.4)
Shift pattern	
Rotation shift (mix of day and night shifts)	13(56.5)
Regular shift (fixed day)	10(43.5)
Shift length	
12 hrs	18(78.3)
>12 hrs	5(21.7)
Consecutive days spent at work	
<8 days	3(13.0)
8 days	6(26.1)
14 days	14(40.9)
Consecutive days spent at work	
<8 days	12(52.2)
8 days	8(34.8)
14 days	3(13.0)
Smoking	
Yes	4(17.4)
No	19(82.6)
Alcohol intake	
Never	4(17.4)

Yes	19(82.6)
Body mass index	
Normal weight	6(26.1)
Overweight	11(47.8)
Obese	6(26.1)
Physical health status	
Poor	3(13.0)
Good	20(87.0)
Psychological distress	
Low/moderate risk	15(65.2)
High/very high risk	8(34.8)

TAFE= Technical and Further Education

8.3.2 Procedure

Workers who agreed to take part in the study were directed to online participant information sheets and provided written informed consent and mobile contact numbers to schedule daily diary assessments via text message. Participants were contacted by the lead author to introduce the research and schedule the daily diary assessments and discuss instructions on how to complete the assessments. All the daily diary assessments started within 2 days of participants consenting to take part in the study.

Daily web-based surveys, hosted on *Qualtrics,* were administered using an online short messaging service (SMS) program *(MessageMedia)* with the embedded survey link, once per day for 28 consecutive days over on-and off-shift days. The use of daily diary assessments in FIFO work is an emerging approach to understanding within-person variability over time, used in this population (65). The assessments were sent to participants' mobile phones at 16:00 Australian Western Standard Time (AWST) every evening and were available until 06:00 the following day, for the participants to report their daily experiences and behaviours over the last 24 hours. Reminder texts were additionally sent: workers received one text message the day before the 28-day protocol with instructions on how to complete the daily assessments, and another text every three days to encourage participants to complete their assessment within the allowed time. The completion of daily diaries was monitored remotely by the lead author.

All participants completing multiple days (at least 6 days) of daily assessments were offered an individualised report including infographics (a sample presented in Appendix H) summarising their data provided over the period of data collection, similar to that provided elsewhere (379). The study was approved by the Curtin University Human Research Ethics Committee (reference number: HRE2020-0693).

8.3.3 Measures

Demographic characteristics and baseline health and health-related behaviours were assessed as described elsewhere (61) (see Appendix D for questionnaire).

Daily sleep quality. Sleep quality was assessed using an item adapted from the Pittsburgh Sleep Quality Index (186) and reframed to cover a single day *"Last night, how would you rate your sleep quality overall?"* on the responses 1=very good to 4=very poor. The use of a single item as a measure of daily sleep quality has been demonstrated to be reliable, readily conceived, and was chosen to limit the burden on participants (380).

Alcohol intake. Daily alcohol intake was assessed using an item adapted from the Alcohol Use Disorders Identification Test-Concise and reframed to cover a single-day timeframe. Each day, participants were asked to report the number of drinks taken over the last 24 hours using the item: *"How many standard alcohol drinks did you consume today?"* and on a counting scale: *0 to 7 or more*, consistent with previous studies (381).

Smoking. Participants were asked to report the number of cigarettes smoked over the last 24 hours since the last survey using the item: *"How many cigarettes did you smoke today?"*, consistent with previous daily study (381).

Fruits and vegetables. Participants were asked to report on the daily number of servings of fruits and vegetables consumed, using the reframed items: *"How many servings of fruits did you consume today?"* and *"How many serves of vegetables did you consume today?"* adapted from the Australian National Health Survey and scored on a scale *0= none* *to 6 = 6 serves or more.* A serving of fruits was indicated to be equivalent to one-half cup of fruit and one serving of vegetables was equivalent to one cup of leafy green or raw salad vegetables (382). As is common with the scale, the number of fruit and vegetable servings was summed to create the fruit and vegetable intake score (383).

Physical activity. Daily leisure time physical activity was assessed using an item from the *International Physical Activity Questionnaire-short form* (188). Participants were asked: *"How many minutes did you do moderate (e.g., bicycling, brisk walking) to vigorous (e.g., aerobic, running, sports) physical activities outside of work for at least 10 minutes at a time today?"*, consistent with the approach demonstrated in previous EMA study, e.g., (384). Leisure-time physical activity is indicated to be beneficial for all workers (385).

Affect. Daily positive and negative affect were assessed using items from the PANAS-X (386). Participants responded to 6 items framed as: *"How [e.g., excited] did you feel today?"* scored on a 5-point Likert scale: *0 =not at all to 4 =extremely*. Using the subscales of the PANAS, three affect indices were generated; positive affect (happy; excited, Spearman-Brown = 0.87), anxious affect (nervous; worried, Spearman-Brown = 0.83), and depressed affect (sad, lonely, Spearman-Brown = 0.79) All subscale scores ranged from 0 to 8. Higher scores were indicative of higher levels of affects and consistent with the approach demonstrated in previous EMA studies, e.g., (387).

Job demand. Workload is indicated as part of the regular job demand faced by workers (388) and was used as a measure of job demand in this study. *Daily job demand* was measured with 2 items adapted from the Job Content Questionnaire: designed to assess the psychosocial characteristics of jobs including *decision latitude, psychological demands and social support* (389) and as used in a previous study (51). The items were *"Today, my workload was too heavy"* and *"Today, I did not have enough time to do my work to the best of my ability"* scored on a 7-point rating scale: *0=strongly disagree to 6 = strongly agree*.

The items were summed (ranging from 0-12; Spearman-Brown = 0.78) and an average was taken to give a daily workload variable with a high score indicating high job demand.

Job control. Job autonomy is indicated as an important job resource (390) and was measured as job control in this study. *Daily job control* was measured using items adapted from the Work Design Questionnaire, which measures work design characteristics including task, knowledge, social and work content characteristics (391). Two items from the task characteristics of work design were measured on a 7-point rating scale: *0=strongly disagree to 6 = strongly* agree and were *"Today, I had autonomy to decide on the order in which things are done on my job"* and *"Today, I had autonomy in making decisions on my job"*. The items were summed (ranging from 0-12; Spearman-Brown = 0.78) and the average was taken to give a daily job control variable with a high score indicating a high level of job control.

8.3.4 Data analysis plan

An initial examination of sample descriptive statistics was performed, followed by a Spearman's Rank correlation matrix of the various person-mean scores for our daily diary and baseline assessments. Panel plots of daily data are presented in Supplementary Information S13 (Appendix I). With the daily diary data, intraclass correlation coefficients (ICC) were computed to examine the partitioning of variance to within-person or between-person. A higher ICC (potential range 0 to 1) indicates less variability across time. Cigarette smoking was intended to be assessed as a dependent variable, but was excluded as only a few of the participants (n= 4) indicated smoking, with high ICC (0.93) showing almost no within-person variance.

All hypotheses were tested using multilevel models, with linear mixed models for continuous outcomes (positive affect, anxious affect, depressive mood and sleep quality) and generalized linear mixed modelling for counts and binary outcomes (fruit and vegetable intake, alcohol and physical activity). A negative binomial distribution with a log link function was used for the model predicting counts of fruits and vegetables. Alcohol and physical activity data showed highly zero-inflated distributions and were transformed into dichotomous variables: alcohol intake categorised into days with no alcohol intake (0) and days with at least 1 standard drink intake (1); and moderate-to-vigorous physical activity (MVPA) categorised into less than 30 minutes of MVPA (0) and at least 30 minutes of MVPA (1). Alcohol intake and physical activity were modelled using binomial distributions with a logit link function. Spaghetti plots of the within-person relationships are presented in Appendix I: Supplementary Information S13.

Data were structured such that daily assessments (Level 1) were nested within individuals (Level 2). To test the first hypothesis, separate models tested the effect of work period (on-shift (1) vs off-shift (0)) on psychological states (anxious, depressed and positive affects) and behavioural (sleep quality, alcohol intake, fruits and vegetable intake and physical activity) outcomes. To test the second is hypothesis, separate models assessed the direct effects of job demand-resource factors (job demand, job control) on daily psychological states and behavioural outcomes. To assess the influence of work-related factors on the next day's sleep quality, the sleep quality variable was transformed into a lag sleep quality outcome variable by removing the first day's sleep quality reports for each participant. job demand and control were entered as both level-1 (within-person) and level-2 (between-person) predictors: raw scores were person-mean centred and entered at level-1, and person-mean scores were then grand-mean centred and entered at level-2. Demographic and FIFO work characteristics (age, sex, marital status, shift pattern, shift length, FIFO length), were entered as level-2 predictors as covariates to adjust for potential confounders based on existing literature. A time variable, being days into the study, was also entered.

To test the moderation hypotheses, the interaction of job control with workload was tested in two models: first, we tested whether the within-person effect of demand on outcomes was moderated by the within-person effect of control (i.e., that the effect of a particularly demanding day is attenuated on days with more control than usual) and, secondly, a cross-level interaction of between-person job control (i.e., that the effect of a particularly demanding day is attenuated for those who generally enjoy more job control).

All models allowed for fixed and random effects of shift periods (on-shift vs off-shift) and random intercepts, and full information maximum likelihood estimation. Models did not converge with random slopes, so these were omitted. All models employed robust standard error estimation and estimated random effects using an unstructured covariance matrix and autocorrelation of residuals using a first-order autoregressive covariance matrix. All data analyses were completed in SPSS (Version 26) and statistical significance was set at $\alpha = .05$. For parsimony, we do not present full tables for all models in the paper, but all are reported in full in Appendix I: Supplementary Information S14.

8.4 Results

8.4.1 Descriptive statistics

The 23 participants completed 434 of a possible 644 days (67.4% overall compliance with the protocol). On average, participants completed 18.87(SD=5.77) days of data, with 11.26 (SD=4.11) on-shift and 7.61 (SD=4.30) off-shift days. On average, respondents reported experiencing modest levels of positive affect (M=1.75, SD=1.06, range 0-4) and low levels of anxious affect (M=0.73, SD=0.87, range 0-4) and depressive mood (M=0.83, SD=0.96, range 0-4) per day. On average, participants reported fairly good sleep quality (M = 1.81, SD = 0.81, range 0-3). The respondents typically reported consuming 1.00(SD=1.82) standard alcoholic drinks and 3.48(SD=1.98) serves of fruits and vegetables per day. Typically, the study respondents also reported engaging in MVPA for 19.39(SD=26.49) minutes per day. The ICCs showed that between 39% and 90% of the variance in the study variables could be attributed to within-person variation. Variance in sleep quality and MVPA predominantly belonged to within-person variation, with only 10% and 21 % respectively of the variability accounted for by between-person differences (see Table 14).

Table 14. Between-person correlations of daily variables in FIFO workers

Parameter	M(SD)	ICC	1	2	3	4	5	6	7	8	9
1. Positive affect (0-4)	1.75(1.06)	.42	1								
2. Anxious affect (0-4)	0.73(0.87)	.58	-.18***	1							
3. Depressed affect (0-4)	0.83(0.96)	.48	-.42***	.65***	1						
4. Job demand (0-6)	2.20(1.42)	.39	-.17***	.11*	.16***	1					
5. Job control (0-6)	4.12(1.49)	.36	.44***	-.28***	-.33***	-.30***	1				
6. Standard alcohol drinks/day	1.00(1.82)	.52	-.05	.11*	.07	-.06	.05	1			
7. Minutes of MVPA/day	19.39(26.49)	.21	.18***	-.05	-.21***	-.02	.21***	.06	-.11*	1	
8. Sleep quality (0-3)	1.81(0.81)	.10	.28***	-.25***	-.30***	-.13*	.32***	.06	-.11*	.15**	1
9. Fruits and vegetables/day	3.48(1.98)	.61	.02	-.31***	-.10***	-.09	-.01	-.04	-.05	.20***	.27***

*p<.05, **p<.01, ***p<.001; Note: Numbers in parentheses alongside parameter labels represent the range of possible scores on that measure.
M = Mean; SD = Standard deviation; ICC = Intra-class correlation: higher ICC values (potential range 0 to 1) show less variability across time; MVPA=moderate to vigorous physical activity

8.4.2 Main effects of shift period on affects and health behaviours of FIFO workers

Positive affect was significantly lower whilst on-shift compared to off-shift (γ =-0.50, SE=0.14, 95%CI=-0.78, -0.21, p=.001). Similarly, study respondents tended to have poor sleep quality (γ =-0.36, SE=0.11, 95%CI=-0.57, -0.14, p=.002) and consume less alcohol (γ=-1.35, SE=0.48, Exp(γ)=0.26, 95%CI=0.10, 0.67, p=.005) during on-shift compared to off-shift periods. However, there were no significant differences in anxious affect, depressed affect, fruit and vegetable intake, and physical activity during on-shift and off-shift periods (see Tables 15 and 16). Boxplots of the average health outcomes over on-and off-shift periods are shown in Figures 8 and 9.

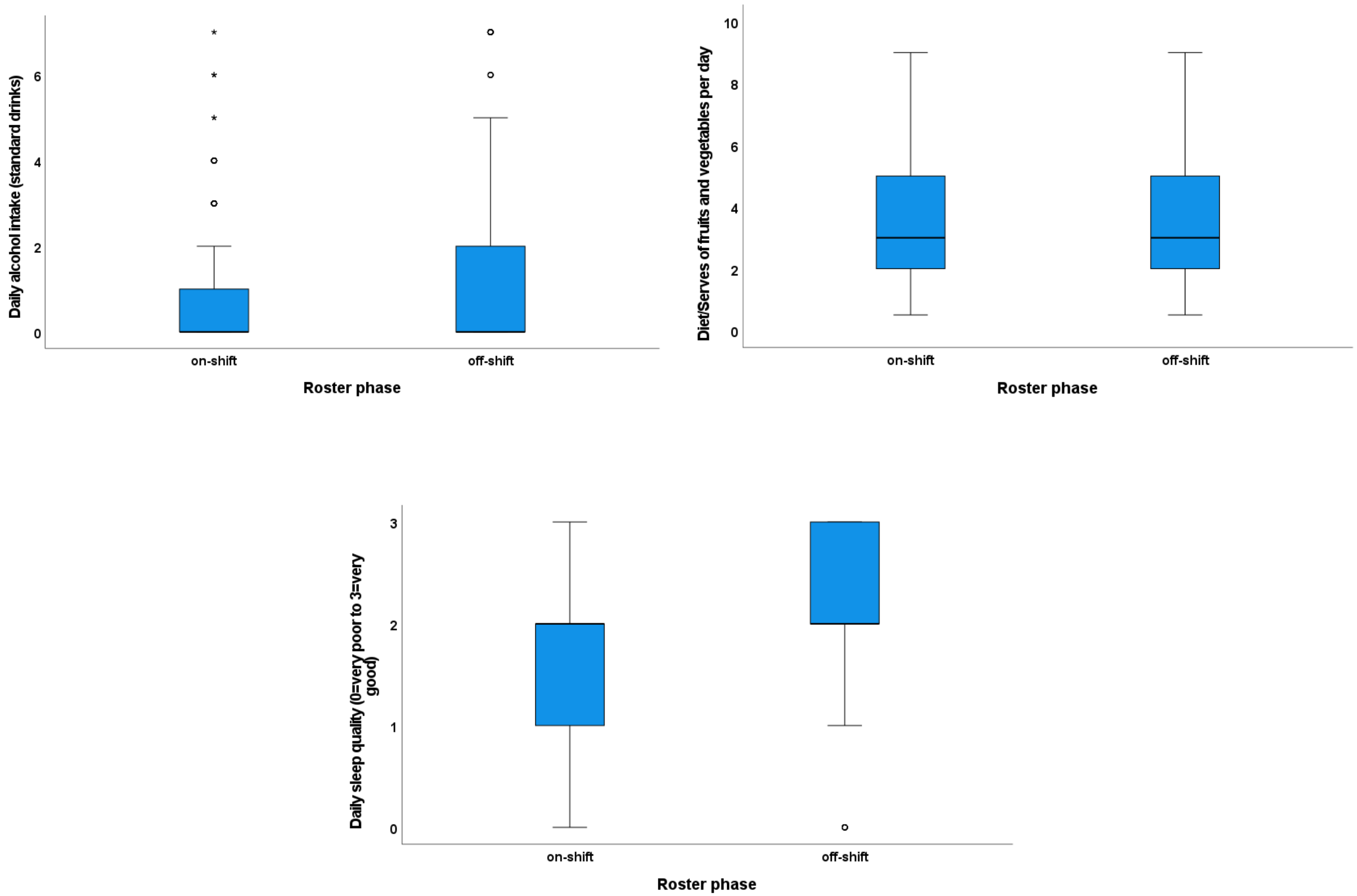

Figure 8. Boxplots of the average daily alcohol intake, fruit and vegetable intake, and sleep quality of FIFO workers during on-shift days and off-shift days.

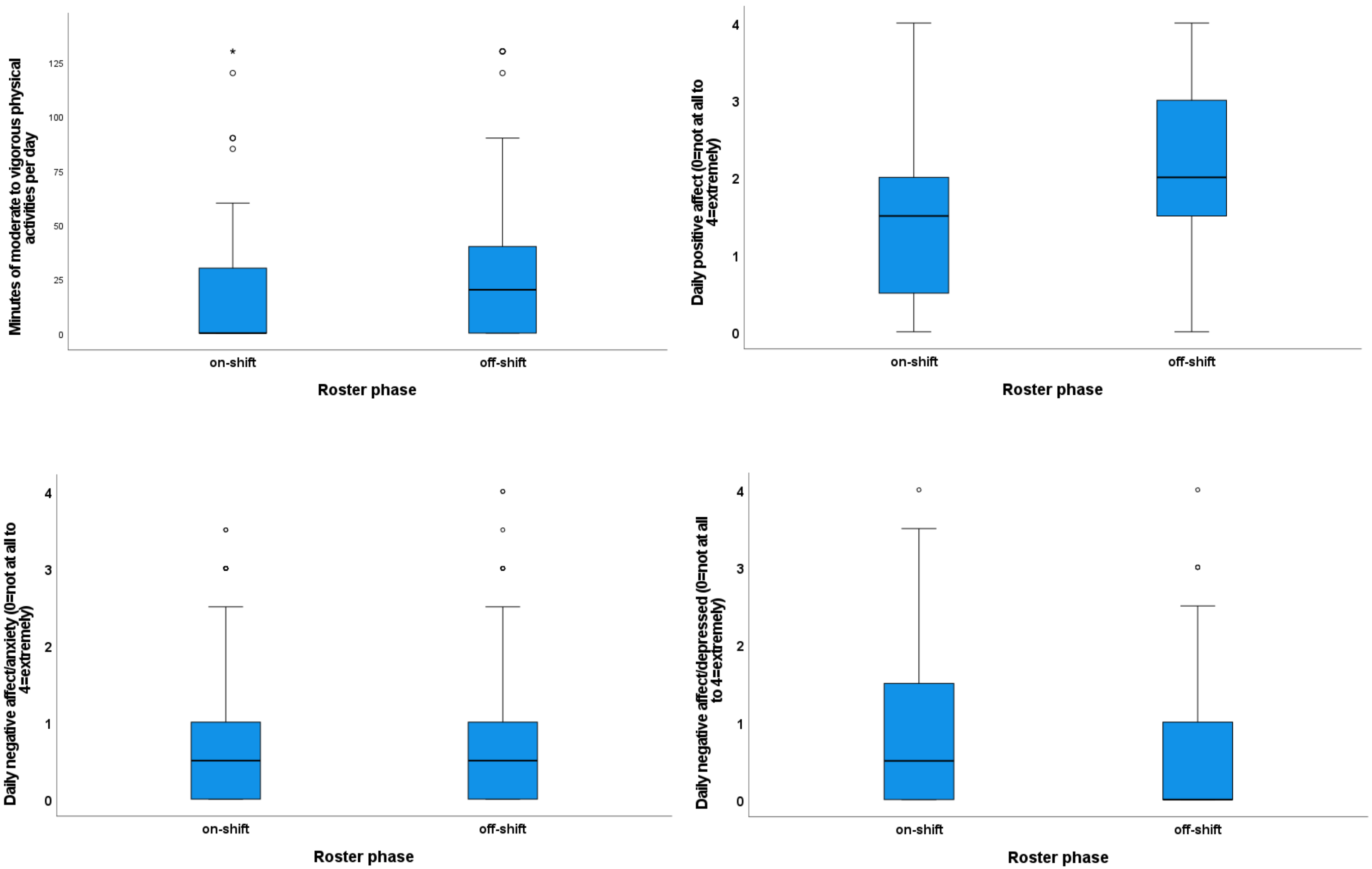

Figure 9. Boxplots of the average daily physical activity time, positive affect, anxious affect and depressive mood of FIFO workers during on-shift days and off-shift days.

Table 15. Multilevel models of the effect of shift period on Affects and sleep quality in FIFO workers

Parameter	Anxious affect			Depressed affect			Positive affect			Sleep quality		
	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value
Fixed Effects												
Intercept	1.50(0.43)	0.61, 2.39	.002	1.56(0.50)	0.54, 2.58	.004	2.33(0.44)	1.45, 3.22	<.001	1.69(0.25)	1.18, 2.20	<.001
Shift period	0.04(0.13)	-0.23, 0.31	.750	0.22(0.17)	-0.13, 0.57	.204	-0.50(0.14)	-0.78, -0.21	.001	-0.36(0.11)	-0.57, -0.14	.002
*Random Effects**	σ^2 (SE)			σ^2 (SE)			σ^2 (SE)			σ^2 (SE)		
Intercept	0.25(0.09)	0.12, 0.50	.005	0.31(0.11)	0.16, 0.63	.005	0.20(0.08)	0.09, 0.45	.018	0.02(0.02)	0.002, 0.21	.426
Shift period	0.29(0.12)	0.13, 0.64	.012	0.51(0.19)	0.24, 1.07	.009	0.27(0.12)	0.11, 0.65	.030	0.11(0.07)	0.03, 0.40	.141
*Residual***												
AR1 diagonal	0.30(0.02)	0.26, 0.36	<.001	0.40(0.03)	0.34, 0.48	<.001	0.55(0.05)	0.45, 0.65	<.001	0.51(0.04)	0.44, 0.61	<.001
AR1 rho	0.16(0.08)	0.01, 0.31	.010	0.29(0.07)	0.16, 0.41	<.001	0.29(0.06)	0.16, 0.40	<.001	0.19(0.07)	0.06, 0.32	.003

SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours

Table 16. Generalised linear mixed models of effects of shift periods on behaviours of FIFO workers

Parameter	Alcohol intake[¥]			Fruits and vegetable[Φ]			Physical activity[¥]		
	[a]Exp(γ)	95%CI	p-value	Exp(γ)	95%CI	p-value	[a]Exp(γ)	95%CI	p-value
Fixed Effects									
Intercept	0.03	0.00, 0.33	.004	2.22	1.46, 3.38	<.001	0.59	0.08, 2.25	.605
Shift period (off-shift vs on-shift)	0.26	0.10, 0.67	.005	0.91	0.78, 1.08	.284	0.39	0.15, 1.07	.066
*Random Effects**	σ^2 (SE)			σ^2 (SE)			σ^2 (SE)		
Intercept	4.50(2.24)	1.69, 11.95	.045	0.20(0.08)	0.09, 0.45	.017	2.83(1.57)	0.95, 8.40	.072
Shift period	2.99(1.55)	1.08, 8.25	.054	0.12(0.05)	0.05, 0.28	.025	3.67(1.76)	1.43, 9.40	.037
*Residual***									
AR1 diagonal	0.67(0.05)	0.57, 0.78	<.001	0.34(0.04)	0.28, 0.42	<.001	0.69(0.07)	0.57, 0.83	<.001
AR1 rho	0.17(0.06)	0.04, 0.29	.009	0.31(0.09)	0.14, 0.47	<.001	0.44(0.06)	0.32, 0.55	<.001

Alcohol intake: yes=1, no=0; fruits and vegetable intake: serves taken; physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1
SE=standard error; CI=confidence interval; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[¥]Logistic models; [Φ]Negative binomial log model; Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle
Models adjusted for covariates: days into assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours
[a]Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) odd in alcohol intake and MVPA for a 1-unit increase in the predictor

8.4.3 Main effects of within-person and between-persons job demand and control on health outcomes of FIFO workers

Psychological well-being. The results show that anxious affect was significantly positively associated with within-person job demand (γ = 0.05, SE= 0.03, 95%CI=0.004, 0.10, p=.035) while negatively associated with within-person job control (γ = -0.14, SE= 0.03, 95%CI= -0.19, -0.09, p<.001). Between-person job control was also positively associated with anxious affect (γ = -0.50, SE= 0.17, 95%CI=-0.85, -0.16, p=.005). In the model predicting depressed affect, only within-person job control was a significant predictor (γ = -0.12, SE= 0.03, 95%CI= -0.17, -0.06, p<.001). The model predicting positive affect indicated that both within-person job control (γ = 0.24, SE= 0.03, 95%CI= 0.17, 0.30, p<.001) and between-person job control (γ= 0.40, SE= 0.16, 95%CI= 0.07, 0.74, p=.021) to be positively associated with positive affect (see Table 17).

Health behaviours. Within-person and between-person job demands and control were not associated with sleep quality (p>.05) (Table 17). Intake of alcohol was associated with between-person job demand (γ =-1.82, SE= 0.74, Exp(γ)= 0.16, 95%CI= 0.04, 0.70, p=.015), such that on average there was a decrease in odds of alcohol consumption with 1-unit increase above the mean in demand. Within-person job control was also associated with alcohol consumption (γ=0.65, SE= 0.17, Exp(γ)= 1.91, 95%CI=1.37, 2.67, p<.001), such that with a 1-unit increase in job control there was the increase in odds of alcohol intake.

Fruits and vegetable intake was associated with between-person demand (γ= -0.16, SE= 0.07, Exp(γ)= 0.86, 95%CI= 0.75, 0.98, p=.022) and job control (γ= -0.20, SE= 0.08, Exp(γ)= 0.82, 95%CI= 0.70, 0.96, p=.016). There was a 14% decrease in fruit and vegetable intake in those with 1-unit higher demand and an 18% decrease in fruit and vegetable intake in those with 1-unit higher job control. The within-person variables were found not to be associated with fruit and vegetable intake. The model predicting physical activity showed within-person job control to be associated with physical activity (γ= 0.41, SE= 0.17, Exp(γ)= 1.51, 95%CI= 1.08, 2.11, p=.016). The odds of physical activity were higher with a 1-unit increase in job control. The between-person variables were found not to be associated with physical activity (see Table 18).

Table 17. Multilevel linear models of within- and between-person fixed effects of job demand and control of affect and sleep quality in workers

Parameters	Anxious affect			Depressed affect			Positive affect			Sleep quality		
	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value
Fixed effects												
Intercept	1.80(0.38)	1.01, 2.58	<.001	1.64(0.47)	0.68, 2.61	.002	2.00(0.38)	1.23, 2.78	<.001	2.64(0.32)	2.00, 3.26	<.001
Shift period	-0.11(0.13)	-0.37, 0.15	.385	0.10(0.15)	-0.21, 0.42	.504	-0.27(0.10)	-0.48, -0.07	.012	-0.20(0.14)	-0.48, 0.07	.148
Aggregate job demand (between persons)	-0.09(0.16)	-0.42, 0.24	.593	0.15(0.20)	-0.26, 0.56	.452	-0.06(0.16)	-0.38, 0.26	.708	-0.11(0.12)	-0.36, 0.13	.356
Daily job demand (within-person)	0.05(0.03)	0.004, 0.10	.035	0.02(0.03)	-0.04, 0.08	.530	-0.01(0.03)	-0.07, 0.05	.725	-0.01(0.04)	-0.09, 0.07	.752
Aggregate job control (between persons)	-0.50(0.17)	-0.85, -0.16	.005	-0.28(0.21)	-0.70, 0.15	.190	0.40(0.16)	0.07, 0.74	.021	-0.02(0.13)	-0.27, 0.24	.903
Daily job control (within-person)	-0.14(0.03)	-0.19, -0.09	<.001	-0.12(0.03)	-0.17, 0.06	<.001	0.24(0.03)	0.17, 0.30	<.001	0.01(0.04)	-0.07, 0.09	.838
*Random effects**	σ^2 (SE)			σ^2 (SE)			σ^2 (SE)			σ^2 (SE)		
Intercept[a]	0.17(0.06)	0.08, 0.35	.006	0.26(0.10)	0.13, 0.53	.007	0.15(0.06)	0.07, 0.33	.013	-	-	-
Shift period	0.27(0.11)	0.12, 0.58	.012	0.40(0.16)	0.18, 0.89	.014	0.069419	0.01, 0.44	.327	0.14(0.09)	0.04, 0.50	.126
*Residual***												
AR1 diagonal	0.28(0.02)	0.24, 0.32	<.001	0.39(0.03)	0.33, 0.46	<.001	0.50(0.04)	0.43, 0.59	<.001	0.54(0.05)	0.45, 0.64	<.001
AR1 rho	0.17(0.07)	.0.02, 0.58	.026	0.28(0.07)	0.15, 0.40	<.001	0.28(0.06)	0.16, 0.40	<.001	0.26(0.07)	0.12, 0.38	<.001

Anxious affect (0=not at all to 4=extremely), depressed affect (0=not at all to 4=extremely), positive affect (0=not at all to 4=extremely), sleep quality (0=very poor to 3=very good)
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[a]Random intercept in the model predicting sleep quality was omitted due to non-convergence of the model
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours

Table 18. Generalised linear mixed models of within- and between-person fixed effects of job demand and control on health behaviours of FIFO workers

Parameters	Alcohol intake[¥]			Fruits and vegetable[Φ]			Physical activity[¥]		
	[a]Exp (γ)	95%CI	p-value	Exp (γ)	95%CI	p-value	[a]Exp (γ)	95%CI	p-value
Fixed Effects									
Intercept	0.04	0.002, 0.96	.047	2.54	1.70, 3.79	<.001	0.66	0.06, 7.20	.736
Shift period (on-shift vs off-shift)	0.34	0.12, 0.92	.034	0.90	0.76, 1.07	.223	0.48	0.19, 1.22	.122
Aggregate job demand (between persons)	0.16	0.04, 0.70	.015	0.86	0.75, 0.98	.022	0.76	0.24, 2.38	.636
Daily job demand (within-person)	1.27	0.95, 1.70	.110	0.99	0.97, 1.02	.619	1.12	0.93, 1.34	.225
Aggregate job control (between persons)	0.28	0.04, 1.86	.186	0.82	0.70, 0.96	.016	0.38	0.12, 1.22	.103
Daily job control (within-person)	1.91	1.37, 2.27	<.001	0.98	0.94, 1.02	.228	1.51	1.08, 2.11	.016
*Random Effects**	σ^2 (SE)			σ^2 (SE)			σ^2 (SE)		
Intercept	5.83(3.20)	1.99, 17.12	.069	0.20(0.09)	0.08, 0.49	.027	3.45(1.75)	1.13, 10.56	.080
Shift period	3.85(2.01)	1.39, 10.68	.055	0.12(0.05)	0.05, 0.29	.024	3.33(1.75)	1.19, 9.33	.057
*Residual***									
AR1 diagonal	0.67(0.05)	0.57, 0.78	<.001	0.34(0.03)	0.28, 0.41	<.001	0.72(0.07)	0.60, 0.87	<.001
AR1 rho	0.18(0.07)	0.05, 0.31	.006	0.31(0.07)	0.13, 0.46	<.001	0.44(0.06)	0.31, 0.55	<.001

Alcohol intake: yes=1, no=0; fruits and vegetable intake: serves taken; physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[¥]Logistic models
[Φ]Negative binomial log model
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours
[a]Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) odds in alcohol intake and MVPA for a 1-unit increase in the predictor

8.4.4 Interaction between job demand and job control in predicting health outcomes

Psychological well-being. The results showed a significant interaction between within-person demand and job control in predicting anxious affect. The effect of daily demand on anxiety was lower on days that were accompanied by high control (γ= -0.04, SE= 0.02, 95%CI= -0.07, -0.01, p=.013). There were no significant interactions between within-person demand and job control in predicting depressed affect and positive affect. For the cross-level interaction, the interaction between within-person demand and between-person job control was significant in predicting depressed affect: the effect of daily demand on depressed mood was attenuated in those individuals with typically more control over their jobs (γ= -0.09, SE= 0.04, 95%CI= -0.17, -0.01, p=.023). The same interaction was not quite statistically significant with anxiety as outcome (γ= -0.07, SE= 0.03, 95%CI= -0.13, 0.00, p=.051), but was not significant in predicting positive affect (see Table 19-20).

Health behaviours. There were no significant interactions between within-person demand and job control in predicting sleep quality, alcohol intake, fruit and vegetable intake and physical activity. For cross-level interaction, the interaction between within-person demand and between-person job control was significant in predicting sleep quality and alcohol intake, but not in predicting fruit and vegetable intake and physical activity. Respondents at the typical level of job control across days showed better sleep quality on days with high demand (γ= 0.14, SE= 0.06, 95%CI= 0.02, 0.26, p=.028). Similarly, respondents at the typical level of job control across days showed increased odds of alcohol intake on days with high demand. The within-person main effects of workload and job control remained statistically not significant in the models predicting sleep quality, and fruits and vegetable intake. Furthermore, the within-person main effects of job control remained significant but demand remained statistically not significant in the models predicting alcohol intake and physical activity (Table 21).

Table 19. Multilevel linear models of within- and between-person fixed effects of interactions between job demand and control on affect in workers

Variables	Anxious affect					Depressed affect				
	γ(SE)	df	t	95%CI	p-value	γ(SE)	df	t	95%CI	p-value
Fixed effects										
Intercept	1.76(0.38)	29.06	4.64	0.99, 2.54	<0.001	1.60(0.47)	28.31	3.44	0.65, 2.56	0.002
Shift period	-0.09(0.12)	23.80	-0.74	-0.34, 0.16	0.468	0.13(0.15)	22.52	0.85	-0.18, 0.43	0.404
Aggregate job demand (between-persons)	-0.10(0.16)	27.57	-0.63	-0.43, 0.23	0.532	0.14(0.20)	26.94	0.71	-0.26, 0.55	0.482
Daily job demand (within-person)	0.05(0.03)	387.36	2.11	0.00, 0.10	0.036	0.02(0.03)	404.19	0.67	-0.04, 0.08	0.504
Aggregate Job control (between-persons)	-0.53(0.17)	28.28	-3.20	-0.87, -0.19	0.003	-0.31(0.20)	27.58	-1.53	-0.73, 0.11	0.138
Daily job control (within-person)	-0.12(0.03)	370.61	-4.63	-0.17, -0.07	<0.001	-0.11(0.03)	399.64	-3.47	-0.16, -0.05	<0.001
Daily job demand*daily job control	-0.04(0.02)	389.11	-2.50	-0.07, -0.01	0.013	-0.03(0.02)	393.97	-1.83	-0.07, 0.00	0.068
Daily job demand*aggregate job control	-0.07(0.03)	348.15	-1.96	-0.13, 0.00	0.051	-0.09(0.04)	367.63	-2.28	-0.17, -0.01	0.023
*Random Effects**	σ^2 (SE)	Wald Z				σ^2 (SE)	Wald Z			
Intercept	0.17(0.06)	2.79		0.08, 0.34	0.005	0.25(0.09)	2.73		0.12, 0.52	0.006
Shift period	0.25(0.10)	2.49		0.11, 0.55	0.013	0.36(0.15)	2.38		0.16, 0.81	0.017
*Residual***										
AR1 diagonal	0.27(0.02)	12.81		0.23, 0.31	<0.001	0.38(0.03)	11.88		0.32, 0.45	<0.001
AR1 rho	0.14(0.08)	1.85		-0.01, 0.28	0.065	0.27(0.07)	4.07		0.14, 0.39	<0.001

Anxious affect (0=not at all to 4=extremely), Depressed affect (0=not at all to 4=extremely)
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours

Table 20. Multilevel linear models of within- and between-person fixed effects of interactions between job demand and control on affect and sleep quality of workers

Parameter	Positive affect					Sleep quality				
	γ(SE)	df	t	95%CI	p-value	γ(SE)	df	t	95%CI	p-value
Fixed effects										
Intercept	2.03(0.38)	29.37	5.28	1.24, 2.81	<0.001	2.59(0.31)	107.07	8.36	1.96, 3.20	<0.001
Shift period	-0.29(0.10)	27.21	-2.84	-0.49, -0.08	0.008	-0.19(0.13)	44.14	-1.41	-0.46, 0.08	0.166
Aggregate job demand (between-persons)	-0.06(0.16)	25.76	-0.36	-0.38, 0.27	0.720	-0.11(0.12)	115.34	-0.91	-0.35, 0.13	0.366
Daily job demand (within-person)	-0.01(0.03)	353.58	-0.33	-0.07, 0.05	0.745	-0.03(0.04)	312.05	-0.63	-0.11, 0.05	0.527
Aggregate Job control (between-persons)	0.41(0.16)	26.46	2.47	0.07, 0.74	0.020	0.05(0.13)	101.12	0.40	-0.20, 0.31	0.691
Daily Job control (within-person)	0.23(0.03)	306.65	6.95	0.16, 0.29	<0.001	0.02(0.04)	297.60	0.39	-0.06, 0.10	0.695
Daily job*daily job control	0.03(0.02)	411.68	1.35	-0.01, 0.07	0.178	-0.02(0.03)	300.21	-0.82	-0.07, 0.03	0.415
Daily job demand*aggregate job control	0.04(0.04)	237.72	0.99	-0.04, 0.13	0.322	0.14(0.06)	227.37	2.21	0.02, 0.26	0.028
*Random Effects**	σ^2 (SE)	Wald Z				σ^2 (SE)	Wald Z			
Intercept[a]	0.15(0.06)	2.50		0.07, 0.34	0.012	-	-		-	-
Shift period	0.05(0.06)	0.86		0.01, 0.50	0.390	0.12(0.08)	1.54		0.04, 0.44	123
*Residual***										
AR1 diagonal	0.50(0.04)	12.16		0.43, 0.56	<0.001	0.52(0.05)	11.09		0.44, 0.62	<0.001
AR1 rho	0.29(0.06)	4.71		0.17, 0.41	<0.001	0.23(0.07)	3.39		0.09, 0.35	<0.001

Positive affect (0=not at all to 4=extremely), sleep quality (0=very poor to 3=very good)
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in models predicting sleep quality and was omitted
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours

Table 21. Generalised linear mixed models of within- and between-person fixed effects of interactions between job demand and control on behaviours of workers

Parameter	Alcohol intake					Fruits and vegetable intake					Physical activity				
	γ(SE)	t	Exp(γ)	95%CI	p-value	γ(SE)	t	Exp(γ)	95%CI	p-value	γ(SE)	t	Exp(γ)	95%CI	
Fixed effects															
Intercept	-3.77(1.76)	-2.76	0.02	0.00, 0.74	0.033	0.94(0.21)	4.50	2.56	1.70, 3.85	<0.001	-0.19(1.30)	-0.15	0.82	0.06, 10.58	0.882
Shift period	-1.13(0.56)	-2.02	0.33	0.11, 0.97	0.044	-0.11(0.09)	-1.21	0.90	0.75, 1.07	0.226	-0.78(0.50)	-1.57	0.46	0.17, 1.22	0.117
Aggregate job demand (between-persons)	-2.06(0.80)	-2.58	0.13	0.03, 0.61	0.010	-0.15(0.07)	-2.15	0.86	0.76, 0.99	0.033	-0.34(0.60)	-0.57	0.71	0.22, 2.33	0.571
Daily job demand (within-person)	0.23(0.13)	1.75	1.26	0.97, 1.64	0.080	-0.01(0.01)	-0.65	0.99	0.97, 1.01	0.514	0.06(0.10)	0.61	1.06	0.88, 1.28	0.545
Aggregate Job control (between-persons)	-1.19(0.98)	-1.21	0.31	0.04, 2.11	0.228	-0.18(0.08)	-2.16	0.84	0.71, 0.98	0.031	-1.08(0.61)	-1.78	0.34	0.10, 1.12	0.077
Daily Job control (within-person)	0.77(0.18)	4.25	2.16	1.51, 3.09	<0.001	-0.03(0.02)	-1.40	0.97	0.94, 1.01	0.163	0.40(0.16)	2.44	1.49	1.08, 2.05	0.015
Daily job demand*daily job control	-0.16(0.11)	-1.49	0.85	0.69, 1.05	0.136	0.02(0.01)	1.39	1.02	0.99, 1.05	0.164	0.20(0.11)	1.80	1.22	0.98, 1.52	0.073
Daily job demand*aggregate job control	0.56(0.15)	3.73	1.75	1.30, 2.35	<0.001	0.03(0.02)	1.19	1.03	0.98, 1.07	0.235	-0.03(0.10)	-0.31	o.97	0.79, 1.19	0.759
*Random Effects**	σ^2 (SE)	Z				σ^2 (SE)	Z				σ^2 (SE)	Z			
Intercept	7.86(4.20)	1.87		2.76, 22.39	0.061	0.20(0.09)	2.21		0.08, 0.49	0.027	3.60(2.06)	1.75		1.18, 11.04	0.080
Shift period	5.40(2.63)	2.06		2.08, 14.02	0.040	0.12(0.05)	2.25		0.05, 0.28	0.024	3.57(1.83)	1.95		1.31, 9.76	0.051
*Residual***															
AR1 diagonal	0.59(0.05)	12.93		0.51, 0.69	<0.001	0.34(0.03)	9.80		0.28, 0.41	<0.001	0.71(0.07)	10.33		0.59, 0.86	<0.001
AR1 rho	0.17(0.06)	2.79		0.05, 0.29	0.005	0.31(0.08)	3.64		0.13, 0.46	<0.001	0.44(0.06)	7.15		0.31, 0.55	<0.001

Alcohol intake: yes=1, no=0; fruits and vegetable intake: number of serves taken; physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[¥]Logistic models
[Φ]Negative binomial log model
Shift period: on-shift days (1) vs off shift days (0) of the FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, gender, marital status, have children, FIFO role, Shift pattern, shift hours
[a]Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) odds in alcohol intake and MVPA for a 1-unit increase in the predictor

8.5 Discussion

This study examined the impact of FIFO work on psychological well-being and health-related behaviours, examining the role of job-related factors including job demand and control.

8.5.1 Variability of daily variables over and across FIFO work periods (on-and off-shifts)

This study found significant within and between-persons variations in daily affects, health behaviours and work conditions across on-and off-shift days. This is consistent with the findings of previous FIFO studies, which found daily differences in alcohol intake, exercise, sleep quality, and nutrition quality (13), emotional exhaustion and work conditions (including workload, emotional demands, and co-worker support) (51). Daily variations in affects, health behaviours and work conditions have been documented widely among the general population (e.g., (372,383). The extent of fluctuations in individuals' experiences over time is indicated to impact negatively on their well-being (392), suggesting that FIFO workers could be experiencing diminished well-being (51).

The study indicated partial support for hypothesis 1 on positive affect, sleep quality and alcohol intake. The study found that workers' positive affect was significantly lower during on-shift compared to off-shift days. This is the first study to examine affects during on-and off-shift periods. Several cross-sectional studies have indicated high levels of psychological distress among FIFO workers (e.g., (40,61). FIFO workers, during work periods, are separated from their families and faced with the emotional strain of dealing with being away from families, loneliness and social isolation, anxiety about maintaining family and social relationships and missing important family events (15,39). However, we found no differences in anxious affect and depressed affect during on-and off-shift periods. It is worth noting the small sample included in this study.

The results of the study demonstrated that sleep quality was poorer during on-shift compared to off-shift days. This corroborates the findings made in previous daily studies among FIFO workers in Australia (13,393) and earlier cross-sectional studies (16,61). Though FIFO workers may be free from social and domestic commitments during work periods (15), they typically work long hours and day and night shifts, which are indicated to limit sleep (52,163). Studies have indicated that during off-shift days, workers show signs of recovery from the sleep loss accumulated during work periods (52,393).

Workers reported consuming less alcohol during on-shift periods compared to off-shift periods, aligning with the findings from earlier daily studies (13,98) and earlier cross-sectional studies (61). Workplace practices including daily alcohol testing before the commencement of work (17), and restrictions on alcohol consumption (16) may have impacted the consumption of alcohol during on-shift days. On the other hand, the availability of more alcohol and a sense of liberty from limitations on alcohol consumption (40) are highlighted to contribute to high levels of alcohol consumption during off-shift days.

In contrast to a previous daily diary study, which found FIFO workers to exercise less and poorer nutrition quality during on-shift compared with off-shift periods (13), this study found no differences in physical activity and fruit and vegetable intake during on-and off-shift days. The observed disparities could be explained by the differences in sample sizes between the studies, as a small sample was included in the current study, and differences in the items used in measuring the outcome variables. Further studies with large sample sizes and consistent measuring items are required to explore physical activity and fruit and vegetable intake during on-and off-shift days.

8.5.2 Job demand, job control and affects

The study showed that within-person job demand was a significant predictor of anxious affect; supporting our proposed hypothesis 2. This is consistent with the findings of previous daily studies, where high daily job demand positively predicted day-level negative affect in other working populations (371–373). A daily study among FIFO workers in Australia has also indicated that within-person workload was positively associated with within-person emotional exhaustion (51). The finding in our current study aligns with the health impairment process of the job demand resource model (38), which suggests that a high workload drains the psychological and physical resources of workers and may result in energy exhaustion and subsequently health problems. Our results stress the significant role day-specific workload plays in daily emotional experiences in FIFO workers besides the association attributed to between-person differences (371). However, our study found no significant association between between-person job demands and anxious affect, which could be attributed to the small sample included in the study.

The study found that within-person job control was a significant predictor of low anxious and depressed affects and high positive affect (in-line with hypothesis 2). Similar associations were also observed between between-person job control and anxious affect and positive affect. These findings are consistent with that of earlier daily studies (394–396). In the FIFO context, a daily study has also demonstrated job autonomy to be a significant predictor of worker engagement (51). This finding is consistent with and extends to the FIFO context, the motivational mechanism of the JD-R (38). The impact job control on the psychological well-being of workers is indicated as instrumental in enhancing the mental health of workers and job satisfaction and also decreases workers' burnout by lessening the adverse effect of role strain on burnout (397).

8.5.3 Job demand, job control and health behaviours

The results of the study demonstrated no associations between within-person job demand and health behaviours (alcohol intake, fruit and vegetable intake, physical activity and sleep quality) in contrast to the proposed hypothesis that high daily job demand would be associated with poor health behaviours. Again, these findings are in contrast with previous similar daily diary studies (376,377,398). This is the first known study to examine the effect of day-specific demand on health behaviours in FIFO workers and further studies may therefore be needed. However, the study found some evidence of between-person demand as a predictor of less alcohol consumption and fruit and vegetable intake. Whereas the finding on fruit and vegetable intake mirrors the extant literature, which indicates high between-person job-related stressors are linked to lower consumption of fruits and vegetables, e.g., (399), the findings on alcohol suggest that high demand may have the benefit of decreasing the intake of alcohol in FIFO workers (again worth to note the small sample included in the study).

The study found that within-person job control was a significant predictor of alcohol consumption and physical activity. The finding on physical activity indicates that an increase in daily job control was associated with an increase in daily physical activity and supports the motivational mechanism of the JD-R (38). Job control is indicated to raise the sense of self-determination and support needs satisfaction, which sequentially improves physical activity (400). This finding suggests allowing for some autonomy in work processes on a daily basis could promote daily physical activity among FIFO workers, which is indicated may be engaged in as an activity for recovery after work (401). However, in contrast to our prediction of better health behaviours on days of high job control, this study indicated that an increase in daily job control was associated with an increase in daily alcohol intake. A previous study has also indicated high job control to be associated with the consumption of caffeine (377). This finding could be expounded by the increased chances for alcohol consumption that high-control positions are expected to provide (377).

8.5.4 Interactions between demand and job control on affect and health behaviours

In the third hypothesis, first, the study proposed that there would be interactions between the daily demand and job control, in particular, the negative impact of daily job demand on affects and health behaviours would be low when daily job control is high. In that, the buffering effect suggests high job control may lessen the distress produced by high demand, control the reactions or lessen the negative effects of the reactions to the stress on health (38). There was no evidence to support our prediction of interaction between within-person job demand (workload) and job control in predicting depressed and positive affects, sleep quality, alcohol intake, fruit and vegetable intake, and physical activity. However, there was evidence for interaction between within-person demand and job control on anxious affect to support the proposed prediction in part, suggesting that the association between demand and anxious affect is weaker amid high job control. A similar finding of the buffering effect of job control on the effect of workload in predicting affective distress has been documented (372). This finding indicates that in conditions of high demand, high control on the job may be essential in reducing FIFO workers' anxious experiences.

Secondly, the study proposed there would be cross-level interactions between the daily demand and between-person job control. There was evidence to support this prediction on depressed affect, sleep quality, and alcohol intake. On days with high demand, FIFO workers with greater job control were less likely to experience depressed affect and more likely to have better night sleep quality and consume more alcohol than those with low job control. The evidence from this study largely aligns with the fact that having job control is positive for health, but again shows that high job conditions could also provide the chance for some negative behaviours, e.g., alcohol intake, to thrive.

8.5.5 Implications for practice and research

The study reveals substantial within-person variations in psychological states, health behaviours and demand and job control over the course of FIFO work periods and confirms the significance of these daily variations in work conditions for the health and well-being of FIFO workers. This gives indications to FIFO organizations to acknowledge these within-person processes and actively screen and manage the daily variabilities that may exist in the work conditions and well-being of workers. The findings from our study also suggest that workplace interventions aimed at addressing the psychological states and behaviours of workers should also consider off-shift periods of the FIFO work cycle, particularly for health behaviours (e.g., alcohol intake).

In relation to the direct effect of daily demands on anxious affect, organizational interventions could address high demands through 1) *worker selection*, where there is the conscious effort to recruit and assign workers who have the required knowledge and skills to perform a particular job, 2) *effective training programs*, where workers and managers are offered training to assist develop the knowledge and skills needed to perform their jobs effectively, and 3) *job redesign* involving reassigning of job tasks (402).

With regards to the effect of daily job control on psychological states, alcohol intake and physical activity, FIFO organizations could implement strategies that enhance job controls, including *work redesign interventions* such as *empowerment and self-managing work teams* to efficiently deal with strenuous job demands (403). The findings of the study demonstrate that interventions that emphasise lessening job demands and enhancing job control may not be successful at all times, particularly when it comes to encouraging healthy behaviours. They might be harmful in some situations; for instance, high job controls might cause people to consume more alcohol. With the limitations associated with between-person study designs, which have been highlighted in this study, more future studies may employ within-person daily designs to significantly advance the progress in understanding how FIFO work conditions affect workers' psychological states and behaviours (377). This approach offers a refined lens that provides insight into how FIFO workers experience of health issues and their significant predictors change within day, day-to-day, over time and across context, which potentially provide significant insight into FIFO work lifestyles to inform targeted support to effectively manage workers' wellbeing.

8.5.6 Strengths and limitations of the study

This study tested the health impairment, motivational and moderation/buffer process of the job demands-resources model using a within-person multilevel design, which allows for the assessment of the variability in FIFO workers' psychological states and health behaviours over time and across context. Specifically, this study is to the best of my knowledge the first to examine the variability in psychological states over and across FIFO work periods and examine their associations with demand and job control. Again, this study is also the first to test the buffer process (moderation effects) of the Job Demands-Resources Model using within-person design in the FIFO mining context. This study also measured variables covering one complete FIFO work cycle, which may have accounted for the role of recovery during off-shift days, a time spent outside of FIFO voted work times with no work commitments and indicated to impact on recovery and well-being (51).

However, this study is not without limitations. Firstly, the study relied on self-reported measures of affects and health behaviours, which could be associated with under- and/or over-estimation of study parameters and may not truly reflect participants' experiences/feelings and acceptable health behavioural levels. Secondly, to limit the burden on study participants due to the repeated measurements over time, brief or single items were used in assessing affects and health behaviours, however, such items are indicated to show variability across time (377).

Furthermore, the study assessed affects and health behaviours using the end-of-day approach, where participants report their feelings and behaviours for the entire day at bedtime. Given that variables such as affect are indicated to show rapid variations within days (e.g., (374), more intensive assessment designs could be useful in future studies taking into consideration the FIFO work context. Additionally, the study is limited in establishing causal relationships between daily variables, despite the advantages dairy surveys have over a snapshot cross-sectional survey. Item used to measure sleep quality tend to measure sleep during the night, however, participants who worked night shifts sleep during the day, which may impact the interpretation and the responses given on sleep quality. It is known that years of participants' experience in the mining industry, in FIFO roles/settings and in specific operations could be significant in understanding the influence of job demand and control on health outcomes (404). However, the covariate effects of years of experience in FIFO settings could not be estimated in our model and the effect of years of participants' experience in the mining industry and in specific operations could not be explored due to the unavailability of data. The study was also limited in assessing the availability of facilities such as recreational facilities (including a gym), and wet mess-where alcohol is available and the quality of food provided at FIFO campsites, which could influence workers' choices and their health behaviours. Such contextual factors could be important in understanding daily differences in behaviours, particularly between on and off-shift days.

8.6 Conclusions

The study has demonstrated significant variations in the daily psychological states and health behaviours across the FIFO work cycle: FIFO workers experienced high positive affect and consumed more alcohol during off-shift days compared to on-shift days but had poorer night sleep quality during on-shift days compared to off-shift days. The study has also provided empirical evidence for the significant direct and interaction effects between demand

and job control on the psychological states and health behaviours of FIFO workers, which deepens our understanding of the mechanisms that support and impair daily job-related well-being. Further studies employing within-person daily designs are needed to provide an in-depth understanding of how FIFO work conditions affect workers' psychological states and behaviours.

8.7 Summary and link to other chapters

This Chapter has detailed the multilevel analysis of psychological states and health-related behaviours showing significant within-person variability of the affect states (positive affect) and health-related behaviours (alcohol and sleep quality) and job demand and control as significant predictors over FIFO work roster among FIFO workers. The next Chapter (9) presents further the multilevel analysis of the within-person variability of the psychological states and health-related behaviours among partners of FIFO workers.

Chapter 9: Study Eight

Preface

This chapter presents the seventh study included in this thesis, submitted for publication to *Community, Work and family* in May 2023 and is now under the first round of peer review. The article's content here is as it appears in the manuscript submitted to the journal; however, it has been formatted to align with the rest of this thesis. The systematic reviews identified potential research gaps including limited longitudinal studies that examined within-person health in partners of FIFO workers and daily diary studies as common designs in the FIFO context, this article assessed the affective states, related behaviours, and job demand and resource determinants. The study highlights the within-person effects of job demand, control, and social support on affective states and health behaviours across on and off-shift FIFO work periods.

Author contributions: BYA: conceptualization; methodology; investigation; data curation; formal analysis; visualization; project administration; writing—original draft preparation. DP assisted in formal analysis. SR, DK and DP assisted in conceptualization; funding acquisition; resources; supervision; writing—review & editing. The final manuscript was read and approved by all authors.

Study Eight: Health behaviours and affective states of partners of workers: a daily diary study.

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Acknowledgement

We received support from Mineral Resources Limited, Australia and we express our appreciation to them for supporting the study. Our sincere appreciation also goes to all the partners of FIFO workers who participated in this study.

Funding

The study was funded by the Aberdeen-Curtin Alliance.

Data availability statement

The data that support the findings of this study are not publicly available due to ethical and privacy restrictions.

Declaration of interest statement

The authors declare no potential conflicts of interest.

9.1 Abstract

Partners of Fly-In fly-Out (FIFO) workers are indicated to face increases in demands, particularly in the absence of workers, however, little is known about how the features of their daily life experiences influence their well-being across a FIFO work cycle. The study examined the within-person effects of workload, job control and social support on psychological states and health behaviours of partners of FIFO workers. Forty-four (44) partners of FIFO workers completed online diary surveys once a day for 28 consecutive days during on-and off-shift periods of the FIFO work cycle. Multilevel models analysing day-level data were done. The study indicates significant differences in depressed affect and alcohol consumption during on-and off-shift periods of the FIFO work cycle. Daily increases in workload were associated with anxious affect whereas daily increases in job control and social support were associated with low depressed affect and positive affect. A daily increase in social support was also found to be associated with an increase in daily alcohol intake. Interventions could support partners manage the daily workload and increase and encourage the execution of job controls and social support networks in partners of FIFO workers.

Keywords: FIFO, partners, affects, health behaviours, workload, job control, social support.

9.2 Background

In Australia, non-residential work arrangements have become the standard mode of employment in the mining and resources industry (21), and in recent times have been practised in the healthcare and support services to remote and regional areas (22). Frequently referred to as Fly-In Fly-Out (FIFO), such work arrangements involve workers travelling largely to remote areas to work on rotational schedules of continuous days at the workplace followed by leave periods at home known as ‘rosters’; for example 2 weeks at work and 1 week at home (21). Characteristically, FIFO workers work long hours of between 10-14 hours on day and/or night shift patterns and live in onsite accommodations separately from their families and away from their home communities during work periods (5).

FIFO work lifestyle of alternating presence and absence from home over a period, has been highlighted to impact on the workers’ partners (22,63). For instance, cross-sectional studies have identified high levels of psychological distress among partners of Australian FIFO workers as compared to the general population (7,33). Other cross-sectional studies have established higher levels of alcohol intake (7), poorer sleep quality, inadequate sleep duration, and disproportionate sleepiness (34) among partners than the general population in Australia.

Although the available studies have provided useful information on the impact of FIFO on the health of partners of workers, most of the studies and their findings are largely limited by the shortcomings of cross-sectional designs (63), including the inability to account for within-person differences over time. The unique FIFO lifestyle of intermittent absence and presence of FIFO workers, marked by different contexts and routines, provide a dynamic setting and there is the likelihood of the health outcomes and experiences of partners to vary daily and across contexts. Within-person studies could also offer some useful insights into the health outcomes of at-home partners (e.g., (13,51). However, limited within-person studies have examined the experience of health among at-home partners when workers are at home and away at work (13). The study demonstrated that partners in the absence of workers are found to engage in less exercise and poor dieting, sleep less, and smoke more whilst drinking more when workers are on leave back home (13). Partners, however, showed no differences in the intake of medications for mental health impairment during on-shift and off-shift days (13). Although the findings of the study were significant in tracking the health behaviours of at-home partners, there is still a dearth of evidence assessing the health and well-being of partners of FIFO workers during on-shift and off-shift days. Additionally, the study was limited in examining the features of their daily lives (e.g., job demands, job control and support) that may be important factors in determining the health outcomes of partners.

The Job demands and resources model (JD-R) suggests that job characteristics in every setting can be categorised broadly into two factors: job demands and job resources and such factors combine to determine health and well-being (38). Job demands are indicated as factors related to jobs that necessitate continuous efforts and as such accompanied by psychological and physical costs (38). Job resources refer to the factors that enable growth and development, are helpful to the attainment of job-related goals and limit the negative effects of job demands (38). According to the JD-R Model, exposure to high job demands will lead to health impairments/problems whereas exposure to high job resources results in high work engagement and the attaining job goal, and in effect better health outcomes. These two factors are also suggested to interact in determining the health and well-being of individuals. In that, exposure to high job resources is suggested to buffer the negative effects of job demands on health whereas working environments with low job resources put workers particularly susceptible to the negative effects of job demands (38).

The application of JD-R Model to examining the effect of FIFO work lifestyle on the health of partners of FIFFO workers is scarce. However, some qualitative studies have shown partners of FIFO workers in the absence of workers take up new and additional household duties and responsibilities in addition to their own jobs and domestic duties thereby increasing their workload (15,305). Issues around emotional demands have also been highlighted. For instance, partners are indicated to experience isolation/loneliness (305) and emotional strain arising from being the only ones dealing with daily household commitments such as bringing up the kids in addition to their jobs (15). Partners are also indicated to feel psychologically "disconnected" due to the separation/absence of the workers for a long period and that is indicated to be a source of tension and leads to relationship deterioration and breakdown (15). Furthermore, it is indicated that FIFO couples support each other through communication (15). Partners are also suggested to receive regular support from their social networks and indicated that as means to preserve their *mental health and well-being* (15). Again, some partners in the absence of workers develop a sense of control and freedom to make family decisions (307).

Understanding how partners experience health across the intermittent absence and presence of FIFO workers and how their predictors change over time is essential and has the potential to provide the evidence necessary for targeted interventions that can help improve the health of at-home partners of FIFO workers. The current study aims to examine differences in mental health and health-related behaviours over the course of a FIFO roster cycle and examine the features of their daily lives that influence the health outcomes of partners.

9.3 Methods

9.3.1 Study design, sample and procedures

A daily diary study was conducted among partners of FIFO workers in Australia. Participants were recruited through the social networks of partners of FIFO workers on Facebook. Participants were initially invited to complete an online general baseline questionnaire about their health and well-being, published elsewhere (64) and those agreeing to partake in the daily study responded to subsequent online daily surveys at the end of each day for 28 consecutive days during the on-and off-shift periods of the FIFO worker between July to December 2021.

Before the start of the daily surveys, participants were contacted by phone through their mobile numbers provided at the baseline study to talk over the start of daily surveys and the instructions on how to complete the daily surveys. Participants received the daily online surveys through SMS at 16:00 AWST each day to retrospectively report their day's experiences. The online survey portal was open until 6:00 the following day.

In enhancing participants' compliance, reminder text messages were sent the day prior to the start of the daily surveys, again with instructions on how to complete the daily surveys and every three days to urge participants to complete their surveys within the allowed time. Participants who missed a day's survey were sent text reminders before the next scheduled survey. Participants were also informed of being given personalised infographics (a sample presented in Appendix H) summarising their health outcomes data over the study period (379) and given contact details of available national support organizations for support in cases of adverse findings. All the study participants provided informed consent and the Curtin University Human Research Ethics Committee approved the study protocol (HRE2020-0693).

A total of 248 partners of FIFO workers completed the baseline survey (presented elsewhere (64), of which 79 (31.9%) consented to take part in the daily survey. Thirty-five participants drop out of the study for reasons including; could not be reached to schedule the daily surveys (n= 6), not responding to any of the daily surveys (n=13), and responding to less than required daily surveys (at least 3 daily diaries each in both the on- and off-shift phases) (n=16) (Figure 10).

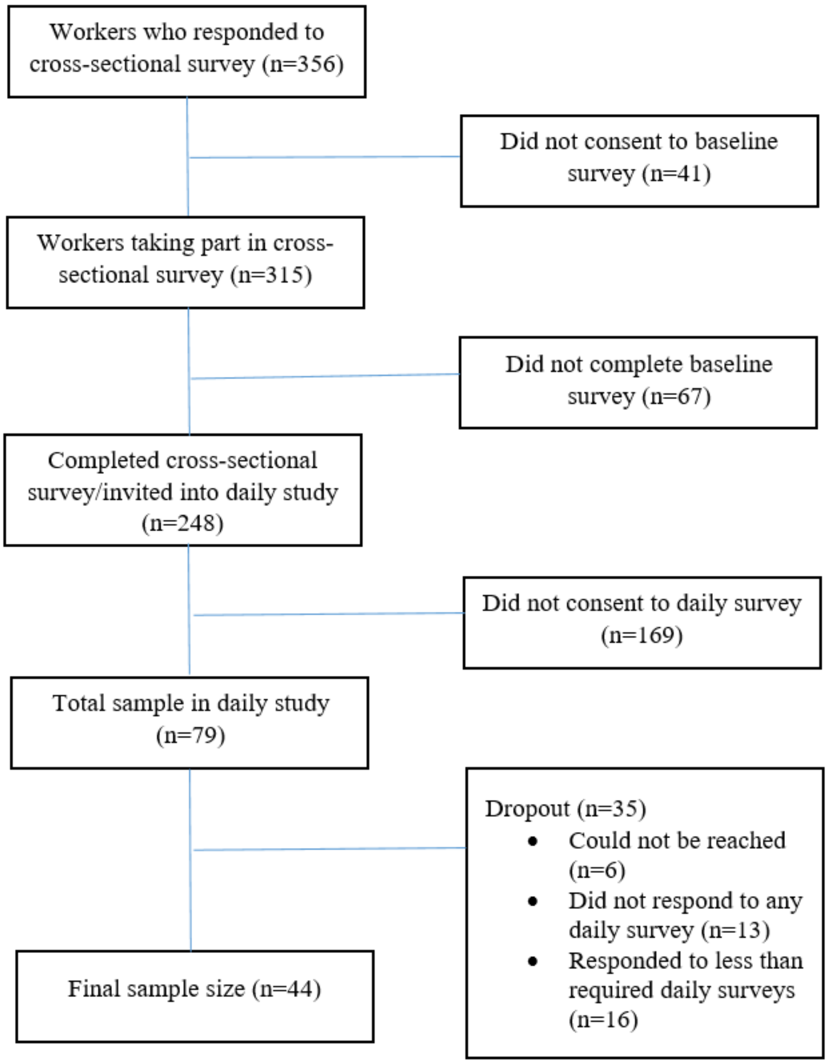

Figure 10. Flow of participants into the present study (partners).

The final study sample of 44 included all females, with a mean age of 37.38(SD=8.23) years. Most of the participants were Caucasians/White (78.3%), married/civil partnership (56.5%), had children (88.6%), and worked paid jobs (70.5%). Less than a quarter of the participants smoked (18.2%) whereas 88.6% consume alcohol. The participants reported an average body mass index of 29.26(SD=7.68)kg/m^2 and 38.6% of them had a high/very high-risk psychological distress, but most rated their physical health status as good (84.1%) (see Table 22).

Table 22. Background information on study participants (partners)

Characteristics	n(%), mean(SD)
Age (mean)	37.38(SD=8.23)
Ethnicity	
Caucasian/White	40(78.3)
Other	4(21.7)
Marital status	
Married/civil partnership	35(56.5)
De-facto/co-habiting	9(26.1)
Have children	
Yes	39(88.6)
No	5(11.4)
Educational level	
TAFE/College/Diploma	18(40.9)
Secondary education	9(20.5)
Bachelor degree	12(27.3)
Postgraduate degree	5(11.4)
Employment status	
Non-paid job	13(29.5)
Paid job	31(70.5)
Partner's duration in FIFO role (mean)	7.39(SD=5.28)
Shift pattern	
Rotation shift (mix of day and night shifts)	26(59.1)
Regular shift (fixed day)	18(40.9)
Shift length	
12 hrs	33(75.0)
>12 hrs	11(25.0)
Partner's consecutive days spent at work	16.34(SD=7.39)
Partner's consecutive days spent at home	10.34(SD=6.40)
Smoking	
Yes	8(18.2)
No	36(81.8)
Alcohol intake	
No	5(11.4)
Yes	39(88.6)
Body mass index (mean/SD)	29.26(SD=7.68)
Physical health status	
Poor	7(15.9)
Good	37(84.1)
Psychological distress	
Low/moderate risk	27(61.4)
High/very high risk	17(38.6)

TAFE= Technical and Further Education

9.3.2 Measures

Health-related behaviours. Daily sleep quality was evaluated using the item *"Last night, how would you rate your sleep quality overall?"* adapted from the Pittsburgh Sleep Quality Index (186). Participants rated their daily sleep quality on the Likert scale: 1=very good to 4=very poor and recoded as 0=very poor and 3=very good, consistent with previous daily surveys (380).

For daily alcohol use, participants were asked *"How many standard alcohol drinks did you consume today?"* adapted from the Alcohol Use Disorders Identification Test-Concise. Participants reported the number of drinks consumed in the last 24 hours selecting from a scale: “0” to “7 or more” consistent with previous studies (381).

For tobacco use, the daily number of cigarettes smoked was assessed using the item: *"How many cigarettes did you smoke today?"* consistent with previous daily study (381).

In assessing daily fruits and vegetable intake, participants were asked; *“How many servings of fruits did you consume today?”* taken from the Australian National Health Survey (192). The item was repeated for vegetables and participants selected from a scale: *0=none to 6= serves or more.* An example of a serving of fruit was given as 1/2 cup and a serving of vegetable was indicated as 1 cup of leafy green or raw salad vegetable.

For physical activity, participants were asked *"How many minutes did you do moderate or vigorous physical activities outside of work for at least 10 minutes at a time today?"* adapted from the International Physical Activity Questionnaire-short form (188) and consistent with a previous EMA study (384). Examples of moderate activities were given as “bicycling, brick walking” and vigorous activities such as aerobics, running, and sports.

Affects. Daily positive and negative affects were measured with the PANAS-X (386). Three affect indices; positive, anxious, and depressed were measured. Two positive emotions; happy and excited (Spearman Brown = 0.85), two negative anxious emotions; nervous and worried (Spearman Brown = 0.88) and another two negative emotions; sad and lonely (Spearman Brown = 0.86) were used to measure positive, anxious and depressed affect respectively. For each item, participants were asked *“How [e.g., happy] did you feel today?”* and the given feelings in the last 24 hours were rated on the scale: *‘0=not at all to*

4=extremely'. The average of the relevant items was calculated to create a composite score each for daily positive affect, daily negative affect (anxious) and daily negative affect (depressed mood), consistent with a previous EMA study (405).

Job demands and resources. Job demand assessed was workload, which is said to be a usual demand experienced by workers (388). The job resources assessed included job autonomy and social support, which are indicated as significant resources (390). Participants responded to all the items on a 7-point rating scale: 1=strongly disagree to 7 = strongly agree and later recoded as 0=strongly disagree to 6 = strongly agree.

Daily workload was assessed with the 2 items: *"Today, my workload was too heavy"* and *"Today, I did not have enough time to do my work to the best of my ability"* adapted from the Job Content Questionnaire and as used in a previous study (51). A composite score for daily workload was determined by calculating the average of the items (Spearman Brown = 0.85).

For *daily job autonomy,* 2 items of the Work Design Questionnaire (391) were used. The items were: *"Today, I had autonomy to decide on the order in which things are done on my job"* and *"Today, I had autonomy in making decisions on my job"*. The average of the items was calculated to create a composite daily job autonomy score (Spearman Brown = 0.93).

Daily social support was measured with the item: *"Today, I felt others were supportive"* adapted from a prior study (51) (see Appendix D for questionaire).

9.3.3 Data analysis

Multilevel data analyses were conducted using SPSS version 28. Descriptive statistics: means, standard deviations, and Spearman's correlations between the study variables were done. Intraclass correlation coefficients (ICCs) were calculated to estimate the attribution of variance between persons (Panels plots of daily data are presented in Appendix

J: Supplementary Information S15). Tobacco use as a dependent variable was excluded as a small number of the participants (n= 8) reported smoking.

The study examined the relationship between each of the three affects (positive, anxious, and depressed affects) and 4 health behaviours (sleep quality, alcohol intake, fruits and vegetable intake and physical activity) and FIFO work shift periods (i.e., on-and off-shift). To test this relationship, seven separate models with daily reports (Level 1) nested within persons (Level 2) were fitted. The question asked was: Are there differences in daily affects and health behaviours when the FIFO worker is at work (on-shift days) and present at home (off-shift days)?

Secondly, the relationships between each of the three affects and 4 health behaviours and job demand-resource factors were examined. To test these relationships, another seven separate models with daily reports (Level 1) nested within persons (Level 2) were fitted. The question asked was: Do higher workload, job control and social support predict affects and health behaviours? Positive, anxious and depressed affects, sleep quality, alcohol intake, fruits and vegetable intake, and physical activity were the dependent variables across models. Alcohol and physical activity were converted into categorical variables: *alcohol intake (days with no intake of alcohol (0) and days with intake of at least 1 standard drink (1))*, and physical activity *(less than 30 minutes of physical activity (0) and at least 30 minutes of moderate-to-vigorous physical activity)*, as their distributions showed zero-inflation. For sleep quality, day 1 assessments were removed for each participant to create a lag sleep quality variable so that same-day job demand and resource factors predict the next day's sleep quality. Spaghetti plots of the within-person relationships are presented in Appendix J: Supplementary Information S16.

Thirdly, the interaction of job control and social support with shift periods were tested: we tested whether the within-person effect of job control and social support on outcomes was moderated by the FIFO worker's present at home (off-shift days) or at work (on-shift days).

Linear models were fitted for positive, anxious and depressed affects and sleep quality. A generalized linear model using a negative binomial distribution with a log link function was fitted for fruit and vegetable intake and that using binomial distributions with a logit link function was fitted for alcohol and physical activity. Predictors were entered as person mean-centred variables (Level 1) to examine the within-person differences and as grand mean-centred variables (Level 2) to examine the between-person differences. Models adjusted for the covariates including age, FIFO partner's shift pattern and shift length, partner's duration in FIFO role, and FIFO partner's consecutive days spent at work and home entered as level-2 predictors. Models allowed for fixed and random effects of FIFO shift periods (on-shift vs off-shift) and random intercepts and used robust standard error estimation. Models did not converge with random slopes, and as such were omitted. An unstructured covariance matrix was used to estimate random effects and a first-order autoregressive covariance matrix was used to estimate residuals. A full information maximum likelihood estimation was specified to account for missing data. A statistical significance was set at $p<.05$. Full tables for all models are reported in full in Appendix J: supplementary information S17.

9.4 Results

9.4.1 Descriptive statistics

The descriptive statistics of the study variables are presented in Table 23. Of the possible 1232 assessments, the 44 included sample responded to 891 of the assessments (72.3%). Study participants completed 20.25(SD=7.56) days of the assessments; completing 12.02 (SD=5.76) assessments during on-shift days and 8.23 (SD=4.83) during off-shift days.

Study participants reported positive affect (M= 1.73, SD=1.01, range 0-4) at modest levels and anxious (M= 0.91, SD=1.11, range 0-4) and depressed (M= 0.98, SD=1.20, range 0-4) affects at low levels. The study participants indicated consuming less alcohol (M= 0.70, SD=1.43 standard drinks) and fruits and vegetables (3.58, SD=2.12 servings) per day. Participants indicated undertaking 18.75(SD=23.84) minutes of moderate to vigorous physical activities per day and reported fairly good sleep quality (M=1.65, SD=0.88, range 0-3).

The ICCs demonstrated that within-person variation accounted for between 38% and 80% of the variance in the study variables. The largest daily variability was seen in alcohol intake, sleep quality and physical activity as between 20% and 28% of the daily variability in these outcomes being explained by individual differences (Table 23).

Table 23. Between-person correlations of daily variables in partners

Parameters	M(SD)	ICC	1	2	3	4	5	6	7	8	9	10	11
1. Positive affect (0-4)	1.73(1.01)	0.35	1										
2. Anxious affect (0-4)	0.91(1.11)	0.57	-0.49***	1									
3. Depressed affect (0-4)	0.98(1.20)	0.52	-0.67***	0.67***	1								
4. Job demand (0-6)	2.09(1.62)	0.43	-0.27***	0.35***	0.23***	1							
6. Job control (0-6)	4.05(1.61)	0.49	0.26***	-0.36***	-0.27***	-0.48***	-0.49***	1					
7. Social support (0-6)	3.83(1. 67)	0.51	0.49***	-0.47***	-0.47***	-0.36***	-0.33***	0.34***	1				
8. Standard alcohol drinks/day	0.70(1.43)	0.20	0.19***	-0.12***	-0.11***	-0.11**	-0.10**	0.03	0.07*	1			
9. Minutes of MVPA/day	18.75(23.84)	0.28	0.17***	-0.11***	-0.12***	0.06	0.11**	0.04	-0.00	0.04	0.02	1	
10. Sleep quality (0-3)	1.65(0.88)	0.20	0.43***	-0.45***	-0.45***	-0.15***	-0.12***	0.22***	0.32***	0.00	0.01	0.11**	1
11. Fruits and vegetables (serves/day)	3.58(2.12)	0.62	0.11***	-0.12***	-0.20***	-0.02	0.01	-0.06	0.05	0.10**	-0.28***	0.09	0.08*

*p<0.05, p<0.01, p<0.001; Note: Numbers in parentheses alongside parameter labels represent the range of possible scores on that measure
M = Mean; SD = Standard deviation; ICC = Intra-class correlation, MVPA==moderate to vigorous physical activity

9.4.2 Effect of FIFO partner's shift periods on affect and health behaviours

Depressed affect was significantly higher during on-shift compared to off-shift days (γ = 0.50, SE=0.16, 95%CI= 0.17, 0.83, p=.004). Positive affect approached significance, where participants show low levels during on-shift compared to off-shift days (γ = -0.24, SE= 0.12, 95%CI= -0.50, 0.01, p=.058). On health behaviours, participants' alcohol intake tended to be less alcohol during on-shift compared to off-shift periods (Exp(γ)= 0.35, 95%CI= 0.22, 0.57, $p<.001$). However, anxious affect, fruit and vegetable intake, and physical activity showed no significant differences during on-and off-shift periods (Tables 24 and 25). Figures 11 and 12 show boxplots of the average health outcomes over on-and off-shift periods.

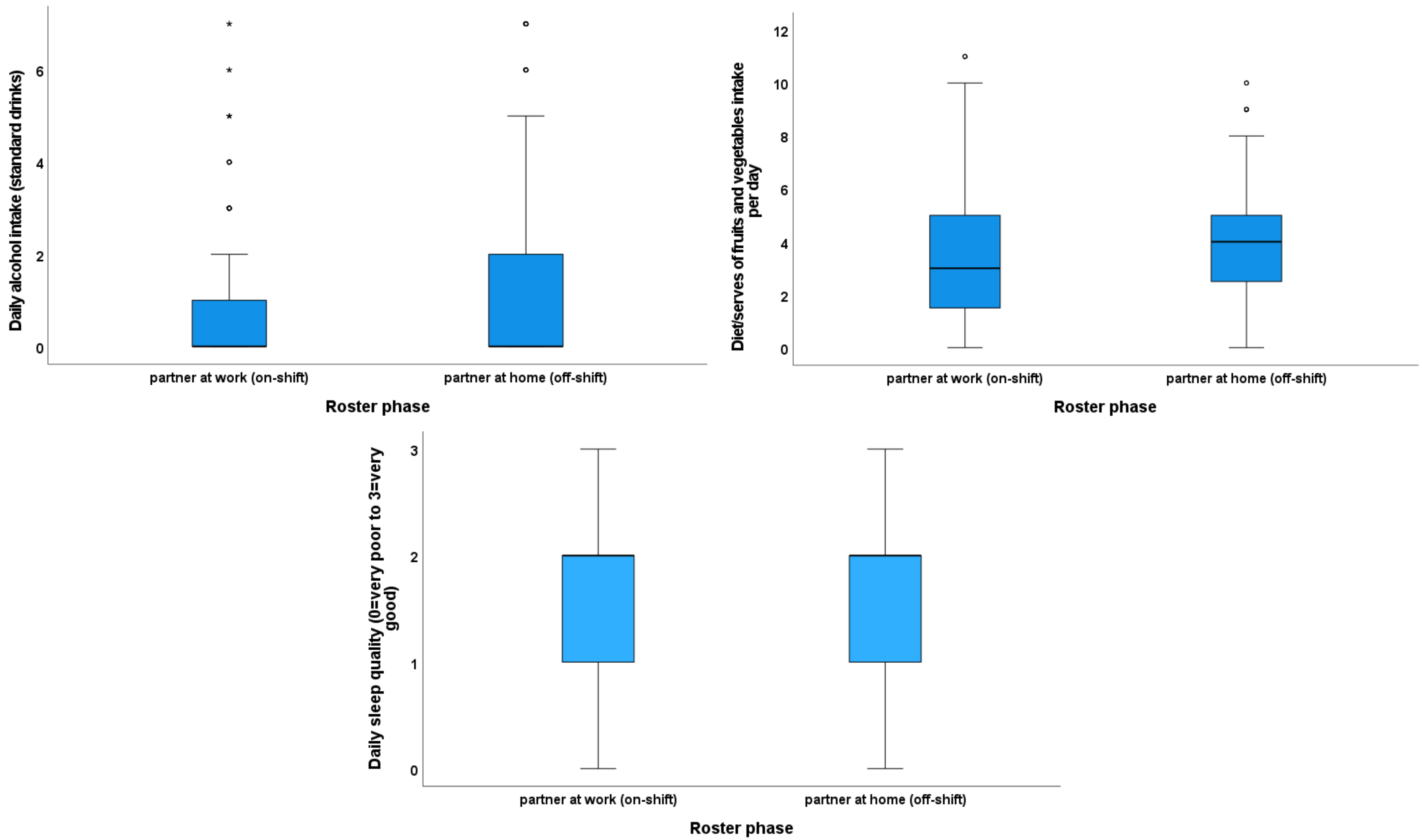

Figure 11. Boxplots of the average daily alcohol intake, fruit and vegetable intake, and sleep quality of partners of FIFO workers during on-shift and off-shift days.

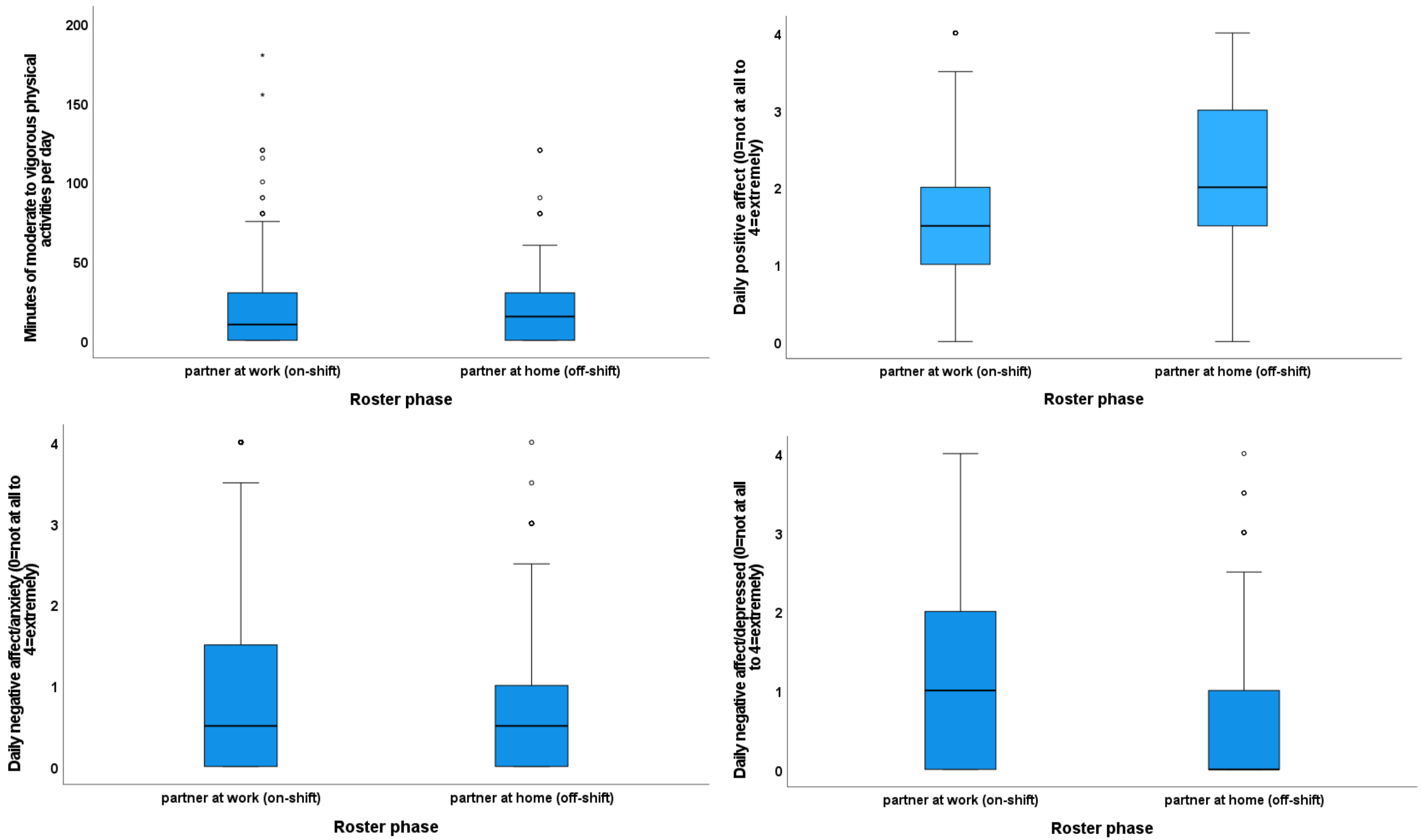

Figure 12. Boxplots of the average daily physical activity time, positive affect, anxious affect and depressive mood of partners of FIFO workers during on-shift and off-shift days.

Table 24. Multilevel linear models on the effect of shift period on affects and sleep quality in partners

Parameter	Anxious affect			Depression affect			Positive affect			Sleep quality		
	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value
Fixed effects												
Intercept	0.45(0.26)	-0.07, 0.97	0.090	0.45(0.24)	-0.03, 0.94	0.064	2.19(0.31)	1.56, 2.83	<0.001	2.19(0.20)	1.79, 2.60	<0.001
Shift period	0.17(0.12)	-0.06, 0.41	0.144	0.50(0.16)	0.17, 0.83	0.004	-0.24(0.12)	-0.50, 0.01	0.058	-0.10(0.10)	-0.30, 0.11	0.344
Random Effects												
Intercept	0.13(0.05)	0.06, 0.27	0.007	0.10(0.04)	0.05, 0.23	0.016	0.21(0.07)	0.11, 0.41	0.004	0.05(0.03)	0.02, 0.15	0.069
Shift period	0.30(0.10)	0.16, 0.59	0.003	0.70(0.20)	0.40, 1.24	<0.001	0.33(0.12)	0.17, 0.67	0.005	0.17(0.07)	0.08, 0.36	0.011
Residual												
AR1 diagonal	0.44(0.03)	0.40, 0.50	<0.001	0.40(0.02)	0.36, 0.45	<0.001	0.50(0.03)	0.44, 0.56	<0.001	0.56(0.03)	0.50, 0.63	<0.001
AR1 rho	0.11(0.05)	0.03, 0.20	0.012	0.16(0.05)	0.07, 0.25	<0.001	0.21(0.05)	0.12, 0.30	<0.001	0.12(0.05)	0.02, 0.21	0.015

SE=standard error; CI=confidence interval

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)

Shift period: on-shift days (1) vs off shift days (0) of a FIFO roster cycle

Models adjusted for covariates: day of assessment (centred at day 14), age, have children, employment status, duration spent in FIFO, partner's FIFO role, partner's shift pattern, partner's shift hours, partner's days spent at home, partner's days spent at work

Table 25. Generalised linear mixed models of fixed effects of shift period on behaviours in partners

Parameter	Alcohol intake[¥]			Fruits and vegetable[Φ]			Physical activity[¥]		
	Exp(γ)	95%CI	p-value	Exp(γ)	95%CI	p-value	Exp(γ)	95%CI	p-value
Fixed Effects									
Intercept	0.11	0.01, 1.09	0.059	2.47	1.08, 5.62	0.032	0.23	0.06, 0.88	0.031
Shift period (off-shift vs on-shift)	0.35	0.22, 0.57	<0.001	1.02	0.95, 1.10	0.559	1.26	0.63, 2.49	0.513
*Random Effects**	σ^2(SE)			σ^2(SE)			σ^2(SE)		
Intercept	2.97(1.20)	1.34, 6.57	0.014	0.35(0.12)	0.18, 0.67	0.002	2.64(1.16)	1.11, 6.25	0.023
Shift period	0.29(0.43)	0.02, 5.58	0.510	-	-	-	2.15(0.96)	0.90, 5.17	0.025
*Residual***									
AR1 diagonal	0.81(0.05)	0.72, 0.91	<0.001	0.43(0.03)	0.37, 0.50	<0.001	0.77(0.05)	0.68, 0.86	<0.001
AR1 rho	0.16(0.05)	0.07, 0.25	<0.001	0.41(0.05)	0.31, 0.51	<0.001	0.15(0.05)	0.06, 0.24	0.001

Alcohol intake: yes=1, no=0; fruits and vegetable intake: serves taken; physical activity: less than 30 minutes=0, at least 30 minutes=1
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[¥]Logistic models
[Φ]Negative binomial log model
Shift period: on-shift days (1) vs off shift days (0) of a FIFO roster cycle
[a]Random effect of shift period did not fit with covariance and when estimating variances only (diagonal) in the model predicting fruits and vegetable intake and was omitted
Models adjusted for covariates: day of assessment (centred at day 14), age, have children, employment status, duration spent in FIFO, partner's FIFO role, partner's shift pattern, partner's shift hours, partner's days spent at home, partner's days spent at work

9.4.3 Within and between-person effects of job demand, job control and social on affect and health behaviour

For anxious affect, a significant positive within-person association was found between anxious affect and workload (γ = 0.09, SE=0.02, 95%CI= 0.04, 0.13, p<.001), which indicated that participants who had a higher job demand (workload) than their daily average had a higher daily anxious affect. On the other hand, significant negative within-persons associations were observed between job control and social support and anxious affect. In that, on days participants had higher job control (γ = -0.05, SE=0.03, 95%CI= -0.10, -0.01, p=.031) and social support (γ = -0.09, SE= 0.07, 95%CI= -0.13, -0.04, p<.001) than their daily average, they reported low levels of anxious affect. Similarly, significant negative between-persons associations were also observed between job control (γ = -0.15, SE=0.07, 95%CI=-0.30, -0.01, p=.043) and social support (γ = -0.19, SE=0.07, 95%CI= -0.33, -0.06, p=.006) and anxious affect. In the model predicting depressed affect, there was a significant negative within-person association between social support and depressed affect, which showed that participants who received higher social support than their daily average had low levels of depressed affect (γ = -0.19, SE= 0.02, 95%CI= -0.23, -0.15, p<.001). Likewise, there was also a significant negative between-person association between social support (γ = -0.20, SE=0.05, 95%CI=-0.301, -0.09, p=<.001) and depressed affect. For positive affect, significant positive within-person associations were found between job control (γ = 0.05, SE= 0.02, 95%CI=0.001, 0.09, p=.047) and social support (γ = 0.19, SE=0.02, 95%CI= 0.14, 0.24, p<.001) and positive affect, showing that participants who had higher job control and social support than their daily average had a higher daily positive affect. The between-person main effects of social support approached statistical significance (γ = 0.18, p=.053) in the model.

The model predicting sleep quality showed no significant within-person associations, but a significant positive between-person association between social support (γ = 0.19, SE=

0.07, 95%CI=0.06, 0.33, p=.007) and sleep quality. The results indicated that, on average, participants who experienced higher levels of social support than their counterparts reported good sleep quality (Table 26).

For alcohol intake, there was a significant association between within-person social support and alcohol consumption (Exp(γ)= 1.34, 95%CI=1.10, 1.63, p=.003), such that with a 1-unit increase in social support received there was a 34% increase in alcohol intake. Furthermore, the models predicting fruit and vegetable intake and physical activity showed no significance predicting the main effects of workload, job control and social support (Table 27).

9.4.4 Interaction between job demand, job control, social support and roster phase in predicting health outcomes

The results showed significant interaction between within-person social support and roster phase in predicting positive affect and alcohol intake. The effect of daily social support on positive affect was lower on days that FIFO workers are absent (γ= -0.10, SE=0.05, 95%CI= -0.19, -0.001, p=.047). Similarly, partners at a high level of daily social support showed reduced odds of alcohol intake on days when FIFO workers are absent (γ=-0.56, SE=0.28, Exp(γ)= 0.57, 95%CI=0.33, 0.99, p=.046). Significant interaction was also shown between within-person workload and roster phase in predicting fruits and vegetable intake. Partners at a high level of daily workload showed increased odds of fruits and vegetable intake on days when FIFO workers were absent (γ= 0.06, SE=0.02, Exp(γ)= 1.06, 95%CI=1.01, 1.11, p=.046). Further, results showed significant interaction between within-person job control and roster phase in predicting sleep quality. The effect of daily job control on sleep quality was lower on days that FIFO workers were absent (γ= -0.15, SE=0.06, 95%CI= -0.27, -0.03, p=.015). There were no significant interactions between within-person workload, job control and roster phase in predicting depressed and anxious affects and physical activity. For tables presenting full results, see Appendix J: Supplementary Information S16.

Table 26. Multilevel linear models of within- and between-person fixed effects of psychosocial factors on affects and sleep quality in partners

Parameter	Anxious affect			Depressed affect			Positive affect			Sleep quality		
	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value	γ(SE)	95%CI	p-value
Fixed effects												
Intercept	0.74(0.20)	0.33, 1.15	<0.001	0.78(0.17)	0.44, 1.13	<0.001	1.90(0.28)	1.33, 2.47	<0.001	2.11(0.22)	1.67, 2.55	<0.001
Shift period	0.13(0.12)	-0.11, 0.36	0.282	0.45(0.17)	0.12, 0.79	0.010	-0.21(0.12)	-0.45, 0.02	0.072	-0.10(0.10)	-0.30, 0.10	0.305
Aggregate workload (between-persons)	-0.02(0.09)	-0.20, 0.16	0.800	-0.02(0.07)	-0.17, 0.13	0.793	-0.03(0.12)	-0.28, 0.23	0.831	0.15(0.09)	-0.03, 0.33	0.101
Daily workload (within-person)	0.09(0.02)	0.04, 0.13	<0.001	0.00(0.02)	-0.04, 0.04	0.826	-0.03(0.02)	-0.07, 0.01	0.172	0.04(0.03)	-0.01, 0.10	0.113
Aggregate Job control (between-persons)	-0.15(0.07)	-0.30, -0.01	0.043	-0.08(0.06)	-0.20, 0.04	0.176	0.10(0.10)	-0.10, 0.31	0.306	0.11(0.07)	-0.04, 0.25	0.156
Daily Job control (within-person)	-0.05(0.03)	-0.10, -0.01	0.031	-0.01(0.02)	-0.06, 0.03	0.543	0.05(0.02)	0.001, 0.09	0.047	-0.01(0.03)	-0.07, 0.05	0.752
Aggregate social support (between -persons)	-0.19(0.07)	-0.33, -0.06	0.006	-0.20(0.05)	-0.31, -0.09	<0.001	0.18(0.09)	-0.002, 0.37	0.053	0.19(0.07)	0.06, 0.33	0.007
Daily social support (within-person)	-0.09(0.07)	-0.13, -0.04	<0.001	-0.19(0.02)	-0.23, -0.15	<0.001	0.19(0.02)	0.14, 0.24	<0.001	-0.02(0.03)	-0.08, 0.03	0.415
Random Effects	σ^2(SE)			σ^2(SE)			σ^2(SE)			σ^2(SE)		
Intercept	0.05(0.03)	0.02, 0.15	0.063	0.02(0.02)	0.00, 0.16	0.407	0.14(0.05)	0.07, 0.29	0.009	0.04(0.03)	0.01, 0.15	0.147
Shift period	0.31(0.10)	0.16, 0.58	0.002	0.74(0.21)	0.43, 1.29	<0.001	0.28(0.10)	0.14, 0.58	0.007	0.13(0.06)	0.05, 0.33	0.041
Residual												
AR1 diagonal	0.41(0.03)	0.37, 0.46	<0.001	0.36(0.02)	0.32, 0.41	<0.001	0.44(0.03)	0.38, 0.50	<0.001	0.54(0.04)	0.48, 0.62	<0.001
AR1 rho	0.12(0.05)	0.03, 0.21	0.011	0.20(0.05)	0.20(0.05)	<0.001	0.22(0.05)	0.13, 0.31	<0.001	0.10(0.05)	-0.01, 0.20	0.071

Anxious affect (0=not at all to 4=extremely), depressed affect (0=not at all to 4=extremely), positive affect (0=not at all to 4=extremely), sleep quality (0=very poor to 3=very good)
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
Shift period: on-shift days (1) vs off shift days (0) of a FIFO roster cycle
Models adjusted for covariates: day of assessment (centred at day 14), age, have children, employment status, duration spent in FIFO, partner's FIFO role, partner's shift pattern, partner's shift hours, partner's days spent at home, partner's days spent at work

Table 27. Generalised linear mixed models of within- and between-person fixed effects of psychosocial factors on health behaviours of partners

Parameters	Alcohol intake[¥]			Fruits and vegetable[Φ]			Physical activity[¥]		
	Exp (γ)	95%CI	p-value	Exp (γ)	95%CI	p-value	Exp (γ)	95%CI	p-value
Fixed Effects									
Intercept	0.10	0.01, 0.64	0.015	2.53	1.35, 4.75	0.004	0.20	0.04, 0.90	0.036
Shift period (on-shift vs off-shift)	0.38	0.24, 0.60	<0.001	1.02	0.95, 1.09	0.618	1.29	0.64, 2.61	0.483
Aggregate workload (between-persons)	2.07	0.83, 5.13	0.117	1.01	0.74, 1.36	0.975	1.71	0.92, 3.18	0.088
Daily workload (within-person)	0.99	0.83, 1.18	0.913	1.01	0.98, 1.03	0.653	0.95	0.81, 1.13	0.567
Aggregate job control (between-persons)	1.06	0.60, 1.89	0.836	0.90	0.74, 1.09	0.293	1.75	0.80, 3.84	0.160
Daily job control (within-person)	0.97	0.80, 1.18	0.778	0.98	0.95, 1.01	0.235	1.00	0.84, 1.18	0.954
Aggregate social support (between-persons)	1.28	0.61, 2.68	0.512	1.00	0.81, 1.24	0.996	1.04	0.67, 1.63	0.865
Daily social support (within-person)	1.34	1.10, 1.63	0.003	1.02	0.99, 1.05	0.257	1.10	0.97, 1.26	0.145
*Random Effects**	σ^2(SE)			σ^2(SE)			σ^2(SE)		
Intercept	3.40(1.42)	1.49, 7.72	0.017	0.39(0.14)	0.20, 0.78	0.004	3.13(1.45)	1.26, 7.76	0.031
Shift period[a]	_-	-	-	-	-	-	2.16(0.98)	0.88, 5.25	0.028
*Residual***									
AR1 diagonal	0.87(0.05)	0.77, 0.97	<0.001	0.42(0.03)	0.36, 0.49	<0.001	0.76(0.05)	0.68, 0.86	<0.001
AR1 rho	0.17(0.04)	0.09, 0.26	<0.001	0.40(0.05)	0.29, 0.49	<0.001	0.16(0.05)	0.06, 0.25	<0.001

Alcohol intake: yes=1, no=0; fruits and vegetable intake: serves taken; physical activity: less than 30 minutes=0, at least 30 minutes=1
SE=standard error; CI=confidence interval
*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
[¥]Logistic models
[Φ]Negative binomial log model
Shift period: on-shift days (1) vs off shift days (0) of a FIFO roster cycle
[a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in models predicting alcohol and fruits and vegetable intake and was omitted
Models adjusted for covariates: day of assessment (centred at day 14), age, have children, employment status, duration spent in FIFO, partner's FIFO role, partner's shift pattern, partner's shift hours, partner's days spent at home, partner's days spent at work

9.5 Discussion

9.5.1 Summary of main findings

The study indicates significant variations in depressed affect and alcohol consumption during the on-and off-shift periods of the FIFO work cycle. The study also indicated daily increases in workload to be associated with anxious affect whereas daily increases in job control and social support were associated with low depressed affect and positive affect. A daily increase in social support was also found to be associated with an increase in daily alcohol intake.

9.5.2 Variability in psychological states and health behaviours across FIFO work cycle (on-and off-shifts)

Depressed affect was found to be significantly higher during on-shift than on off-shift days. Separations from partners occasioned during on-shift days are suggested to create physical and a sense of psychological distance, which is indicated as a source of distress for partners (15). Again, partners in the absence of FIFO workers are indicated to experience distress as they are faced with increased demands from the extra domestic roles including sole parenting (15,305). The study found no differences in anxious affect but showed partners may experience positive affect during off-shift days (p=.058). Regular and reliable communication between workers and their partners is indicated to foster interactions and family relationships (15,307). Furthermore, supporting partners, for instance through training, to develop skills to cope with the increased demands and emotional strains that accompany family separation during work periods may be needed (287).

On health behaviours, similar to the findings in a previous daily study (13) alcohol intake tended to be less during on-shift periods. Evidence has linked the consumption of alcohol in partners to the intake of alcohol in their spouses (322) since drinking alcohol is usually considered a social activity influenced by friends and family (319). The high intake of alcohol observed during off-days in partners could be attributed to the high level of alcohol consumption indicated among FIFO workers during off-shift days (40). This finding suggests that interventions targeted at addressing risky alcohol intake among FIFO workers may be extended to their partners and consider the contextual factors of alcohol drinking at home.

The study found no differences in sleep quality, fruit and vegetable intake and physical activity during on-and off-shift days. These findings do not align with a previous daily study, which has indicated poorer sleep quality, nutrition quality and less exercise during on-shift compared to off-shift days (13). While taking note of the differences in samples and measurements that may exist between the studies, further research into the impact of a FIFO work cycle on the daily health behaviours of partners of workers is warranted.

9.5.3 Workload, job control and social support on affects and health behaviours

The study indicated that participants who had a higher daily workload experienced higher daily anxious affect. Previous daily studies have similarly documented daily workload to be positively associated with daily negative emotions in different populations (371,372). As noted by the JD-R model, high workload demands need great effort expenditure and could drain workers' mental and physical resources, which could result in exhaustion and strain (38). Negative emotions have been indicated to be widely associated with job stressors (371). Importantly, this study is the first to demonstrate the effect of partners' workload on their well-being and findings have shown the significance of day-to-day workload in determining the daily psychological state of partners of FIFO workers. This suggests interventions could help partners of FIFO workers manage their daily experiences of workload, particularly during on-shift periods of a FIFO work cycle where increased demands from extra and multiple roles are indicated (15). Such interventions could include, as suggested earlier, assisting partners to develop their stress management and coping competencies to deal with the emotional strains associated with the increases in demands during work periods.

In line with documented evidence in previous literature (394), this study revealed that daily increases in job control were associated with daily low levels of anxious and depressed affects and daily increases in positive affect. Similarly, daily increases in social support were associated with daily low levels of anxious and depressed affects, and daily increases in positive affect, consistent with the finding of a previous daily study in a different population (406). These findings align with the motivational process of the JD-R model, which postulates that job resources promote engagement and reduce the psychological costs of job demands (38). Job resources are indicated to support effective coping (407). It is suggested that job control and social support facilitate active problem-solving as a strategy for coping with work demands, hence promoting well-being (408). Daily social support, for example, can assist individuals in managing the demands of their challenging jobs by offering them both practical/instrumental assistance and safeguarding them from the negative effects of stress (409). Again, our findings have indicated the significance of daily control and social support in determining the day-to-day psychological well-being of the partners of FIFO workers. Practically, interventions could target enabling partners to identify and increase available controls and social support (408) through increasing social networks (15). Interventions could also encourage partners to solve problems through available control and social support (408), particularly during on-shift periods of FIFO workers where there is increased in demands from the extra domestic roles (15).

On health behaviours, our study indicated increases in daily social support were associated with increased alcohol consumption. A similar finding has been documented in college students (410). Social motives are indicated to be among the important reasons for alcohol use and social camaraderie has been indicated to be related more strongly to alcohol use than stress-relieving coping mechanisms (411). Again, evidence suggests drinking more could be used to promote interpersonal interactions in persons with high self-esteem (412). Specific social support from friends and family is also indicated to have a negative effect on substance use if the interactions negatively encourage alcohol consumption (413). Partners of FIFO workers have indicated receiving social support from FIFO workers and peer social networks (15), and FIFO workers are indicated to consume high levels of alcohol, particularly during off-shift days providing the social context for alcohol consumption in partners. This finding suggests interventions could target the social contextual factors (social motives) in addressing alcohol consumption among partners of FIFO workers and not necessarily only target stress-coping mechanism by increasing social support.

The study found daily workload, job control and social support not to be significantly associated with sleep quality, fruit and vegetable intake and physical activity. However, previous studies have documented the effects of job demands and resources on various health behaviours in other populations (e.g., (377,398). This study is the first to examine the effects of workload, job control and social support on the health behaviours of partners of FIFO workers and further investigations are needed to further explore the effect of daily job demands and resources on the health behaviours of partners of FIFO workers.

9.5.4 Interactions between workload, job control, social support and roster phase on affect and health behaviours

FIFO roster phases are indicated to be distinct and characterised by different schedules and responsibilities for partners of workers (15). For instance, there is the indication of increased workload/demands during on-shift periods of the roster phase when partners have to up additional responsibilities in addition to their own jobs (15) and as such effects of such factors on health may be profound during on-shift periods. There was evidence for interaction between job factors including workload, job control and social support and roster phase in predicting positive affect, sleep quality, and intake of alcohol and fruits and vegetable in partners. However, the finding may not align with the above stated notion of the possible profound effect of suggested increase in workload in the absence of workers, as high workload was associated with more fruits and vegetable intake. On the other hand, findings suggest the effects of job resources (including control and support) that may mitigate the negative effects of job demands were mixed, but may be lowered in the absence of workers. The effect of daily social support on positive affect was lower but showed a positive effect in reducing the odds of alcohol intake on days when FIFO workers are absent. The effect of daily job control on sleep quality was also lower on days that FIFO workers are absent. This is the first known study to examine the interactive effect of day-specific demand and resources on health outcomes in partners of FIFO workers and further studies may therefore be needed.

9.5.5 Strengths and limitations

This study is to the best of our knowledge the first to examine the variability in psychological states over and across FIFO work periods among partners of FIFO workers. It is also the first to examine the effects of workload, job control and social support on the psychological states and health behaviours of the partners of FIFO workers applying within-person study design.

However, some limitations to the study are identified. Despite the advantages diary surveys have over a snapshot cross-sectional survey, causal interpretations of findings are limited in this study. Daily measures were reported at the end of the day, summarising participants' feelings and behaviours over the day. However, within-day variability has been shown in variables including affects (374) and may warrant more intensive assessment designs to capture the existing temporal dynamics in such variables. The study's reliance on self-reported measures of affects and health behaviours may fail to accurately capture participants' experiences and health-related behaviours. Short or single questions were chosen to measure affects and health behaviours to maintain brevity, however, such items are likely to vary over time (377). A smaller number of participants was included in the study and that may limit the extent to which the findings of the study could be generalised.

9.6 Conclusion

The study has shown partners of FIFO workers experience higher daily depressed affect during on-shift days compared to off-shift days and consume more alcohol during off-shift days than during on-shift days. The study indicated daily increases in workload to be associated with anxious affect whereas daily increases in job control and social support were associated with low depressed affect and positive affect. Daily increases in social support were also found to be associated with increases in daily alcohol intake. Interventions could support partners manage their daily workload and increase and encourage the execution of job controls and social support networks. Further within-person design studies are required to provide a further in-depth understanding of the effect of daily conditions on health, particularly the health behaviours of partners of FIFO workers.

9.7 Summary and link to other chapters

This Chapter has described the multilevel analysis of psychological states and health-related behaviours showing significant within-person variability of the affect states (depressed affect) and health-related behaviours (alcohol) and job demand, control and social support as significant predictors over a FIFO work roster among partners of FIFO workers. The next chapter provides a general summary and discussion of the key findings of the research presented in this thesis.

Chapter 10: General discussion and conclusion

10.1 Overview of the chapter

This thesis presents an in-depth research on health-related outcomes in FIFO workers and their families. This research is one of the first studies to evaluate health-related work productivity loss cost specifically in FIFO workers and use within-person design to examine job stress factors and test the moderation (buffering) of job resources on the effect of job demands on health outcomes of workers and their partners across the FIFO roster cycle. Through the included published work, this research has highlighted a number of important findings worthy of consideration.

This chapter summarises the key findings of the research in the context of other literature and current Australian occupational health policy and recommendations for FIFO work arrangements. It also outlines the strengths and limitations of the research and describes implications for policy, practice and future research in FIFO work arrangements. Figure 13 presents an overview of the key findings relevant to each research objective and implications.

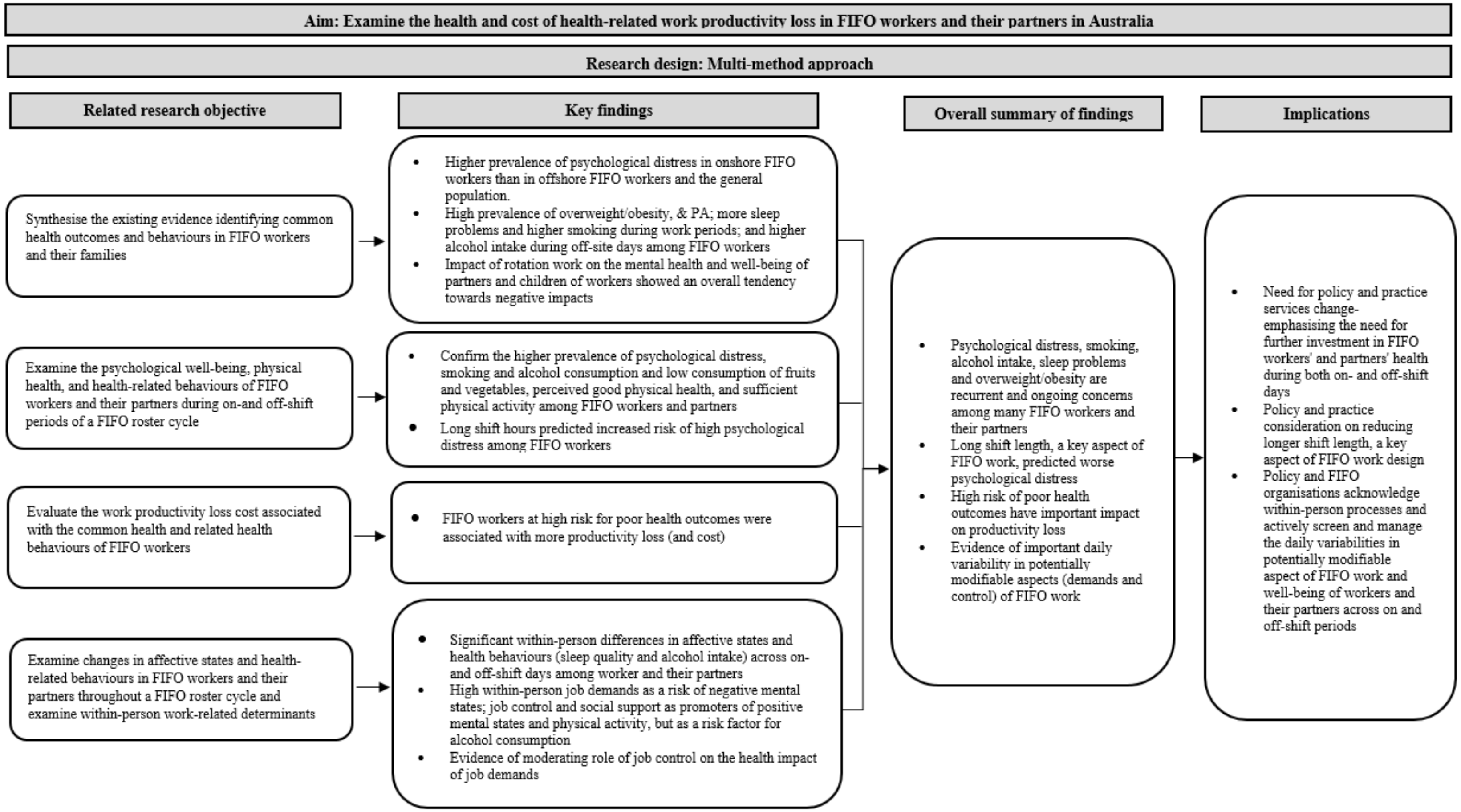

Figure 13. Overview of the key findings relevant to each research objective and implications

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10.2 Summary and discussion of key findings of the research program

10.2.1 Worldwide evidence on the key health outcomes related to FIFO work among workers and their families

Results from the first two systematic reviews (chapters 2 and 5) showed a higher prevalence of psychological distress in onshore FIFO workers than in offshore FIFO workers and the general population. FIFO workers generally perceived their physical health status as good and reported a high prevalence of physical activity. However, they also reported a high prevalence of overweight and obesity and perceived poor nutrition on worksites. Furthermore, workers reported more sleep problems and higher levels of smoking during work periods; and higher alcohol intake during off-shift days. Previous reviews reported similar results on distress in onshore and sleep, smoking and alcohol intake in offshore rotation workers (7,74).

The results from the reviews showed that the impact of rotation work on the mental health and well-being of partners and children of rotation workers though mixed, showed an overall tendency towards negative impacts. Findings suggested partners may experience greater loneliness and poorer sleep quality during on-shift days, and children's emotions and behaviours may be negatively affected by FIFO work arrangements. Similar observations have also been made in previous reviews (7,22) and a recent study, which indicated children show mixed (positive and negative) emotions and behaviours in adjusting to the rotation workers' transition to work and back home (414).

10.2.2. Psychological well-being, physical health and behaviours of FIFO workers and their partners over the course of a FIFO roster cycle

Given the research gaps identified in the reviews, two studies were carried out with cross-sectional designs to examine the psychological well-being, physical health, and health-related behaviours of FIFO workers (Chapter 3) and their partners (Chapter 6) across a FIFO roster cycle. The results demonstrated that FIFO workers and partners had a high prevalence of psychological distress, smoking, alcohol consumption and overweight/obese, and low intake of fruits and vegetables. The findings also showed that FIFO workers engaged in sufficient MET minutes of physical activity and had good physical health status. These results are in line with the findings from previous studies examining psychological distress (7,27,28,33,415), physical health (13,304), and health behaviours (7,35,99) of FIFO workers and their partners. The observed rates of psychological distress, smoking, alcohol intake and overweight/obesity are higher than reported in the general Australian population (194,201,213,332,416).

The analysis also demonstrated longer sleep duration and better sleep quality, alcohol intake more often at risky levels, and higher vegetable intake during off-shift days, whereas engaging in more MET minutes of physical activity among workers during on-shift days. Partners reported shorter sleep duration, poorer sleep quality and smoking more cigarettes during on-shift days. These findings are consistent with the results of earlier studies (13,16,34,52). Working long shifts was associated with an increased risk of high psychological distress among FIFO workers. Similar to the results in previous studies among mining workers (29,215) and a recent study among FIFO workers (415).

10.2.3 Cost of health-related work productivity loss among FIFO workers in the mining industry in Australia

Whilst the chapters above provided new information about psychological distress, physical health and related behaviours among FIFO workers and their partners, it was also important to examine absenteeism and presenteeism among workers as a measure of the financial impact of their health on work productivity loss. The research results presented in Chapter 4 showed that among FIFO workers, a high risk for psychological distress, poor physical health, smoking, sleep problems, weight problems, risky alcohol intake, poor diet, and insufficient physical activity was, on average, associated with 3.87% more productivity loss (absenteeism: 1.27% and presenteeism: 2.88%) than those with low risk. These findings were consistent with evidence from previous studies among the general mining population (47,232,239). The results showed that health and related behaviours account for an estimated annual additional productivity cost due to absenteeism of AUD 8.82 million, presenteeism of AUD 14.08 million and a total productivity loss of AUD 20.96 million per 1000 workers. Previous studies have documented comparable findings in the Australian general mining population (46,47,49). Furthermore, the results observed that a high risk of psychological distress, poor physical health, poor sleep and insufficient physical activity independently predicted work productivity loss. These findings align with existing studies' findings among the general working population (239,245,254,259,261–264,417).

10.2.4 Within-person effects of job demands and resources on affective states and health behaviours of FIFO workers and their partners across the FIFO work cycle

This research demonstrates significant levels of psychological distress and risky health behaviours among FIFO workers and their partners, highlighting cross-sectional differences in health-related behaviours across on-and off-shift periods of the FIFO lifestyle. The within-person analysis showed that workers (Chapter 8) had significantly lower positive affect, poorer sleep quality, and consumed less alcohol during on-shift compared to off-shift days. Partners (Chapter 9) also reported significantly higher depressed affect during on-shift days and alcohol consumption during off-shift days. Similar findings on sleep quality and alcohol intake are reported in previous daily studies among FIFO workers (13,393) and their partners (13) in Australia; however, this study is the first to examine affective states during on-and off-shift periods.

Evidence (Chapter 8) showed that within-person job demand significantly predicted anxious affect. Within-person job control was a significant predictor of low anxious and depressed affects, high positive affect, and increased daily physical activity and alcohol consumption among FIFO workers. Analysis also showed an interaction between job demand and control on anxious affect, depressed affect, sleep quality, and alcohol intake in FIFO workers, suggesting that the effect of job demand is weaker amid high job control.

Furthermore, results in partners (Chapter 9) also indicated that daily increases in job demand were associated with anxious affect. In contrast, daily job control and social support increases were associated with low depressed affect and high positive affect. Further, a daily increase in social support was associated with increased daily alcohol intake among partners. Analysis also showed an interaction between job factors including workload, job control and social support and roster phase in predicting positive affect, sleep quality, and intake of alcohol and fruits and vegetable in partners, suggesting that the effects of job resources (including control and support) may be lowered in the absence of workers.

Similarly, a daily study among construction FIFO workers in Australia has also indicated that within-person workload is positively associated with daily emotional exhaustion, and job autonomy is a significant predictor of daily work engagement (51). The finding in this current research broadly aligns with the health impairment, motivational and buffering effect processes of the job demand resource model (38). The health impairment process suggests that high job demands drain the psychological and physical resources of workers and may result in energy exhaustion and subsequently health problems whereas the motivational process proposes that job resources promote engagement and reduce the psychological costs of job demands (38). In the buffering effect process, the motivational factors are indicated the lessen the effects of the health impairment process of job demands (38).

10.3 Implications

Addressing health challenges faced by FIFO workers should be essential for policymakers and resource industry management. In this regard, organisations should support interventions that identify, prioritise and mitigate against mental health issues and promote well-being and positive behavioural changes. The various chapters presented in this thesis provide a detailed discussion of the implications of the study findings. The broad implications of the research program are presented below.

10.3.1 Policy and practice

Psychological distress/mental health. The findings of this thesis demonstrate high levels of psychological distress in FIFO workers and their partners. These findings have shown psychological distress as a recurrent and ongoing concern among FIFO work populations (workers and partners). Evidence suggests that the intermittent presence and absence of FIFO workers can negatively impact at-home partners (64). These findings suggest the need for continuous efforts/interventions aimed at helping workers to adapt and maintain balance in life and promote the mental health and well-being of workers. The findings also suggest that policy and organisations wishing to promote the mental health and well-being of workers should extend support mechanisms to the families of the workers.

Current policy and code of practice in Australia require FIFO organisations to create "*a mentally healthy workplace"*- meaning, *"preventing or mitigating harm"* (214) (p1). For instance, providing early support for workers showing signs of or experiencing distress (214). The research demonstrated long shift length, a key aspect of FIFO work, to be associated with high mental distress among workers. Long shift length is indicated to prolong exposure to job demands, and adverse physical conditions and reduced time for recreational activities (415). Interventions targeted at reducing longer shift length and adding more frequent and longer breaks could reduce distress experienced by workers.

Interventions/strategies could also include improved communication with families, and promoting a supportive environment (7,15). Individual and organizational focused interventions that enhance the coping skills of workers to deal with or manage job related stress have been indicated to improve the mental health of workers in the mining sector (418). Mindfulness-based and behavioural activation interventions (419,420) entailing training and developing stress coping skills/resiliency and behavioural activation (an aspect of cognitive behaviour therapy that assists distressed individuals to reconnect with possible/potential sources of positive reinforcement, develop task-driven objectives, decrease negative reinforcement trends and lower avoidance (421)) have been indicated to reduce symptoms of depression and anxiety among mining workers. Interventions could include developing training and mentoring programs to increase the capacity to understand and manage the demands and challenges of rotation work lifestyles (306) and to deal with the family demands among partners (305). Programs could also include developing workers' and partners' stress management skills and their ability to cope with the associated emotions around the intermittent presence and absence of spouses and demands of FIFO work (305,306).

Employee Assistance Programs (EAP) (39,422) include increasing awareness and providing assistance on mental health problems have been indicated. Such peer-support networks that are able to identify at risk individuals and assist co-workers and families in identifying where to seek mental support have also demonstrated positive outcomes for FIFO workers and their families. Available onsite support programs such as onsite peer-based mental health programs (422) and chaplaincy and services such as counselling services (39,151) have the potential to help workers overcome the worry that they might lose their job if they seek help for mental health issues. Corporate chaplains or a modern “workplace chaplain” could include priests and laypersons with different training and religious (or non-religious) backgrounds (146). Again, such programs can mitigate the stigmatisation and workplace culture of masculinity associated with seeking help for mental health issues and promote the mental health and well-being of workers (151).

Sleep and health behaviours. The findings of this thesis demonstrate relatively high levels of smoking, alcohol intake and sleep problems, and low consumption of fruit and vegetables in FIFO workers and their partners. Continued and strengthened efforts/interventions in addressing these high-risk health behaviours are needed. For instance, stress management programs (206,207), including mindfulness exercises and behavioural activations and interventions. Behavioural interventions could include behavioural change techniques such as action planning, coping planning, and habit formation to put healthy behaviours into practice to ensure that health behaviours during on- and off-shifts are optimised. Family members who are left at home could also be targeted with behavioural and social support interventions. Workers and partners could support each other emotionally through consistent and effective communication when the FIFO person is away. Furthermore, intervention could continue to emphasise the restriction of the availability of alcohol and increasing awareness of the negative health consequences of risky alcohol intake and smoking (423). Other interventions may include reducing long shift length. Reducing the length of long shifts could lessen workers' prolonged exposure to job demands, reduce their level of distress, and address the health behaviour problems that have been identified among FIFO workers. It has been shown that these behaviours may be primarily used as coping mechanisms for high levels of distress. The reduction of long shift length can increase off-shift time to engage in recreational activities and rest/sleep and to reduced the accumulation of fatigue (415). FIFO work schedules that target delayed morning shift starts and allow for breaks and enough periods between shifts could also be considered to promote sleep for rest and recovery (52).

Within-person variability across on-and off-shift days. The research demonstrated substantial within-person variations in affective states, health behaviours, job demands, job control, and support over on-and-off FIFO work periods. Evidence indicates that policy and FIFO organisations acknowledge these within-person processes and actively screen and manage the daily variabilities in the work conditions and well-being of workers and their partners. The findings from the research also suggest that workplace interventions aimed at addressing the psychological states and behaviours of workers may also consider off-shift periods of the FIFO work cycle, particularly for health behaviours (e.g., alcohol intake) and also include the partners of these workers.

Currently, the code of practice in Australia requires organisations "*to protect and promote the health and well-being of workers"*, which includes "*identifying then eliminating or minimising work-related psychosocial hazards by managing their associated risks"* p1(214). Interventions should target creating work environments that minimise the negative aspects of rotation workstyle and maximise the positive aspects to support rotation workers to reduce job stress and promote health. This research suggested ongoing strategies and interventions that identify and address high job demand (e.g., workload). FIFO organisations could implement strategies that seek to enhance job control, including work redesign interventions such as empowerment and self-managing work teams (or self-managing teams) to deal with strenuous job demands (403) efficiently. With self-managing teams, jobs are reconfigured for workers to increase role coordination and additionally, empowered them to take charge of a variety of supervisory responsibilities (424). Usually, members of the team share responsibility for accomplishments, have autonomy in task distribution and work schedule, can carry out multiple roles simultaneously, coach each other to acquire different job skills, assess each other's contributions, and are accountable for the overall quality of work produced by the team (424). Self-managing teams have been indicated to be more effective compared to conventional-managed groups (425); increasing proactivity of workers (426), job autonomy (427) and job satisfaction (424). For instance, a self-managing team approach (e.g., peer coaching), have been found to increase the proactivity and well-being of digital engineering workers in Finland (426) and increase autonomy and job satisfaction among Nurses in elderly care (427).

Furthermore, interventions should also be extended to partners of FIFO workers to help manage their daily experiences of job demands and identify and increase job controls and social support (408) through increasing social networks (15). Partners could be encouraged to solve problems by enhancing their autonomy and social support systems (408), particularly during on-shift periods of a FIFO work cycle, where increased demands from different and multiple roles are indicated (15).

Co-design programs and interventions that support workers and their families with health and well-being could also be considered. It is suggested that peer support, personalised choices, connections and a sense of identity, as well as the ability to obtain information and skills training, may be the driving forces behind the success of such interventions, especially for people dealing with mental health issues (428). Such interventions could be delivered through online platforms and mobile devices, particularly for populations that are physically spread out such as the FIFO work population, which may pose considerable logistical difficulties (429). For instance, a co-designed intervention administered through social media has been indicated as practical and linked to decreased psychological distress among emergency service personnel and their partners (430).

The research demonstrated that interventions that emphasise lessening job demands and enhancing job control and social support may not always be successful, particularly when it comes to encouraging specific behaviours such as alcohol intake. Future research should explore further the effects of job resources on the health behaviours of the FIFO work population.

Financial impact. There is an urgent need for cost-effective workplace interventions to improve health and well-being among workers and partners, which may reduce work productivity loss (271,272). Evidence from this research has given a strong indication of the financial implications of high health risk in FIFO workers. It has highlighted the financial justification that could support the need for targeted/prioritised workplace health interventions and the basis for evaluating the impact of those interventions.

10.4 Strengths and limitations of the research

10.4.1 Strengths of the research

This research was the first to examine the variability in affective states of workers and partners and examine the effects of job demand, job control and social support on the psychological states and health behaviours of workers and their partners applying within-person study design across FIFO work periods. This study is also the first to test the buffer process (moderation effects) of the job demands-resources model using within-person design in the FIFO mining context. Additionally, this research is one of the first to evaluate the work productivity loss cost associated with multiple health outcomes specifically in FIFO workers

The research, through systematic reviews, provided a comprehensive overview of the health and well-being of rotation workers and their families and associated factors in the resource industry, assessing the literature across different work sectors, countries and relevant health indicators. The use of a mixed methods approach was also a strength providing in-depth insights into the health outcomes of rotation work. The reviews were conducted per international standards/guidelines and registered in the prospective international register of systematic reviews (PROSPERO).

This research provides a theoretical viewpoint into the health and well-being of the FIFO work population, mostly limited in FIFO research (7). This research used several theoretical frameworks to explain the health and well-being of FIFO workers and their partners.

A further strength of this research is the measure variables covering one complete FIFO work cycle, which may have accounted for the role of recovery during off-shift days, a time spent outside of FIFO voted work times with no work commitments and indicated to impact on recovery and well-being (51). This research recruited participants from multiple sources, including a diverse sample (from different ranges of site locations and organisations) and presented diverse insights into the perspectives of the health and experiences of FIFO workers and partners. This thesis also comprises several published studies that have undergone a rigorous peer review process- strengthening and confirming the quality and importance of the research.

10.4.2 Limitations of the research

The limitations of this research should be acknowledged. First, the systemic reviews included only published research and studies published in English; as such, the study results might be subject to publication bias and have limited scope.

Second, this research employed a non-random sampling technique to recruit participants, which may present samples not typical or representative of the FIFO workers and partners' population and self-selection bias, where the workers and partners who were either positively or negatively affected by FIFO lifestyle may select to take part or not to take part in the study. Also, it is acknowledged that the research was conducted in Western Australia (WA); whilst WA is the biggest state with the majority of the mining industry it may not be representative of the broader Australian context. However, the use of an additional online recruitment strategy through the social media platform Facebook to recruit general FIFO mining workers in Australia could have assisted in increasing the diversity of the participants included in the research.

The study relied on self-reported measures of study variables, which could be associated with under-and/or over-estimating study outcomes relative to the use of objective measures. The use of non-validated scales in measuring some outcomes is also acknowledged as a limitation in the current research. Furthermore, the study assessed affects and health behaviours using the end-of-day approach, where participants reported their feelings and behaviours for the entire day. Given that variables such as affects are likely to show rapid variations within days (e.g., (374), a more intensive assessment design could be useful in future studies taking into consideration the FIFO work context.

Additionally, the findings from this research do not allow for the establishment of causal interpretations regarding the relationships between shift periods and work-related factors and the health and well-being of FIFO workers and partners. Despite the inclusion of longitudinal dairy studies, which has advantages over a cross-sectional survey, the key variables were evaluated at the end of the day in the same questionnaire and cannot capture if the predictor occurred before the outcome in time (431).

Finally, the research was conducted at a heightened time of global distress caused by the COVID-19 pandemic. Data collection was conducted between July and December 2021 when restrictions, interstate and international border closures and quarantines associated with the pandemic were still in force in Australia, and had necessitated changes to FIFO work arrangements, such as prolonged FIFO rosters and restrictions on workers returning home. These measures have been linked to negative health-related behaviours (216,217) and psychological distress (218), and could/will have impacted the results of this research.

10.4.3 Future research directions

The effect of several personal and work-related characteristics on psychological and physical health was not statistically significant in this research (Chapter 2 and Chapter 5). Future research using more representative samples of the FIFO work population and across the broader Australian context would be needed to further examine what personal and FIFO work-related characteristics (such as roster length, roster ratio, shift patterns, shift length, job types) influence the health and behaviours of workers and their partners across the FIFO roster cycle. Future research could further examine the influence of other FIFO schedule attributes/factors such as shift start times, short breaks within shifts, and travel times between home and the worksite, which have been highlighted as related stressors and could impact on the health and well-being of FIFO workers (7,23,52,53,142,164,369). Future research could also include cross country comparisons to explore the differences in aspects of FIFO work across countries that impact the health and wellbeing of workers and their families.

Given the limitations associated with between-person study designs, future studies may employ within-person designs to increase understanding of how FIFO work conditions impact workers' psychological states and behaviours (377) that change over time. This research is the first to examine the effects of job demand, job control, and social support on the health behaviours of workers and partners of FIFO workers. Further investigations using assessment designs that are more intensive than once daily would be needed to explore the within-day dynamics of job demands and resources. It is probable that the acute demands and availability of resources vary significantly even within days and this may help elucidate more-specific job factors that are particularly stress-sensitive. This would need to be balanced against the additional burden that such an assessment protocol would bring. Further longitudinal dairy studies may also test the causal relationships between job demands and resources predictors and health outcomes of workers and their partners in time.

In addition to the ideas outlined above future research could focus on a number of areas outlines below:

1) The co-design, implementation and evaluation of workplace interventions aimed at improving the health outcomes of workers and to support their families across on-and off-shift periods of the FIFO work roster cycle and those targeted at roster patterns and shift length of FIFO work. Such research could employ randomized control trial and within-person designs to examine the effectiveness and explore the within-persons, within-day, day-to-day, over time and across context variability and impact/effectiveness of interventions.
2) Effectiveness evaluation of interventions could include prior and regular analysis of productivity loss cost using possible objective measures of work productivity loss (particularly absenteeism) and health outcomes (from medical records), and cost effectiveness of interventions.
3) Analysis of the impact of new industry measures aimed at controlling substance use during on-shift periods including some level or full alcohol restrictions at some worksites, and pre-shift breath tests for alcohol and unplanned substances/drugs testing on substance use (such as alcohol and drugs) during off-shift periods.
4) Evaluation of new FIFO accommodation styles/options and examine their impact on the health and wellbeing of workers and their families as the organization our research collaborated with in WA has set to roll out new styles such as the Resort-style accommodations.

10.5 Conclusions

This research has provided evidence of the broad overview of the health and well-being outcomes and their work-related predictors in FIFO workers and their families. The research gives valuable insights about the health-related work productivity loss cost, the health implication of FIFO roster (on-and off-shift days) and within-person job demands (workload) and resources and the buffering effect of job resources to inform policy, occupational health practitioners and targeted interventions among FIFO workers and their partners.

The research brings to light the issues of psychological distress, smoking, high alcohol intake and sleep problems, low consumption of fruits and vegetables, and overweight/obesity as recurrent and ongoing concerns among FIFO workers and their partners, and are associated with high work productivity loss cost. Significantly, the research draws attention to the differences in psychological states and behaviours that may exist across on-and off-shift periods; high within-person job demands as a risk of negative mental states; job control and social support as promoters of positive mental states and physical activity, but as a risk factor for alcohol consumption; and the moderating role of job control on the health impact of job demands.

In addressing these concerns, the research suggests potentially modifiable aspects of FIFO work – particularly job control – may help alleviate the impact of job demand (workload) on poorer health behaviours and mood. The presented research's overall implications point towards the need for policy and company service provision change – emphasising the need for further investment in FIFO workers' and their partners' health during both on-shift and off-shift days.

References

1. Storey K. The evolution of commute work in the resource sectors in Canada and Australia. Extr Ind Soc. 2016;3(3):584–93.

2. Storey K. Fly-in/fly-out and fly-over: Mining and regional development in Western Australia. Aust Geogr. 2001;32(2):133–48.

3. Mckenzie FH. Fly-in fly-out : the challenges of transient populations in rural landscapes. In: Luck G, Black R, Race D, editors. Demographic Change in Australia's Rural Landscapes Landscape Series. Springer, Dordrecht; 2010. p. 325–74.

4. Korneeva Y, Simonova N. Job Stress and Working Capacity among Fly-In-Fly-Out Workers in the Oil and Gas Extraction Industries in the Arctic. Int J Environ Reserch Public Heal. 2020;17(21):7759.

5. McKenzie FHM, Hoath A. The socio-economic impact of mine industry commuting labour force on source communities. Resour Policy. 2014;42:45–52.

6. Barclay M, Harris J, Everingham J, Kirsch P, Arend S, Shi S, et al. Factors linked to the well-being of fly-in, fly-out' workers. Brisbane, QLD: University of Queensland; 2014.

7. Parker S, Fruhen L, Burton C, McQuade S, Loveny J, Griffin M, et al. Impact of FIFO work arrangements on the mental health and wellbeing of FIFO workers. Australia: Centre for Transformative Work Design; 2018.

8. Parkes KR. Working hours in the offshore petroleum industry, Current knowledge and research needs regarding extended work periods and shift work offshore. In: Work time arrangements in the petroleum industry. Stavanger, Norway: Petroleum Safety Authority; 2007. p. 1–27.

9. Parkes K. Work environment, overtime and sleep among offshore personnel. Accid Anal Prev. 2015;99:383–8.

10. Rodrigues Menezes MC, Nogueira Pires ML, Benedito-Silva AA, Tufik S. Sleep parameters among offshore workers: an initial assessment in the Campos Basin, Rio De Janeiro, Brazil. Chronobiol Int. 2004;21(6):889–97.

11. Mckenzie F, Mckenzie FH, Hoath A. Fly-In/Fly-Out, Flexibility and the Future: Does Becoming a Regional FIFO Source Community Present Opportunity or Burden? Geogr Res. 2014;52(4):430–41.

12. Perry M, Rowe JE. Fly-in, fly-out, drive-in, drive-out: The Australian mining boom and its impacts on the local economy. Local Econ. 2015;30(1):139–48.

13. Rebar AL, Alfrey KL, Gardner B, Vandelanotte C. Health behaviours of Australian fly-in, fly-out workers and partners during on-shift and off-shift days: an ecological momentary assessment study. BMJ Open. 2018;8(12):1–7.

14. Australian Bureau of Statistics. Fly-In Fly-Out (FIFO) Workers No. 6105.0. Canberra, Australia; 2014.

15. Gardner B, Alfrey KL, Vandelanotte C, Rebar AL. Mental health and well-being concerns of fly-in fly-out workers and their partners in Australia: a qualitative study. BMJ Open. 2018;8(3).

16. Tuck J, Temple EC, Sipek M. Wellbeing of fly-in /fly-out and drive-in/drive-out employees : Evidence from Australia. 6th Int Conf Sustain Dev 603 Miner Ind 30 June – 3 July 2013, Milos island, Greece. 2013;8(June):95–100.

17. Australian Mines and Metals Association. AMMA Drug & Alcohol Testing Survey 2016 [Internet]. Vol. 1. 2016. Available from: http://www.areea.com.au/wp-content/uploads/2016/10/AMMA-Drug-and-Alcohol-Testing-Survey-report-2016-final.pdf

18. Al R, Fitzgerald S, Ellem B, Goods C. FIFO and global production network: exploring the issues. Abl. 2014;40(2):98–115.

19. Parkes KR. Psychosocial aspects of stress, health and safety on North Sea installations. Scand J Work Environ Heal. 1998;24(5):321–33.

20. Gallegos D. Fly-in fly-out employment: Managing the parenting transitions [Internet]. 2006. Available from: http://researchrepository.murdoch.edu.au/id/eprint/10916/1/aeroplanes.pdf

21. Storey K. Fly-in/fly-out: Implications for community sustainability. Sustainability. 2010;2(5):1161–81.

22. Meredith V, Rush P, Robinson E. Fly-in fly-out workforce practices in Australia: the effects on children and family relationships. Child, Family, Community Australia; Information Exchange. Melbourne: Australian Institute of Family Studies; 2014.

23. Henry P, Hamilton K, Watson S, MacDonald N. FIFO DIDO Mental Health Research Report. Perth: Sellenger Centre for Research in Law, Justice and Social Change, Edith Cowan University; 2013. 1–107 p.

24. Langdon RR, Biggs HC, Rowland B. Australian fly-in, fly-out operations: Impacts on communities, safety, workers and their families. Work. 2016 Oct;55(2):413–27.

25. Education and Health Standing Committee. The Impact of FIFO Work Practices on Mental Health: Final report. Report 5. Perth: Parliament of Western Australia; 2015. 1–167 p.

26. House of Representatives Standing Committee on Regional Australia. Cancer of the Bush or Salvation for our Cities?: Fly-in, fly-out and drive-in, drive-out workforce practices in Regional Australia. Canberra, Australia: The Parliament of the Commonwealth of Australia; 2013.

27. Bowers J, Lo J, Miller P, Mawren D, Jones B. Psychological distress in remote mining and construction workers in Australia. Med J Aust. 2018;208(9):391–7.

28. Sellenger M, Oosthuizen J. Quantitative analysis of mental wellbeing of fly-in fly-out construction project support service workers. J Prev Med Heal. 2017;1(1):1001.

29. James C, Tynan R, Roach D, Leigh L, Oldmeadow C, Rahman M, et al. Correlates of psychological distress among workers in the mining industry in remote Australia: evidence from a multi-site cross-sectional survey. PLoS One. 2018;13(12):e0209377.

30. Tynan RJ, Considine R, Wiggers J, Lewin TJ, James C, Inder K, et al. Alcohol consumption in the Australian coal mining industry. Occup Environ Med. 2017;74(4):259–67.

31. James C, Tynan R, Bezzina A, Rahman M, Kelly B. Alcohol Consumption in the Australian Mining Industry: The Role of Workplace, Social, and Individual Factors. Work Heal Saf. 2021;69(9):423–34.

32. Miller P, Brook L, Stomski NJ, Ditchburn G, Morrison P. Depression, suicide risk, and workplace bullying: a comparative study of fly-in, fly-out and residential resource workers in Australia. Aust Heal Rev. 2019;44(2):3–8.

33. Lester L, Waters S, Spears B, Epstein M, Watson J, Wenden E. Parenting adolescents: developing strategies for FIFO parents. J Child Fam Stud. 2015;24(12):3757–66.

34. Wilson KI, Ferguson SA, Rebar A, Alfrey K, Vincent GE. Comparing the Effects of FIFO/DIDO Workers Being Home versus Away on Sleep and Loneliness for Partners of Australian Mining Workers. Clocks & Sleep. 2020;1:86–98.

35. Clifford S. The effects of fly-in/fly-out commute arrangements and extended working hours on the stress, lifestyle, relationships and health characteristics of Western Australian mining employees and their partners [Internet]. PhD Thesis. The University of Western Australia; 2009. Available from: http://repository.uwa.edu.au:80/R

36. Dittman CK. The importance of parenting in influencing the lives of children. Sanders MR, Turner KMT, editors. Handbook of Parenting and Child Development Across the Lifespan. Springer International Publishing; 2018. 3–26 p.

37. Bakker AB, Demerouti E. The Job Demands-Resources model: state of the art. J Manag Psychol. 2007;22(3):309–28.

38. Demerouti E, Bakker AB. The Job Demands?Resources model: Challenges for future research. SA J Ind Psychol. 2011;37(2):1–9.

39. Torkington AM, Larkins S, Gupta T Sen. The psychosocial impacts of fly-in fly-out and drive-in drive-out mining on mining employees: a qualitative study. Aust J Rural Health. 2011;19(3):135–41.

40. Asare BY-A, Kwasnicka D, Powell D, Robinson S. Health and well--being of rotation workers in the mining, offshore oil and gas, and construction industry: a systematic review. BMJ Glob Heal. 2021;6(7):e005112.

41. Greenhaus JH, Beutell NJ. Sources of Conflict Between Work and Family Roles. Acad Manag Rev. 1985;10(1):76–88.

42. Bakker AB, Demerouti E. The spillover – crossover model. In: Grzywacz JG, Demerouti E, editors. New Frontiers in Work and Family Research. Taylor & Francis Group; 2013. p. 54–70.

43. Bowlby J. Attachment and Loss: Loss and depression. Vol. 3. New York: Basic Books; 1980. 355 p.

44. Bronfenbrenner U. Ecologial Models of Human Development. In: International Encyclopedia of Education. 2nd ed. Oxford, England: Elsevier Sciences; 1994. p. 1643–7.

45. Lerner D, Amick BC, Lee JC, Rooney T, Rogers WH, Chang H, et al. Relationship of employee-reported work limitations to work productivity. Med Care. 2003;41(5):649–59.

46. Ling R, Kelly B, Considine R, Tynan R, Searles A, Doran CM. The economic impact of psychological distress in the Australian coal mining industry. J Occup Environ Med. 2016;58(5):e171–6.

47. Street TD, Lacey SJ. Accounting for employee health: The productivity cost of leading health risks. Heal Promot J Aust. 2019;30(2):228–37.

48. Velander F, Schineanu A, Liang W, Midford R. Digging for gold and coming up blue: A health survey in the mining industry. J Heal Saf Environ. 2010;26(5):389–401.

49. Street TD, Lacey SJ, Somoray K. Employee stress, reduced productivity, and interest in a workplace health program: A case study from the Australian mining industry. Int J Environ Res Public Health. 2019;16(1):1–13.

50. Shi Y, Sears LE, Coberley CR, Pope JE. The association between modifiable well-being risks and productivity: A longitudinal study in pooled employer sample. J Occup Environ Med. 2013;55(4):353–64.

51. Albrecht SL, Anglim J. Employee engagement and emotional exhaustion of fly-in-fly-out workers: a diary study. Aust J Psychol. 2018;70(1):66–75.

52. Paech GM, Jay SM, Lamond N, Roach GD, Ferguson SA. The effects of different roster schedules on sleep in miners. Appl Ergon. 2010;41(4):600–6.

53. Ferguson SA, Baker AA, Lamond N, Kennaway DJ, Dawson D. Sleep in a live-in mining operation: the influence of start times and restricted non-work activities. Appl Ergon. 2010;42(1):71–5.

54. Usher K, Durkin J, Bhullar N. The COVID-19 pandemic and mental health impacts. Int J Ment Health Nurs. 2020;29(3):315–8.

55. Department of Health. First confirmed case of novel coronavirus in Australia [Internet]. Minister’s media release. 2020 [cited 2021 Jul 4]. p. 1–2. Available from: https://www.health.gov.au/ministers/the-hon-greg-hunt-mp/media/first-confirmed-case-of-novel-coronavirus-in-australia

56. Moosa IA. The effectiveness of social distancing in containing Covid-19. Appl Econ. 2020;52(58):6292–305.

57. Gilbert JM, Fruhen LS, Burton CT, Parker SK. The mental health of fly-in fly-out workers before and during COVID-19: a comparison study. Aust J Psychol. 2023;75(1).

58. Asare BY-A, Thomas E, Affandi JS, Schammer M, Brown P, Pilbeam M, et al. Mental Well-Being during COVID-19 : A Cross-Sectional Study of Fly-In Fly-Out Workers in the Mining Industry in Australia. Int J Environ Res Public Health. 2021;18(22):12264.

59. Asare BY-A, Thomas E, Affandi JS, Schammer M, Harris C, Kwasnicka D, et al. Multiple health-related behaviours among Fly- In Fly-Out workers in the mining industry in Australia: A cross-sectional survey during the COVID-19 pandemic. PLoS One. 2022;17(10):e0275008.

60. Schaufeli WB, Taris TW. A Critical Review of the Job Demands-Resources Model: Implications for Improving Work and Health. In: Bauer GF, Hämmig O, editors. Bridging occupational, organizational and public health: A transdisciplinary approach. Springer; 2014. p. 43–68.

61. Asare BY-A, Robinson S, Powell D, Kwasnicka D. Health and related behaviours of fly-in fly-out workers in the mining industry in Australia : a cross-sectional study. Int Arch Occup Environ Health. 2022;96(2023):105–20.

62. Asare BY-A, Makate M, Powell D, Kwasnicka D, Robinson S. Cost of Health-Related Work Productivity Loss among Fly-In Fly-Out Mining Workers in Australia. Int J Environ Res Public Health. 2022;19(16):10056.

63. Asare BY-A, Powell D, Robinson S, Kwasnicka D. Rotation work in the resources sector: a systematic review of the impact on workers' families. Psychol Health. 2023;1–30.

64. Asare BY-A, Kwasnicka D, Robinson S, Powell D. Health and related behaviours of partners of fly-in fly-out workers in Australia : a cross-sectional study. Community Work Fam. 2022;1–20.

65. Asare BY-A, Robinson S, Kwasnicka D, Powell D. Application of Ecological Momentary Assessment in Studies with Rotation Workers in the Resources and Related Construction Sectors: A Systematic Review. Saf Health Work. 2022;14(1):10–6.

66. Vodden K, Hall H. Long distance commuting in the mining and oil and gas sectors: Implications for rural regions. Extr Ind Soc. 2016;3(3):577–83.

67. Langdon RR, Biggs HC, Rowland BD. Australian fly-in, fly-out operations: Impacts on communities, safety work- ers and their families. Work. 2016;55(2):413–27.

68. Parkes K. Shift schedules on North Sea oil/gas installations: A systematic review of their impact on performance, safety and health. Saf Sci. 2012;50(7):1636–51.

69. Chen WQ, Wong TW, Yu TS. Direct and interactive effects of occupational stress and coping on ulcer-like symptoms among Chinese male off-shore oil workers. Am J Ind Med. 2009;52(6):500–8.

70. Chen WQ, Yu ITS, Wong TW. Impact of occupational stress and other psychosocial factors on musculoskeletal pain among Chinese offshore oil installation workers. Occup Environ Med. 2005;62(4):251–6.

71. Ljoså CH, Tyssen R, Lau B. Mental distress among shift workers in Norwegian offshore petroleum industry - Relative influence of individual and psychosocial work factors. Scand J Work Environ Heal. 2011;37(6):551–5.

72. Carter A, Muller R. Hydration knowledge, behaviours and status of staff at the residential camp of a fly-in/fly-out minerals extraction and processing operation in tropical North-Eastern Australia. Ind Health. 2007;45(4):579–89.

73. Vojnovic P, Bahn S. Depression, anxiety and stress symptoms among Fly-In Fly-Out Australian resource industry workers. J Heal Saf Env. 2015;31(3):207–23.

74. Gibson Smith K, Paudyal V, Stewart D, Klein S. The health and wellbeing of offshore workers : a narrative review of the published literature. J Inst Remote Healthc. 2015;6(2):10–23.

75. Fossum IN, Bjorvatn B, Waage S, Pallesen S. Effects of shift and night work in the 0ffshore petroleum industry: a systematic review. Ind Health. 2013;51(5):530–44.

76. Lizarondo L, Stern C, Carrier J, Godfrey C, Rieger K, Salmond S, et al. Mixed methods systematic reviews. Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. Jonna Briggs Institute; 2020. 271–307 p.

77. Moher D, Liberati A, Tetzlaff J, Altman DG, Grp P. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Ann Intern Med. 2009;151(4):264–9.

78. World Health Organization. Mental health [Internet]. Key facts. 2022 [cited 2023 Sep 16]. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response#:~:text=Mental health is a state,and contribute to their community

79. Babineau J. Product Review: Covidence (Systematic Review Software). J Can Heal Libr Assoc l'Association des bibliothèques la santé du Canada. 2014;35(2):68.

80. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, et al. Systematic reviews of etiology and risk. In: Aromataris E, Munn Z, editors. Joanna Briggs Institute Reviewer's Manual [Internet]. The Joanna Briggs Institute; 2017. p. 6. Available from: http://joannabriggs.org/research/critical-appraisal-tools.htmlwww.joannabriggs.org%0Ahttp://joannabriggs.org/research/critical---appraisal---tools.html

81. Turgoose D, Maddox L. Predictors of compassion fatigue in mental health professionals: A narrative review. Traumatology (Tallahass Fla). 2017;23(2):172–85.

82. Duran B. Posttraumatic growth as experienced by childhood cancer curvivors and their families: a narrative synthesis of qualitative and quantitative research. J Pediatr Oncol Nurs. 2013;30(4):179–97.

83. Lucas PJ, Baird J, Arai L, Law C, Roberts HM. Worked examples of alternative methods for the synthesis of qualitative and quantitative research in systematic reviews. BMC Med Res Methodol. 2007;7(4):1–7.

84. Miller P, Brook L, Stomski N, Ditchburn G, Morrison P. Bullying in Fly-In-Fly-Out employees in the Australian resources sector: a cross-sectional study. PLoS One. 2020;15(3):e0229970.

85. Riethmeister V, Bültmann U, De Boer M, Gordijn M, Brouwer S. Examining courses of sleep quality and sleepiness in full 2 weeks on/2 weeks off offshore day shift rotations. Chronobiol Int. 2018;35(6):759–72.

86. Riethmeister V, Bültmann U, Gordijn M, Brouwer S, de Boer M. Investigating daily fatigue scores during two-week offshore day shifts. Appl Ergon. 2018;71(April):87–94.

87. Riethmeister V, Matthews R, Dawson D, de Boer M, Brouwer S, Bültmann U. Time-of-day and days-on-shift predict increased fatigue over two-week offshore day-shifts. Appl Ergon. 2019;78(May 2018):157–63.

88. Riethmeister V, Brouwer S, Van Der Klink J, Bültmann U. Work, eat and sleep: towards a healthy ageing at work program offshore. BMC Public Health. 2016;16(1):1–11.

89. Hanoa R, Baste V, Kooij A, Sommervold L, Moen BE. No difference in self reported health among coalminers in two different shift schedules at Spitsbergen, Norway, a

two years follow-up. Ind Health. 2011;49(5):652.

90. Harris A, Waage S, Ursin H, Hansen ÅM, Bjorvatn B, Eriksen HR. Cortisol, reaction time test and health among offshore shift workers. Psychoneuroendocrinology. 2010;35(9):1339–47.

91. Waage S, Pallesen S, Moen BE, Bjorvatn B. Sleep and health in oil rig workers-before and after a two week work period offshore. Ind Health. 2013;51(2):172–9.

92. Sutherland VJ, Cooper CL. Personality, stress and accident involvement in the offshore oil and gas industry. Manag Occup Organ Stress Res. 1991;12(2):195–204.

93. Waage S, Moen BE, Pallesen S, Eriksen HR, Ursin H, Åkerstedt T, et al. Shift work disorder among oil rig workers in the North Sea. Sleep. 2009;32(4):558–65.

94. Waage S, Pallesen S, Moen BE, Bjorvatn BØ. Shift work and age in the offshore petroleum industry. Public Health. 2010;16(4):251–7.

95. Kecklund G, Ekstedt M, Akerstedt T, Dahlgren A, Samuelson B. The effects of double-shifts (15.5 hours) on sleep, fatigue and health. J Hum Ergol (Tokyo). 2001;30(1–2):53–8.

96. Light IM, Gibson MG. Application of weight-height relations for assessing adiposity in a United Kingdom offshore workforce. Br J Ind Med. 1987;44(3):201–5.

97. Light IM, Gibson M. Perrcentage body fat and prevalence of obesity in a UK offshore population. Br J Nutr. 1986;56(1):97–104.

98. Muller R, Carter A, Williamson A. Epidemiological diagnosis of occupational fatigue in a fly-in-fly-out operation of the mineral industry. Ann Occup Hyg. 2008;52(1):63–72.

99. Joyce SJ, Tomlin SM, Somerford PJ, Weeramanthri TS. Health behaviours and outcomes associated with fly-in fly-out and shift workers in Western Australia. Intern Med J. 2013;43(4):440–4.

100. Gibson Smith K, Paudyal V, Quinn F, Klein S, Stewart D. Offshore workers and health behaviour change: an exploration using the Theoretical Domains Framework. Int Marit Health. 2018;69(4):248–56.

101. Gann M, Corpe U, Wilson I. The application of a short anxiety and depression questionnaire to oil industry staff. Occup Med (Chic Ill). 1990;40(4):138–42.

102. Rodrigues VF, Fischer FM, Brito MJ. Shift work at a modern offshore drilling rig. J Hum Ergol. 2001;30(1–2):167–72.

103. Oshaug A, Østgård LI, Trygg KU. Diet among oil-workers on off-shore oil installations in the Norwegian sector of the North Sea. Br J Nutr. 1992;68(1):11–9.

104. Sutherland VJ. The use of a stress audit. Leadersh Organ Dev J. 1993;14(1):22–8.

105. Aiken GJM, McCance C. Alcohol consumption in offshore oil rig workers. Br J Addict. 1982;77(3):305–10.

106. Maniscalco P, Lane R, Welke M, Mitchell JH, Husting L. Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med. 1999;41(9):813–20.

107. Sneddon A, Mearns K, Flin R. Stress, fatigue, situation awareness and safety in offshore drilling crews. Saf Sci. 2013;56:80–8.

108. Kalteh HO, Khoshakhlagh AH, Rahmani N. Prevalence of musculoskeletal pains and effect of work-related factors among employees on offshore oil and gas installations in Iran. Work. 2018;61(3):347–55.

109. Gibson Smith K, Paudyal V, Klein S, Stewart D. Health, self-care and the offshore workforce: opportunities for behaviour change interventions, an epidemiological survey. Rural Remote Health. 2018;18(2).

110. Barclay M, Harris J, Everingham J, Kirsch P, Shi M. Geologists, FIFO work practices and job satisfaction. Appl Earth Sci. 2016;125(4):221–30.

111. Sadeghniiat-haghighi K, Aminian O, Najafi A, Rahimi-golkhandan A, Zahabi A. Sleep quality in shift workers of offshore petroleum industries. 2018;3(1):36–40.

112. Parkes KR. Shift work and age as interactive predictors of body mass index among offshore workers. Scand J Work Environ Heal. 2002;28(1):64–71.

113. Parkes KR. Age, smoking, and negative affectivity as predictors of sleep patterns among shiftworkwers in two Environments. J Occup Health Psychol. 2002;7(2):156–73.

114. Berthelsen M, Pallesen S, Bjorvatn B, Knardahl S. Shift schedules, work factors, and mental health among onshore and offshore workers in the Norwegian petroleum industry. Ind Health. 2015;53(3):280–92.

115. Bjerkan AM. Work and health: a comparison between Norwegian onshore and offshore employees. Work. 2011;40(2):125–42.

116. Bjerkan AM. Health, environment, safety culture and climate - analysing the relationships to occupational accidents. J Risk Res. 2010;13(4):445–77.

117. Mathisen GE, Bergh LIV. Action errors and rule violations at offshore oil rigs: the role of engagement, emotional exhaustion and health complaints. Saf Sci. 2016;85(2016):130–8.

118. Ulleberg P, Rundmo T. Job stress, social support, job satisfaction and absenteeism among offshore oil personnel. Work Stress. 1997;11(3):215–28.

119. Pavicic Zezelj S, Cvijanović OP, Mika F, Stamenković S, Mahmutović SV, Šabanagić Hajrić S. Anxiety and depression symptoms among gas and oil industry workers. Occup Med (Chic Ill). 2019;69(1):22–7.

120. Parkes KR. Mental health in the oil industry: a comparative study of onshore and offshore employees. Psychol Med. 1992;22(4):997–1009.

121. Parkes K. Shift rotation, overtime, age, and anxiety as predictors of offshore sleep patterns. J Occup Health Psychol. 2015;20(1):27–39.

122. Parkes K. Sleep patterns of offshore day-workers in relation to overtime work and age. Appl Ergon. 2015;48:232–9.

123. Parkes KR. Shiftwork, job type, and the work environment as joint predictors of health-related outcomes. J Occup Health Psychol. 1999;4(3):256–68.

124. Parkes KR. Sleep patterns, shiftwork, and individual differences: a comparison of onshore and offshore control-room operators. Ergonomics. 1994;37(5):827–44.

125. Parkes KR. Age and work environment characteristics in relation to sleep: additive, interactive and curvilinear effects. Appl Ergon. 2016;54(May 2016):41–50.

126. Hope S, Øverland S, Brun W, Matthiesen SB. Associations between sleep, risk and safety climate: a study of offshore personnel on the Norwegian continental shelf. Saf Sci. 2010;48(4):469–77.

127. Cooper CL, Sutherland VJ. Job stress, mental health, and accidents among offshore workers in the oil and gas extraction industries. J Occup Med. 1987;29(2):119–25.

128. Nielsen MB, Hystad SW, Eid J. The Brief Norwegian Safety Climate Inventory (Brief NORSCI)- psychometric properties and relationships with shift work, sleep, and health. Saf Sci. 2016;83:23–30.

129. Nielsen MB, Glasø L, Matthiesen SB, Eid J, Einarsen S. Bullying and risk-perception as health hazards on oil rigs. J Manag Psychol. 2013;28(4):367–83.

130. Nielsen MB, Eid J, Hystad SW, Sætrevik B, Saus ER. A brief safety climate inventory for petro-maritime organizations. Saf Sci. 2013;58:81–8.

131. Cooke DC, Kendall G, Li J, Dockery M. Association between pregnant women's experience of stress and partners' fly-in-fly-out work. Women and Birth. 2019;32(4):e450–8.

132. Dittman CK, Henriquez A, Roxburgh N. When a non-resident worker is a non-resident parent: investigating the family impact of Fly-In, Fly-Out work practices in Australia. J Child Fam Stud. 2016;25(9):2778–96.

133. Stewart A, Ledingham R, Furnace G, Schranz N, Nevill A. The ability of UK offshore workers of different body size and shape to egress through a restricted window space. Appl Ergon. 2016;55:226–33.

134. Stewart AD, Ledingham RL, Furnace G, Williams H, Nevill AM. Shape change and obesity prevalence among male UK offshore workers after 30 years: new insight from a 3D scanning study. Am J Hum Biol. 2017;29(4):1–7.

135. Chen WQ, Wong TW, Yu TS, Lin YZ, Cooper CL. Determinants of perceived occupational stress among Chinese offshore oil workers. Work Stress. 2003;17(4):287–305.

136. Chen WQ, Wong TW, yu TS. Review Article: Influence of occupational stress on mental health among Chinese off-shore oil workers. Scand J Public Health. 2009;37(7):766–73.

137. Chen WQ, Wong TW, Yu TS. Mental health issues in Chinese offshore oil workers. Occup Med (Chic Ill). 2009;59(8):545–9.

138. Chen WQ, Wong TW, Yu ITS. Association of occupational stress and social support with health-related behaviors among Chinese offshore oil workers. J Occup Health. 2008;50(3):262–9.

139. Merkus SL, Huysmans MA, Holte KA, Van Mechelen W, Van Der Beek AJ. An active transition from offshore work to family life: activities that may impact recovery.

Work. 2017;58(3):371–81.

140. Sadeghniiat-Haghighi K, Zahabi A, Najafi A, Rahimi-Golkhandan A, Aminian O. Evaluating the quality and duration of sleep using actigraphy in petroleum industry shift workers. Sleep Heal. 2020;6(3):407–10.

141. Saksvik IB, Bjorvatn B, Harvey AG, Waage S, Harris A, Pallesen S. Adaptation and readaptation to different shift work schedules measured with sleep diary and actigraphy. J Occup Health Psychol. 2011;16(3):331–44.

142. Thorne H, Hampton S, Morgan L, Skene DJ, Arendt J. Differences in sleep, light, and circadian phase in offshore 18:00-06:00 h and 19:00-07:00 h shift workers. Chronobiol Int. 2008;25(2–3):225–35.

143. Thorne H, Hampton SM, Morgan LM, Skene DJ, Arendt J. Returning from night shift to day life: beneficial effects of light on sleep. Sleep Biol Rhythms. 2010;8(3):212–21.

144. Haward BM, Lewis CH, Griffin MJ. Motions and crew responses on an offshore oil production and storage vessel. Appl Ergon. 2009;40(5):904–14.

145. Nielsen MB, Tvedt SD, Matthiesen SB. Prevalence and occupational predictors of psychological distress in the offshore petroleum industry: a prospective study. Int Arch Occup Environ Health. 2013;86(8):875–85.

146. Merkus S, Holte K, Huysmans M, Van De Ven P, Van Mechelen W, Van Der Beek A. Self-reported recovery from 2-week 12-hour shift work schedules: a 14-day follow-up. Saf Health Work. 2015;6(3):240–8.

147. Parkes KR. Demographic and lifestyle predictors of body mass index among offshore oil industry workers: cross-sectional and longitudinal findings. Occup Med (Chic Ill). 2003;53(3):213–21.

148. Devine SG, Muller R, Carter A. Using the Framework for Health Promotion Action to address staff perceptions of occupational health and safety at a fly-in/fly-out mine in north-west Queensland. Heal Promot J Aust. 2008;19(3):196–202.

149. Perring A, Pham K, Snow S, Buys L. Investigation into the effect of infrastructure on fly-in fly-out mining workers. Aust J Rural Health. 2014;22(6):323–7.

150. Pirotta J. An exploration of the experiences of women who FIFO. Aust Community Psychol. 2009;21(2):37–51.

151. Ebert A, Strehlow K. Does on-site chaplaincy enhance the health and well being of fly-in, fly-out (FIFO) personnel? Heal Promot J Aust. 2017;28(2):118–22.

152. Wright AC, Griep Y. Burning the midnight oil: Examining wellbeing and vulnerability in Alberta's oil patch. Extr Ind Soc. 2019;6(1):77–84.

153. Carter T, Kaczmarek EA. An Exploration of Generation Y's experience of offshore Fly-in/Fly-out employment. Aust Community Psychol. 2009;21(2):52–66.

154. Bergh LIV, Leka S, Zwetsloot GIJM. Tailoring psychosocial risk assessment in the oil and gas industry by exploring specific and common psychosocial risks. Saf Health Work. 2018;9(1):63–70.

155. Bergh LIV, Hinna S, Leka S, Zwetsloot GIJM. Developing and testing an internal audit tool of the psychosocial work environment in the oil and gas industry. Saf Sci.

2015;88:232–41.

156. Waage S, Harris A, Pallesen S, Saksvik IB, Moen BE, Bjorvatn B. Subjective and objective sleepiness among oil rig workers during three different shift schedules. Sleep Med. 2012;13(1):64–72.

157. Slade T, Johnston A, Teesson M, Whiteford H, Burgess P, Pirkis J, et al. The mental health of Australians 2: report on the 2007 national survey of mental health and wellbeing. Report on the. Canberra, Australia: Department of Health and Ageing; 2009.

158. Miller P, Brook L, Stomski NJ, Ditchburn G, Morrison P. Suicide risk and social support in Australian resource sector employees: a cross-sectional study. J Community Psychol. 2019;47(3):652–62.

159. Cantwell LB, Henao OL, Hoekstra RM, Scallan E. The effect of different recall periods on estimates of acute gastroenteritis in the United States, FoodNet population survey 2006-2007. Foodborne Pathog Dis. 2010;7(10):1225–8.

160. Zhao Y, Richardson A, Poyser C, Butterworth P, Strazdins L, Leach LS. Shift work and mental health: a systematic review and meta-analysis. Int Arch Occup Environ Health. 2019;92(6):763–93.

161. Costa G. The problem: shiftwork. Chronobiol Int. 1997;14(2):89–98.

162. Vojnovic P, Michelson G, Jackson D, Bahn S. Adjustment, well-being and help-seeking among Australian FIFO mining employees. Abl. 2014;40(2):242–61.

163. Rhéaume A, Mullen J. The impact of long work hours and shift work on cognitive errors in nurses. J Nurs Manag. 2018;26(1):26–32.

164. Kecklund G, Axelsson J. Health consequences of shift work and insufficient sleep. BMJ. 2016;355:1–13.

165. Ferguson SA, Paech GM, Dorrian J, Roach GD, Jay SM. Performance on a simple response time task: is sleep or work more important for miners? Appl Ergon. 2011;42(2):210–3.

166. Wright KP, Bogan RK, Wyatt JK. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev. 2013;17(1):41–54.

167. McKenna H, Wilkes M. Optimising sleep for night shifts. BMJ. 2018;360:j5637.

168. Tucker PE, Cohen PA, Bulsara MK, Acton J. Fatigue and training of obstetrics and gynaecology trainees in Australia and New Zealand. Aust New Zeal J Obstet Gynaecol. 2017;57(5):502–7.

169. Shen J, Botly LCP, Chung SA, Gibbs AL, Sabanadzovic S, Shapiro CM. Fatigue and shift work. J Sleep Res. 2006;15(1):1–5.

170. World Health Organization. Alcohol [Internet]. Key facts. 2019 [cited 2020 Nov 20]. p. 1–5. Available from: www.who.int/news-room/fact-sheets/detail/alcohol

171. Collinson DL. "Shift-ing lives": Work-home pressures in the North Sea oil industry. Can Rev Sociol Anthropol. 1998;35(3):301–24.

172. Wilsnack RW, Wilsnack SC, Gmel G, Kantor LW. Gender differences in binge

drinking. Alcohol Res. 2018;39(1):57–76.

173. Todd M. Daily processes in stress and smoking: effects of negative events, nicotine dependence, and gender. Psychol Addict Behav. 2004;18(1):31–9.

174. World Health Organization. Tobacco [Internet]. Key facts. 2021 [cited 2020 Nov 20]. p. 1–7. Available from: https://www.who.int/news-room/fact-sheets/detail/tobacco

175. Cahill K, Lancaster T. Workplace interventions for smoking cessation. Cochrane Database Syst Rev. 2014;2017(12).

176. Shrestha A, Pyakurel P, Shrestha A, Gautam R, Manandhar N, Rhodes E, et al. Facilitators and barriers to healthy eating in a worksite cafeteria: a qualitative study from Nepal. Heart Asia. 2017;9(2):e010956.

177. Leedo E, Beck AM, Astrup A, Lassen AD. The effectiveness of healthy meals at work on reaction time, mood and dietary intake: a randomised cross-over study in daytime and shift workers at an university hospital. Br J Nutr. 2017;118(2):121–9.

178. World Health Organization. Healthy diet [Internet]. Vol. 2025, Key facts. 2020 [cited 2020 Nov 20]. Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet

179. Neimann Rasmussen L, Montgomery P. The prevalence of and factors associated with inclusion of non-English language studies in Campbell systematic reviews: a survey and meta-epidemiological study. Syst Rev. 2018;7(1):1–12.

180. Allen TD, Herst DE, Bruck CS, Sutton M. Consequences associated with work-to-family conflict: a review and agenda for future research. J Occup Health Psychol. 2000;5(2):278–308.

181. Vojnovic P, Jacobs L, Brook L, Ashton C, Pulé P. Submission to the Legislative Assembly Health and Education Standing Committee inquiry into mental illness and suicide in fly-in , fly-out workers. Perth, Australia; 2014.

182. James C, Rahman M, Bezzina A, Kelly B. Factors associated with patterns of psychological distress, alcohol use and social network among Australian mineworkers. Aust N Z J Public Health. 2020;44(5):390–6.

183. Kessler RC, Andrew G, Colpe L, Hiripi E, Mroczek D, SLT N, et al. Short screening scales to monitor population prevalences and trends in non-specific psychological distress. Psychol Med. 2002;32:959–76.

184. Furukawa TA, Kessler RC, Slade T, Andrews G. The performance of the K6 and K10 screening scales for psychological distress in the Australian National Survey of Mental Health and Well-Being. Psychol Med. 2003;33(2):357–62.

185. Ware JE, Kosinski M, Dewey JE, Gandek B. How to score and interpret single-item health status measures: a manual for users of the SF-8 health survey. Lincoln, RI Qual Inc. 2001;15(10):5.

186. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research. Vol. 28(2), Psychiatry Research. 1989. p. 193–213.

187. Bradley KA, Debenedetti AF, Volk RJ, Williams EC, Frank D, Kivlahan DR. AUDIT-

C as a brief screen for alcohol misuse in primary care. Alcohol Clin Exp Res. 2007;31(7):1208–17.

188. Craig C, Marshall A, Sjostrom M, Bauman A, Lee P, Macfarlane D, et al. International Physical Activity Questionnaire-Short Form. J Am Coll Heal [Internet]. 2017 [cited 2020 Mar 28];65:491–501. Available from: https://sites.google.com/site/ theipaq/

189. IPAQ Research Committee. Guidelines for data processing and analysis of the IPAQ-short and long forms [Internet]. IPAQ scoring protocol. 2005 [cited 2021 May 21]. Available from: http://www.ipaq.ki.se/scoring.pdf

190. Kyu HH, Bachman VF, Alexander LT, Mumford JE, Afshin A, Estep K, et al. Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: Systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013. BMJ. 2016;354:1–10.

191. Biernat E, Stupnicki R, Lebiedziński B, Janczewska L. Assessment of physical activity by applying IPAQ questionnaire. Phys Educ Sport. 2008;52(1):46–52.

192. Australian Bureau of Statistics. National Health Survey 2011-12 Questionnaire [Internet]. 2011 [cited 2021 Jun 4]. p. 1–371. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/39433889d406eeb9ca2570610019e9a5/9f4d8e85b3aab3b7ca257a9a00790bea/$FILE/National Health Survey 2011-12 questionnaire.pdf

193. Australian Bureau of Statistics. Dietary Behaviour [Internet]. Dietary behaviour, 2017-18 financial year. 2018 [cited 2021 Nov 4]. Available from: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/dietary-behaviour/latest-release

194. Australian Institute of Health and Welfare. Overweight and obesity [Internet]. Australian’s health 2020. 2020 [cited 2021 Dec 29]. Available from: https://www.aihw.gov.au/reports/australias-health/overweight-and-obesity

195. Hirshkowitz M, Whiton K, Albert SM, Alessi C, Bruni O, Doncarlos L, et al. National Sleep Foundation’s sleep time duration recommendations: methodology and results summary. Sleep Heal. 2015;1(1):40–3.

196. Sachdeva A, Goldstein C. Shift Work Sleep Disorder. In: Auger RR, editor. Circadian Rhythm Sleep-Wake Disorders. Cham: Springer International Publishing; 2020. p. 149–82.

197. Sibbel AM, Kaczmarek EA, Drake D. Fly-In/Fly-Out Accommodation: Workers’ Perspectives. In: Labour Force Mobility in the Australian Resources Industry: Socio-Economic and Regional Impacts. Singapore: Springer; 2016. p. 137–56.

198. Devine SG, Muller R, Carter A. Using the Framework for Health Promotion Action to address staff perceptions of occupational health and safety at a fly-in/fly-out mine in north-west Queensland. Heal Promot J Aust Off J Aust Assoc Heal Promot Prof. 2008 Dec;19(3):196–202.

199. Australian Institute of Health and Welfare. Tobacco smoking [Internet]. Determinants of Health. 2021 [cited 2021 Aug 31]. p. 1–9. Available from: https://www.aihw.gov.au/reports/australias-health/tobacco-smoking

200. Stubbs B, Veronese N, Vancampfort D, Prina AM, Lin PY, Tseng PT, et al. Perceived

stress and smoking across 41 countries: A global perspective across Europe, Africa, Asia and the Americas. Sci Rep. 2017;7(1):1–8.

201. Australian Institute of Health and Welfare. Alcohol, tobacco & other drugs in Australia [Internet]. Alcohol. 2021 [cited 2021 Dec 29]. Available from: https://www.aihw.gov.au/reports/alcohol/alcohol-tobacco-other-drugs-australia/contents/harm-minimisation/supply-reduction

202. Barker JM, Taylor JR. Sex differences in incentive motivation and the relationship to the development and maintenance of alcohol use disorders. Physiol Behav. 2019;203:91–9.

203. Carter T. An exploration of Generation Y's experiences of offshore Fly-in / Fly-out (FIFO) employment [Internet]. Edith Cowan University; 2008. Available from: https://ro.ecu.edu.au/theses_hons/1166%0A

204. Duncan B. Boom Towns, Drug Towns? Mining, Alcohol and Other Drugs? Subst Natl Mag Alcohol, Tob Other Drugs. 2009 Jan 1;7(1):24–6.

205. The Chamber of Minerals & Energy of Western Australia. Safe and Respectful Behaviours – Andustry Alcohol Guideline [Internet]. Perth, Western Australia; 2022. Available from: https://www.cmewa.com.au/wp-content/uploads/2022/05/WHS-Industry-Alcohol-Guideline-Final-1.pdf

206. Chiesa A, Serretti A. Are mindfulness-based interventions effective for substance use disorders? A systematic review of the evidence. Subst Use Misuse. 2014;49(5):492–512.

207. Hill D, Conner M, Clancy F, Moss R, Wilding S, Bristow M, et al. Stress and eating behaviours in healthy adults: a systematic review and meta-analysis. Health Psychol Rev. 2022;16(2):280–304.

208. Tryon MS, Carter CS, DeCant R, Laugero KD. Chronic stress exposure may affect the brain's response to high calorie food cues and predispose to obesogenic eating habits. Physiol Behav. 2013;120:233–42.

209. Mikolajczyk RT, El Ansari W, Maxwell AE. Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. Nutr J. 2009;8(1):1–8.

210. Paans NPG, Bot M, Brouwer IA, Visser M, Roca M, Kohls E, et al. The association between depression and eating styles in four European countries: The MooDFOOD prevention study. J Psychosom Res. 2018;108:85–92.

211. World Health Organization. Obesity and overweight [Internet]. Key facts. 2021 [cited 2022 Jan 3]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

212. Perring A, Pham K, Snow S, Buys L. Investigation into the effect of infrastructure on fly-in fly-out mining workers. Aust J Rural Health. 2014 Dec;22(6):323–7.

213. Australian Bureau of Statistics. Mental health [Internet]. Mental health, 2017-18 financial year. 2018. Available from: https://www.abs.gov.au/statistics/health/mental-health/mental-health/latest-release#psychological-distress

214. Commission for Occupational Safety and Health. Mentally healthy workplaces for fly-

in fly-out (FIFO) workers in the resources and construction sectors-code of practice. Perth, Western Australia: Department of Mines, Industry Regulation and Safety; 2019. 19 p.

215. Considine R, Tynan R, James C, Wiggers J, Lewin T, Inder K, et al. The contribution of individual, social and work characteristics to employee mental health in a coal mining industry population. PLoS One. 2017;12(1):1–15.

216. Neill E, Meyer D, Toh WL, van Rheenen TE, Phillipou A, Tan EJ, et al. Alcohol use in Australia during the early days of the COVID-19 pandemic: Initial results from the COLLATE project. Psychiatry Clin Neurosci. 2020;74(10):542–9.

217. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, et al. Depression, anxiety and stress during COVID-19: Associations with changes in physical activity, sleep, tobacco and alcohol use in Australian adults. Int J Environ Res Public Health. 2020;17(11):1–13.

218. Fisher JRW, Tran TD, Hammarberg K, Sastry J, Nguyen H, Rowe H, et al. Mental health of people in Australia in the first month of COVID-19 restrictions: a national survey. Med J Aust. 2020;213(10):458–64.

219. Gilbert J, Fruhen L, Parker SK. FIFO Worker Mental Health and Wellbeing : FIFO work then and now [Internet]. Perth, Australia; 2020. Available from: https://www.transformativeworkdesign.com/_files/ugd/8bd0f0_d4095d531c654528810b8c5e4710a988.pdf

220. Dandurand F, Shultz TR, Onishi KH. Comparing online and lab methods in a problem-solving experiment. Behav Res Methods. 2008;40(2):428–34.

221. Carrington K, McIntosh A. Wellness, Wellbeing and Quality of Life Issues as they Impact upon the Australian Mining Sector. Brisbane, Australia; 2013.

222. Howard KJ, Howard JT, Smyth AF. The Prolem of Abesenteeism and Presenteeism in the Workplace. In: Gatchel R, Schultz I, editors. Handbook of Occupational Health and Wellness. Boston, MA: Springer; 2012. p. 151–79.

223. Kowlessar NM, Goetzel RZ, Carls GS, Tabrizi MJ, Guindon A. The relationship between 11 health risks and medical and productivity costs for a large employer. J Occup Environ Med. 2011;53(5):468–77.

224. Zhang W, Bansback N, Anis AH. Measuring and valuing productivity loss due to poor health: A critical review. Soc Sci Med. 2011;72(2):185–92.

225. Kigozi J, Jowett S, Lewis M, Barton P, Coast J. The Estimation and Inclusion of Presenteeism Costs in Applied Economic Evaluation: A Systematic Review. Value Heal. 2017;20(3):496–506.

226. Strömberg C, Aboagye E, Hagberg J, Bergström G, Lohela-Karlsson M. Estimating the Effect and Economic Impact of Absenteeism, Presenteeism, and Work Environment–Related Problems on Reductions in Productivity from a Managerial Perspective. Value Heal. 2017;20(8):1058–64.

227. Holden L, Scuffham PA, Hilton MF, Ware RS, Vecchio N, Whiteford HA. Which health conditions impact on productivity in working Australians? J Occup Environ Med. 2011;53(3):253–7.

228. Yoshimoto T, Oka H, Fujii T, Nagata T, Matsudaira K. The Economic Burden of Lost Productivity due to Presenteeism Caused by Health Conditions Among Workers in Japan. J Occup Environ Med. 2020;62(10):883–8.

229. Shiels C, Gabbay MB, Ford FM. Patient factors associated with duration of certified sickness absence and transition to long-term incapacity. Br J Gen Pract. 2004;54(499):86–91.

230. Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, Absence, Disability, and Presenteeism Cost Estimates of Certain Physical and Mental Health Conditions Affecting U.S. Employers. J Occup Environ Med. 2004;46(4):398–412.

231. Kessler RC, Akiskal HS, Ames M, Birnbaum H, Greenberg P, Hirschfeld RM, et al. Prevalence and effects of mood disorders on work performance in a nationally representative sample of U.S. workers. Am J Psychiatry. 2006;163(9):1561–8.

232. Burton WN, Chen CY, Conti DJ, Schultz AB, Pransky G, Edington DW. The association of health risks with on-the-job productivity. J Occup Environ Med. 2005;47(8):769–77.

233. Hilton MF, Scuffham PA, Vecchio N, Whiteford HA. Using the interaction of mental health symptoms and treatment status to estimate lost employee productivity. Aust N Z J Psychiatry. 2010;44(2):151–61.

234. Evers KE, Castle PH, Prochaska JO, Prochaska JM. Examining relationships between multiple health risk behaviors, well-being, and productivity. Psychol Rep. 2014;114(3):843–53.

235. Kirkham HS, Clark BL, Bolas CA, Lewis GH, Jackson AS, Fisher D, et al. Which modifiable health risks are associated with changes in productivity costs? Popul Health Manag. 2015;18(1):30–8.

236. Schultz AB, Edington DW. Employee health and presenteeism: a systematic review. J Occup Rehabil. 2007;17(3):547–79.

237. Goettler A, Grosse A, Sonntag D. Productivity loss due to overweight and obesity: A systematic review of indirect costs. BMJ Open. 2017;7(10).

238. Henke RM, Carls GS, Short ME, Pei X, Wang S, Moley S, et al. The Relationship Between Health Risks and Health and Productivity Costs Among Employees at Pepsi Bottling Group. 2010;52(5):519–27.

239. Boles M, Pelletier B, Lynch W. The relationship between health risks and work productivity. J Occup Environ Med. 2004;46(7):737–45.

240. Musich S, Hook D, Baaner S, Edington DW. The association of two productivity measures with health risks and medical conditions in an Australian employee population. Am J Heal Promot. 2006;20(5):353–63.

241. Pereira MJ, Coombes BK, Comans TA, Johnston V. The impact of onsite workplace health-enhancing physical activity interventions on worker productivity: A systematic review. Occup Environ Med. 2015;72(6):401–12.

242. Minerals Council of Australia. Independent mining statistics should be used accurately [Internet]. 2022 [cited 2022 Jul 10]. Available from:

https://www.minerals.org.au/news/independent-mining-statistics-should-be-used-accurately#:~%7B%7D:text=Mining employment has trebled from,above-award wages and conditions

243. KPMG. Minerals Council of Australia - Analysis of the Changing Resident Demographic Profile of Australia's Mining Communities [Internet]. 2013. p. 70. Available from: http://www.minerals.org.au/file_upload/files/reports/MCA-13-ResidentialProfile0131-MYR.pdf

244. Qualtrics Online Data Collection Software. Make every customer interaction an experience that matters [Internet]. [cited 2021 May 21]. Available from: https://www.qualtrics.com/au/

245. Lenneman J, Schwartz S, Giuseffi DL, Wang C. Productivity and health: An application of three perspectives to measuring productivity. J Occup Environ Med. 2011;53(1):55–61.

246. Reilly M, Zbrozek A, Dukes E. The validity and reproducibility of a work productivity and activity impairment instrument. Pharmacoeconomics. 1993;4(3):353–65.

247. Lee DW, Lee J, Kim HR, Kang MY. Health-related productivity loss according to health conditions among workers in South Korea. Int J Environ Res Public Health. 2021;18(14).

248. Australian Bureau of Statistics. Employee Earnings and Hours, Australia, May 2021 [Internet]. Earnings and work hours. 2021 [cited 2022 Oct 19]. Available from: https://www.abs.gov.au/statistics/labour/earnings-and-work-hours/employee-earnings-and-hours-australia/latest-release

249. Kozak M, Piepho HP. What's normal anyway? Residual plots are more telling than significance tests when checking ANOVA assumptions. J Agron Crop Sci. 2018;204(1):86–98.

250. Bolge SC, Doan JF, Kannan H, Baran RW. Association of insomnia with quality of life , work productivity , and activity impairment. Qual Life Res. 2009;18:415–22.

251. d'Errico M, Pavlova M, Spandonaro F. The economic burden of obesity in Italy: a cost-of-illness study. Eur J Heal Econ. 2022;23:177–92.

252. Farrance I, Frenkel R. Uncertainty in measurement: A review of monte carlo simulation using microsoft excel for the calculation of uncertainties through functional relationships, including uncertainties in empirically derived constants. Clin Biochem Rev. 2014;35(1):37–61.

253. Belotti F, Deb P, Norton EC. twopm : Two-part models. Stata J. 2015;15(1):3–20.

254. Johnston DA, Harvey SB, Glozier N, Calvo RA, Christensen H, Deady M. The relationship between depression symptoms, absenteeism and presenteeism. J Affect Disord. 2019;256:536–40.

255. Baptista MC, Burton WN, Nahas AK, Wang YP, Viana MC, Andrade LH. Absenteeism and Presenteeism Associated with Common Health Conditions in Brazilian Workers. J Occup Environ Med. 2019;61(4):303–13.

256. Hilton MF, Scuffham PA, Sheridan J, Cleary CM, Whiteford HA. Mental ill-health and the differential effect of employee type on absenteeism and presenteeism. J Occup

Environ Med. 2008;50(11):1228–43.

257. Lerner D, Adler DA, Chang H, Berndt ER, Irish JT, Lapitsky L, et al. The clinical and occupational correlates of work productivity loss among employed patients with depression. J Occup Environ Med. 2004;46(6 SUPPL.):46–55.

258. Cuijpers P, Smit F, Oostenbrink J, De Graaf R, Ten Have M, Beekman A. Economic costs of minor depression: A population-based study. Acta Psychiatr Scand. 2007;115(3):229–36.

259. Wee LH, Yeap LLL, Chan CMH, Wong JE, Jamil NA, Swarna Nantha Y, et al. Anteceding factors predicting absenteeism and presenteeism in urban area in Malaysia. BMC Public Health. 2019;19(Suppl 4):1–12.

260. Evans-Lacko S, Knapp M. Global patterns of workplace productivity for people with depression: absenteeism and presenteeism costs across eight diverse countries. Soc Psychiatry Psychiatr Epidemiol. 2016;51(11):1525–37.

261. Merrill RM, Aldana SG, Pope JE, Anderson DR, Coberley CR, Whitmer RW. Presenteeism according to healthy behaviors, physical health, and work environment. Popul Health Manag. 2012;15(5):293–301.

262. Heuvel SG Van Den, Geuskens GA. Productivity Loss at Work ; Health-Related and Work-Related Factors. 2010;331–9.

263. Ishibashi Y, Shimura A. Association between work productivity and sleep health: A cross-sectional study in Japan. Sleep Heal. 2020;6(3):270–6.

264. Rosekind MR, Gregory KB, Mallis MM, Brandt SL, Seal B, Lerner D. The cost of poor sleep: Workplace productivity loss and associated costs. J Occup Environ Med. 2010;52(1):91–8.

265. Dorrian J, Baulk SD, Dawson D. Work hours, workload, sleep and fatigue in Australian Rail Industry employees. Appl Ergon. 2011;42(2):202–9.

266. Mulgrew AT, Ryan CF, Fleetham JA, Cheema R, Fox N, Koehoorn M, et al. The impact of obstructive sleep apnea and daytime sleepiness on work limitation. Sleep Med. 2007;9(1):42–53.

267. Doi Y, Minowa M, Tango T. Impact and correlates of poor sleep quality in Japanese white-collar employees. Sleep. 2003;26(4):467–71.

268. Kerner I, Rakovac M, Lazinica B. Leisure-time physical activity and absenteeism. 2017;159–70.

269. Cancelliere C, Cassidy JD, Ammendolia C, Côté P. Are workplace health promotion programs effective at improving presenteeism in workers? A systematic review and best evidence synthesis of the literature. BMC Public Health. 2011;11:1–11.

270. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. Vol. 44, Sports Medicine. 2014. 81–121 p.

271. Masi DA, Jacobson JM. Outcome measurements of an integrated employee assistance and work-life program. Res Soc Work Pract. 2003;13(4):451–67.

272. Pitt-Catsouphes M, James JB, Matz-Costa C. Workplace-based health and wellness programs: The intersection of aging, work, and health. Gerontologist. 2015;55(2):262–

70.

273. Plaisier I, de Graaf R, de Bruijn J, Smit J, van Dyck R, Beekman A, et al. Depressive and anxiety disorders on-the-job: The importance of job characteristics for good work functioning in persons with depressive and anxiety disorders. Psychiatry Res. 2012;200(2–3):382–8.

274. Rose Sutherland C, Chur-Hansen A, Winefield H. Experiences of Fly-In, Fly-Out and Drive-In, Drive-Out Rural and Remote Psychologists. Aust Psychol. 2017;52(3):219–29.

275. Kaczmarek EA, Sibbel AM. The psychosocial well-being of children from Australian military and fly-in/fly-out (FIFO) mining families. Community, Work Fam. 2008;11(3):297–312.

276. Hoath A, Mckenzie FH. The Socio-Economic Impacts of Long Distance Commuting (LDC) on Source Communities. Perth, Co-operative Research Centre for Remote Economic Participation and Curtin Graduate School of Business; 2013.

277. Rodríguez-Muñoz A, Sanz-Vergel AI, Demerouti E, Bakker AB. Engaged at Work and Happy at Home: A Spillover–Crossover Model. J Happiness Stud. 2014;15(2):271–83.

278. Shimazu A, Bakker AB, Demerouti E. How Job Demands Affect an Intimate Partner: A Test of the Spillover–Crossover Model in Japan Akihito. J Occup Health Psychol. 2009;51(3):239.

279. Bakker AB, Petrou P, Tsaousis I. Inequity in work and intimate relationships: a Spillover-Crossover model. Anxiety, Stress Coping. 2012;25(5):491–506.

280. Shimazu A, Bakker AB, Demerouti E, Fujiwara T, Iwata N, Shimada K, et al. Workaholism, work engagement and child well-being: A test of the spillover-crossover model. Int J Environ Res Public Health. 2020;17(17):1–16.

281. Vormbrock JK. Attachment Theory As Applied to Wartime and Job-Related Marital Separation. Psychol Bull. 1993;114(1):122–44.

282. Medway FJ, Davis KE, Cafferty TP, Chappell KD, O'Hearn RE. Family Disruption and Adult Attachment Correlates of Spouse and Child Reactions to Separation and Reunion Due to Operation Desert Storm. J Soc Clin Psychol. 1995;14(2):97–118.

283. Diamond LM, Hicks AM, Otter-Henderson KD. Every Time You Go Away: Changes in Affect, Behavior, and Physiology Associated With Travel-Related Separations From Romantic Partners. J Pers Soc Psychol. 2008;95(2):385–403.

284. Basham K. Homecoming as safe haven or the new front: Attachment and detachment in military couples. Clin Soc Work J. 2008;36(1):83–96.

285. Vincenzes KA, Haddock L, Hickman G. The Implications of Attachment Theory for Military Wives: Effects During a Post Deployment Period. Prof Couns. 2015;4(2):122–8.

286. Paley B, Lester P, Mogil C. Family Systems and Ecological Perspectives on the Impact of Deployment on Military Families. Clin Child Fam Psychol Rev. 2013;16(3):245–65.

287. Orthner DK, Rose R. Work separation demands and spouse psychological well-being. Fam Relat. 2009;58(4):392–403.

288. Frone MR, Russell M, Cooper ML. Relation of work-family conflict to health outcomes: A four-year longitudinal study of employed. J Occup Organ Psychol. 1997;70:325–35.

289. Leineweber C, Baltzer M, Magnusson Hanson LL, Westerlund H. Work-family conflict and health in Swedish working women and men: A 2-year prospective analysis (the SLOSH study). Eur J Public Health. 2013;23(4):710–6.

290. Borgmann LS, Rattay P, Lampert T. Health-related consequences of work-family conflict from a European perspective: Results of a scoping review. Front Public Heal. 2019;7(JUL):1–12.

291. Westman M. Stress and Strain crossover. Hum Relations. 2001;54(6):717–51.

292. Rholes SW, Simpson JA. Adult Attachment. Vol. 59, Journal of Marriage and the Family. 1997. 775 p.

293. Holden GW. Theoretical perspectives on parenting. In: Parenting: A dynamic perspective. 3rd ed. SAGE Publications Inc; 2010. p. 27–54.

294. Fraley RC, Shaver PR. Airport separations: A naturalistic study of adult attachment dynamics in separating couples. J Pers Soc Psychol. 1998;75(5):1198–212.

295. Mikulincer M, Gillath O, Shaver PR. Activation of the attachment system in adulthood: Threat-related primes increase the accessibility of mental representations of attachment figures. J Pers Soc Psychol. 2002;83(4):881–95.

296. Johnson SM. Attachment Theory: A Guide for Couple Therapy. In: Johnson SM, Whiffen VE, editors. Attachment Processes in Couple and Family Therapy. New: Guilford Publications; 2004. p. 103–23.

297. Sallis JF, Owen N, Fisher EB. Ecological Models of Health Behavior. In: Glanz K, Rimer BK, Viswanath K, editors. Health Behavior and Health Education: Theory, Research and Practice. 4th ed. John Wiley & Sons, Inc; 2008. p. 465–85.

298. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.

299. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Heal. 2015;13(3):179–87.

300. Tessema GA, Laurence CO, Mahmood MA, Gomersall JS. Factors determining quality of care in family planning services in Africa: a systematic review protocol. JBI database Syst Rev Implement reports. 2016;14(8):103–14.

301. Silva-Segovia J, Salinas-Meruane P. With the mine in the veins: emotional adjustments in female partners of Chilean mining workers. Gender, Place Cult. 2016;23(12):1677–88.

302. Mayes R. Mobility, temporality, and social reproduction: everyday rhythms of the 'FIFO family' in the Australian Mining Sector. Gender, Place Cult. 2020;27(1):126–

42.

303. Morrice JKW, Taylor RC, Clark D, McCann K. Oil wives and intermittent husbands. Br J Psychiatry. 1985;147(NOV.):479–83.

304. Taylor R, Morrice K, Clark D, McCann K. The psycho-social consequences of intermittent husband absence: An epidemiological study. Soc Sci Med. 1985;20(9):877–85.

305. Parkes K, Carnell S, Farmer E. “Living two lives”: perceptions, attitudes and experiences of spouses of UK offshore workers. Community, Work Fam. 2005;8(4):413–37.

306. Pini B, Mayes R. Gender, emotions and fly-in fly-out work. Austrilian J Soc Issues. 2012;47(1):71–86.

307. Whalen H, Schmidt G. The women who remain behind: Challenges in the LDC lifestyle. Rural Soc. 2016;25(1):1–14.

308. Lester L, Watson J, Waters S, Cross D. The Association of Fly-in Fly-out Employment, Family Connectedness, Parental Presence and Adolescent Wellbeing. J Child Fam Stud. 2016;25(12):3619–26.

309. MacBeth MM, Sibbel AM. Fathers, adolescent sons and the fly-in/fly-out lifestyle. Aust Community Psychol. 2012;24(2):98–114.

310. Mauthner NS, Maclean C, McKee L. ‘My dad hangs out of helicopter doors and takes pictures of oil platforms’’: Children’s accounts of parental work in the oil and gas industry.’ Community Work Fam. 2000;3(2):133–62.

311. Zargham-Boroujeni A, Shahba Z, Abedi H. Comparison of anxiety prevalence among based and offshore national Iranian drilling company staff’s children in Ahvaz, 2013. J Educ Health Promot. 2015;4(May):37.

312. Robinson K, Peetz D, Murray G, Griffin S, Muurlink O. Relationships between children’s behaviour and parents’ work within families of mining and energy workers. J Sociol. 2017;53(3):557–76.

313. Adams GC, Stoops MA, Skomro RP. Sleep tight: Exploring the relationship between sleep and attachment style across the life span. Sleep Med Rev. 2014;18(6):495–507.

314. Hislop J. A bed of roses or a bed of thorns? Negotiating the couple relationship through sleep. Sociol Res Online. 2007;12(5):1–13.

315. Carmichael CL, Reis HT. Attachment, sleep quality, and depressed affect. Heal Psychol. 2005;24(5):526–31.

316. Shreffler KM, Meadows MP, Davis KD. Firefighting and Fathering: Work-Family Conflict, Parenting Stress, and Satisfaction with Parenting and Child Behavior. Father A J Theory, Res Pract about Men as Father. 2011;9(2):169–88.

317. Jacobsen HB, Reme SE, Sembajwe G, Hopcia K, Stoddard AM, Kenwood C, et al. Work-Family Conflict, Psychological Distress, and Sleep Deficiency among Patient Care Workers. Workplace Health Saf. 2014;62(7):282–91.

318. Buxton OM, Lee S, Beverly C, Berkman LF, Moen P, Kelly EL, et al. Work-family conflict and employee sleep: Evidence from IT workers in the work, family and health

study. Sleep. 2016;39(10):1871–82.

319. Morris H, Larsen J, Catterall E, Moss AC, Dombrowski SU. Peer pressure and alcohol consumption in adults living in the UK: A systematic qualitative review. BMC Public Health. 2020;20(1):1–13.

320. Sudhinaraset M, Wigglesworth C, Takeuchi DT. Social and cultural contexts of alcohol use: Influences in a social–ecological framework. Alcohol Res Curr Rev. 2016;38(1):35–45.

321. Holway GV, Umberson D, Thomeer MB. Binge Drinking and Depression: The Influence of Romantic Partners in Young Adulthood. Soc Ment Health. 2017;7(1):36–49.

322. Polenick CA, Birditt KS, Blow FC. Couples' alcohol use in middle and later life: Stability and mutual influence. J Stud Alcohol Drugs. 2018;79(1):111–8.

323. Liu L, Visher CA. The crossover of negative emotions between former prisoners and their family members during reunion: A test of general strain theory. J Offender Rehabil. 2019;58(7):567–91.

324. Shimazu A. Heavy work investment and work-family balance among Japanese dual-earner couples. In: Cooper CL, Luo L, editors. Handbook of Research on Work-Life Balance in Asia. Cheltenham, UK: Elgar Publishing Ltd; 2015. p. 61–76.

325. Li J, Ohlbrecht H, Pollmann-Schult M, Habib FE. Parents' nonstandard work schedules and children's social and emotional wellbeing: A mixed-methods analysis in Germany. J Fam Res. 2020;32(2):330–56.

326. Strazdins L, Clements MS, Korda RJ, Broom DH, D'Souza RM. Unsociable work? Nonstandard work schedules, family relationships, and children's well-being. J Marriage Fam. 2006;68(2):394–410.

327. Sanders MR, Kirby JN, Tellegen CL, Day JJ. The Triple P-Positive Parenting Program: A systematic review and meta-analysis of a multi-level system of parenting support. Clin Psychol Rev. 2014;34(4):337–57.

328. Sibbel AM. Living FIFO: the experiences and psychosocial wellbeing of Western Australian fly-in/fly-out employees and partners [Internet]. Edith Cowan University; 2010. Available from: https://ro.ecu.edu.au/theses/132

329. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc. 2007;39(8):1423–34.

330. Grace-Martin K. Strategies for Choosing the Reference Category in Dummy Coding [Internet]. The Analysis Factor. 2022 [cited 2022 Feb 3]. Available from: http://www.theanalysisfactor.com/strategies-dummy-coding/

331. Crain TL, Hammer LB, Bodner T, Kossek EE, Meon P, Lilienthal R, et al. Work-Family Conflict, Family-Supportive Supervisor Behaviors (FSSB), and Sleep Outcomes. J Occup Heal Psychol. 2014;19(2):155–67.

332. Australian Institute of Health and Welfare. Tobacco smoking [Internet]. Australian's health 2020. 2021. Available from: https://www.aihw.gov.au/reports/australias-

health/tobacco-smoking

333. Lawless MH, Harrison KA, Grandits GA, Eberly LE, Allen SS. Perceived stress and smoking-related behaviors and symptomatology in male and female smokers. Addict Behav. 2015;51:80–3.

334. Keramat SA, Alam K, Al-Hanawi MK, Gow J, Biddle SJH, Hashmi R. Trends in the prevalence of adult overweight and obesity in Australia, and its association with geographic remoteness. Sci Rep. 2021;11(1):1–9.

335. Huse O, Hettiarachchi J, Gearon E, Nichols M, Allender S, Peeters A. Obesity in Australia. Obes Res Clin Pract. 2018;12(1):29–39.

336. Australian Institute of Health and Welfare. Australian Burden of Disease Study 2018: key findings [Internet]. Burden of Disease. 2021. p. 1–8. Available from: https://www.aihw.gov.au/reports/burden-of-disease/burden-of-disease-study-2018-key-findings/contents/about

337. Keramat SA, Alam K, Gow J, Biddle SJH. A longitudinal exploration of the relationship between obesity, and long term health condition with presenteeism in Australian workplaces, 2006-2018. PLoS One. 2020;15(8 August):1–17.

338. Gravely S, Craig L V., Cummings KM, Ouimet J, Loewen R, Martin N, et al. Smokers' cognitive and behavioural reactions during the early phase of the COVID-19 pandemic: Findings from the 2020 ITC Four Country Smoking and Vaping Survey. PLoS One. 2021;16(6):1–23.

339. Rossell SL, Neill E, Phillipou A, Tan EJ, Toh WL, Van Rheenen TE, et al. An overview of current mental health in the general population of Australia during the COVID-19 pandemic: Results from the COLLATE project. Psychiatry Res. 2021;296:113660.

340. Lingard H, Turner M. Improving the health of male, blue collar construction workers: a social ecological perspective. Constr Manag Econ. 2015;33(1):18–34.

341. Nahum-Shani I, Smith SN, Spring BJ, Collins LM, Witkiewitz K, Tewari A, et al. Just-in-time adaptive interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. Ann Behav Med. 2018;52(6):446–62.

342. Shiffman S, Stone AA, Hufford MR. Ecological Momentary Assessment. Annu Rev Clin Psychol. 2008;4(1):1–32.

343. Smyth JM, Heron KE. Ecological Momentary Assessment (EMA) in Family Research. In: McHale SM, Amato P, Booth A, editors. Emerging methods in family research. New York: Springer; 2014. p. 95–108.

344. Ots P, Riethmeister V, Almansa J, Bültmann U, Brouwer S. The courses of objective physical activity and the association with sleepiness during a 2-week-on/2-week-off offshore shift rotation : an observational repeated- measures study. BMC Public Health. 2021;21:743.

345. Shiffman S. Designing Protocols for Ecological Momentary Assessmen. In: The science of real-time data capture: Self-reports in health research. Oxford University Press; 2007. p. 27–53.

346. Kwasnicka D, Inauen J, Nieuwenboom W, Nurmi J, Schneider A, Short CE, et al. Challenges and solutions for N-of-1 design studies in health psychology. Health Psychol Rev. 2019;13(2):163–78.

347. Beal DJ, Weiss HM. Methods of Ecological Momentary Assessment in Organizational Research. Organ Res Methods. 2003;6(4):440–64.

348. Resources Safety & Health Queensland. Distraction and inattention due to using mobile devices. Mines safety bulletin no. 130. 2013.

349. Stone AA, Shiffman S. Capturing momentary, self-report data: A proposal for reporting guidelines. Ann Behav Med. 2002;24(3):236–43.

350. Cain AE, Depp CA, Jeste D V. Ecological momentary assessment in aging research: A critical review. J Psychiatr Res. 2009;43(11):987–96.

351. Liao Y, Skelton K, Dunton G, Bruening M. A systematic review of methods and procedures used in ecological momentary assessments of diet and physical activity research in youth: An adapted STROBE checklist for reporting EMA Studies (CREMAS). J Med Internet Res. 2016;18(6):1–12.

352. Wen CKF, Schneider S, Stone AA, Spruijt-Metz D. Compliance with mobile ecological momentary assessment protocols in children and adolescents: A systematic review and meta-analysis. J Med Internet Res. 2017;19(4).

353. Bhuanantanondh P, Bandidcharoenlert P, Jalayondeja W, Jalayondeja C, Mekhora K. Fatigue assessment among onshore oil rig shift workers in Thailand. Int J Ind Ergon. 2021;83:103137.

354. Bjorvatn B, Kecklund G, Åkerstedt T. Bright light treatment used for adaptation to night work and re-adaptation back to day life. A field study at an oil platform in the North Sea. J Sleep Res. 1999;8(2):105–12.

355. Bjorvatn B, Stangenes K, Øyane N, Forberg K, Holsten F, Åkerstedt T, et al. Randomized placebo-controlled field study of the effects of bright light and melatonin in adaptation to night work Institute of Occupational Health , the Danish National Research Centre for the Working Environment , and the Norwegian National Institute of. Scand J Work Environ Health. 2007;33(3):204–14.

356. Merkus S, Holte K, Huysmans M, Hansen Å, van de Ven P, van Mechelen W, et al. Neuroendocrine recovery after 2-week 12-h day and night shifts: an 11-day follow-up. Int Arch Occup Environ Health. 2015;88(2):247–57.

357. Bjorvatn B, Kecklund G, Åkerstedt T. Rapid adaptation to night work at an oil platform, but slow readaptation after returning home. J Occup Environ Med. 1998;40(7):601–8.

358. Bolger N, Davis A, Rafaeli E. Diary Methods: Capturing Life as it is Lived. Annu Rev Psychol. 2003;54:579–616.

359. Myin-Germeys I, Oorschot M, Collip D, Lataster J, Delespaul P, Van Os J. Experience sampling research in psychopathology: Opening the black box of daily life. Psychol Med. 2009;39(9):1533–47.

360. Schembre SM, Liao Y, O'connor SG, Hingle MD, Shen SE, Hamoy KG, et al. Mobile ecological momentary diet assessment methods for behavioral research: Systematic

review. JMIR mHealth uHealth. 2018;6(11):1–14.

361. Broderick JE, Schwartz JE, Shiffman S, Hufford MR, Stone AA. Signaling Does Not Adequately Improve Diary Compliance. Ann Behav Med. 2003;26(2):139–48.

362. Intille S. Technological Innovations Enabling Automatic, Context-Sensitive Ecological Momentary Assessment. In: Stone AA, editor. The science of real-time data capture: self-reports in health research. Oxford University Press; 2007. p. 308–37.

363. Stone AA, Shiffman S, Schwartz JE, Broderick JE, Hufford MR. Patient compliance with paper and electronic diaries. Control Clin Trials. 2003;24(2):182–99.

364. Konjarski M, Murray G, Lee VV, Jackson ML. Reciprocal relationships between daily sleep and mood: A systematic review of naturalistic prospective studies. Sleep Med Rev. 2018;42:47–58.

365. Romanzini CLP, Romanzini M, Batista MB, Barbosa CCL, Shigaki GB, Dunton G, et al. Methodology used in ecological momentary assessment studies about sedentary behavior in children, adolescents, and adults: Systematic review using the checklist for reporting ecological momentary assessment studies. J Med Internet Res. 2019;21(5).

366. Wolfson AR, Carskadon MA, Acebo C, Seifer R, Fallone G, Labyak SE, et al. Evidence for the validity of a sleep habits survey for adolescents. Sleep. 2003;26(2):213–6.

367. Schwartz JE, Stone AA. Strategies for analyzing ecological momentary assessment data. Heal Psychol. 1998;17(1):6–16.

368. Heck RH, Thomas SL, Tabata LN. Introduction to Multilevel Modeling with IBM SPSS. In: Multilevel and Longitudinal Modeling with IBM SPSS. 2nd ed. 2013. p. 1–34.

369. Paech GM, Ferguson SA, Banks S, Dorrian J, Roach GD. The influence of break timing on the sleep quantity and quality of Fly-in, Fly-out shiftworkers. Ind Health. 2014;52(6):521–30.

370. Stansfeld SA, Pike C, McManus S, Harris J, Bebbington P, Brugha T, et al. Occupations, work characteristics and common mental disorder. Psychol Med. 2013;43(5):961–73.

371. Ilies R, Schwind KM, Wagner DT, Johnson MD, DeRue DS, Ilgen DR. When Can Employees Have a Family Life? The Effects of Daily Workload and Affect on Work-Family Conflict and Social Behaviors at Home. J Appl Psychol. 2007;92(5):1368–79.

372. Ilies R, Dimotakis N, De Pater IE. Psychological and physiological reactions to high workloads: Implications for well-being. Pers Psychol. 2010;63(2):407–36.

373. Schusterschitz C, Danay E, Geser W. Emotional reactions to daily workload: The moderating role of attachment orientations. Work Stress. 2018;32(3):262–80.

374. Röcke C, Li SC, Smith J. Intraindividual Variability in Positive and Negative Affect Over 45 Days: Do Older Adults Fluctuate Less Than Young Adults? Psychol Aging. 2009;24(4):863–78.

375. Nahrgang JD, Morgeson FP, Hofmann DA. Safety at Work: A Meta-Analytic Investigation of the Link Between Job Demands, Job Resources, Burnout,

Engagement, and Safety Outcomes. J Appl Psychol. 2011;96(1):71–94.

376. Nielsen MB, Gjerstad J, Frone MR. Alcohol Use and Psychosocial Stressors in the Norwegian Workforce. Subst Use Misuse. 2018;53(4):574–84.

377. Jones F, O'Connor DB, Conner M, McMillan B, Ferguson E. Impact of Daily Mood, Work Hours, and Iso-Strain Variables on Self-Reported Health Behaviors. J Appl Psychol. 2007;92(6):1731–40.

378. Radi S, Ostry A, LaMontagne AD. Job stress and other working conditions: Relationships with smoking behaviors in a representative sample of working australians. Am J Ind Med. 2007;50(8):584–96.

379. Kwasnicka D, Dombrowski SU, White M, Sniehotta FF. N-of-1 study of weight loss maintenance assessing predictors of physical activity, adherence to weight loss plan and weight change. Psychol Heal. 2017;32(6):686–708.

380. Sullivan Bisson AN, Robinson SA, Lachman ME. Walk to a better night of sleep: testing the relationship between physical activity and sleep. Sleep Heal. 2019;5(5):487–94.

381. Hequembourg AL, Blayney JA, Bostwick W, Van Ryzin M. Concurrent Daily Alcohol and Tobacco Use among Sexual Minority and Heterosexual Women. Subst Use Misuse. 2020;55(1):66–78.

382. Australian Nutrition Foundation. Australian Dietary Guidelines : Standard serves [Internet]. Factsheet. 2021 [cited 2021 Jul 21]. Available from: https://nutritionaustralia.org/fact-sheets/adgs-standard-serves/

383. Anderson AR, Fowers BJ. Lifestyle behaviors, psychological distress, and well-being: A daily diary study. Soc Sci Med. 2020;263:113263.

384. Fredrickson BL, Arizmendi C, Van Cappellen P. Same-day, cross-day, and upward spiral relations between positive affect and positive health behaviours. Psychol Heal. 2020;36(4):444–60.

385. Prince SA, Rasmussen CL, Biswas A, Holtermann A, Aulakh T, Merucci K, et al. The effect of leisure time physical activity and sedentary behaviour on the health of workers with different occupational physical activity demands: a systematic review. Int J Behav Nutr Phys Act. 2021;18(1):1–17.

386. Watson D, Clark LA. The PANAS-X Manual for the Positive and Negative Affect Schedule - Expanded Form. Iowa: University of Iowa; 1994. 1–28 p.

387. Stevenson BL, Dvorak RD, Kramer MP, Peterson RS, Dunn ME, Leary A V., et al. Within- and between-person associations from mood to alcohol consequences: The mediating role of enhancement and coping drinking motives. J Abnorm Psychol. 2019;128(8):813–22.

388. Dijkhuizen J, Veldhoven M Van. Development and Validation of the Entrepreneurial Job Demands Scale Development and Validation of the Entrepreneurial Job Demands Scale. Int J Knowledge, Innov Entrep. 2014;2(1):70–88.

389. Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol.

1998;3(4):322–55.

390. Hätinen M, Kinnunen U, Pekkonen M, Kalimo R. Comparing Two Burnout Interventions: Perceived Job Control Mediates Decreases in Burnout. Int J Stress Manag. 2007;14(3):227–48.

391. Morgeson FP, Humphrey SE. The Work Design Questionnaire (WDQ): Developing and validating a comprehensive measure for assessing job design and the nature of work. J Appl Psychol. 2006;91(6):1321–39.

392. Kuppens P, Van Mechelen I, Nezlek JB, Dossche D, Timmermans T. Individual differences in core affect variability and their relationship to personality and psychological adjustment. Emotion. 2007;7(2):262–74.

393. Maisey G, Cattani M, Devine A, Lo J, Fu SC, Dunican IC. Digging for data: How sleep is losing out to roster design, sleep disorders, and lifestyle factors. Appl Ergon. 2022;99:103617.

394. Xanthopoulou D, Bakker AB, Demerouti E, Schaufeli WB. A diary study on the happy worker: How job resources relate to positive emotions and personal resources. Eur J Work Organ Psychol. 2012;21(4):489–517.

395. Daniels K, Beesley N, Wimalasiri V, Cheyne A. Problem Solving and Well-Being: Exploring the Instrumental Role of Job Control and Social Support. J Manage. 2013;39(4):1016–43.

396. Reis HT, Sheldon KM, Gable SL, Roscoe J, Ryan RM. Daily Well-Being:The Role fo Autonomy,Competence,and Relatedness. Personal Soc Psychol Bull. 2000;26(4):419–35.

397. Zhou E. The “Too-Much-of-a-Good-Thing” Effect of Job Autonomy and Its Explanation Mechanism. Psychology. 2020;11(02):299–313.

398. Gillet N, Huyghebaert-Zouaghi T, Réveillère C, Colombat P, Fouquereau E. The effects of job demands on nurses’ burnout and presenteeism through sleep quality and relaxation. J Clin Nurs. 2020;29(3–4):583–92.

399. Devine CM, Stoddard AM, Barbeau EM, Naishadham D, Sorensen G. Work-to-family spillover and fruit and vegetable consumption among construction laborers. Am J Heal Promot. 2007;21(3):175–82.

400. Abdel Hadi S, Mojzisch A, Parker SL, Häusser JA. Experimental evidence for the effects of job demands and job control on physical activity after work. J Exp Psychol Appl. 2021;27(1):125–41.

401. van Hooff MLM, de Grave RMB, Geurts SAE. No Pain, No Gain? Recovery and Strenuousness of Physical Activity. J Occup Health Psychol. 2018;20:2022.

402. Bowling NA, Kirkendall C. Workload: A Review of Causes, Consequences, and Potential Interventions. Contemp Occup Heal Psychol Glob Perspect Res Pract. 2012;2:221–38.

403. Parker S, Sprigg C. Minimizing strain and maximizing learning: The role of job demands, job control, and proactive personality. J Appl Psychol. 1999;84(6):925–39.

404. Abbe OO, Harvey CM, Ikuma LH, Aghazadeh F. Modeling the relationship between

occupational stressors, psychosocial/physical symptoms and injuries in the construction industry. Int J Ind Ergon [Internet]. 2011;41(2):106–17. Available from: http://dx.doi.org/10.1016/j.ergon.2010.12.002

405. Dvorak RD, Pearson MR, Day AM. Ecological Momentary Assessment of Acute Alcohol Use Disorder Symptoms : Associations With Mood , Motives , and Use on Planned Drinking Days. 2014;22(4):285–97.

406. Griffin AM, Sulkowski ML, Bámaca-Colbert MY, Cleveland HH. Daily social and affective lives of homeless youth: What is the role of teacher and peer social support? J Sch Psychol. 2019;77(July 2018):110–23.

407. Bakker AB, Demerouti E, Euwema MC. Job resources buffer the impact of job demands on burnout. J Occup Health Psychol. 2005;10(2):170–80.

408. Daniels K, Harris C. A daily diary study of coping in the context of the job demands-control-support model. J Vocat Behav. 2005;66(2):219–37.

409. Tadić M, Bakker AB, Oerlemans WGM. Challenge versus hindrance job demands and well-being: A diary study on the moderating role of job resources. J Occup Organ Psychol. 2015;88(4):702–25.

410. Aldridge-Gerry AA, Roesch SC, Villodas F, McCabe C, Leung QK, Da Costa M. Daily stress and alcohol consumption: Modeling between-person and within-person ethnic variation in coping behavior. J Stud Alcohol Drugs. 2011;72(1):125–34.

411. Labrie JW, Hummer J. F, Pedersen ER. Reasons for Drinking in the College Student Context: The Differential Role and Risk of the Social Motivator. J Stud Alcohol Drugs. 2007;68(3):393–8.

412. DeHart T, Tennen H, Armeli S, Todd M, Mohr C. A diary study of implicit self-esteem, interpersonal interactions and alcohol consumption in college students. J Exp Soc Psychol. 2009;45(4):720–30.

413. Groh DR, Jason LA, Davis MI, Olson BD, Ferrari JR. Friends, family, and alcohol abuse: An examination of general and alcohol-specific social support. Am J Addict. 2007;16(1):49–55.

414. Dittman CK, Rathbone JA. ‘I Have to be the Mum and Dad for 4 Weeks Straight’. Exploring the Experiences and Support Needs of Australian Parents and Partners Engaged in Fly-In/Fly-Out Work Practices. J Fam Issues. 2022;

415. Parkes KR, Fruhen LS, Parker SK. Direct, indirect, and moderated paths linking work schedules to psychological distress among fly-in, fly-out workers. Work Stress. 2022;1–21.

416. Australian Institute of Health and Welfare. Alcohol, tobacco & other drugs in Australia [Internet]. Canberra; 2021 [cited 2021 Oct 27]. Available from: https://www.aihw.gov.au/reports/alcohol/alcohol- tobacco-other-drugs-australia

417. Holden L, Scuffham PA, Hilton MF, Ware RS, Vecchio N, Whiteford HA. Health-related productivity losses increase when the health condition is co-morbid with psychological distress: Findings from a large cross-sectional sample of working Australians. BMC Public Health. 2011;11.

418. Asare-Doku W, Rich J, Kelly B, James C. Mental health interventions in the mining

industry: a narrative review. Ment Heal Rev J. 2020;25(2):153–67.

419. Deady M, Johnston D, Milne D, Glozier N, Peters D, Calvo R, et al. Preliminary effectiveness of a smartphone app to reduce depressive symptoms in the workplace: feasibility and acceptability study. JMIR mHealth uHealth. 2018;6(12).

420. Molek-Winiarska D, Żołnierczyk-Zreda D. Application of mindfulness-based stress reduction to a stress management intervention in a study of a mining sector company. Int J Occup Saf Ergon. 2018;24(4):546–56.

421. Soucy Chartier I, Provencher MD. Behavioural activation for depression: Efficacy, effectiveness and dissemination. J Affect Disord. 2013;145(3):292–9.

422. Tynan RJ, James C, Considine R, Skehan J, Gullestrup J, Lewin TJ, et al. Feasibility and acceptability of strategies to address mental health and mental ill-health in the Australian coal mining industry. Int J Ment Health Syst. 2018;12(1):1–10.

423. World Health Organization. Alcohol [Internet]. Facts sheet. 2018 [cited 2021 Aug 31]. p. 1–5. Available from: Www.who.int/news-room/fact-sheets/detail/alcohol

424. Tang TL-P, Crofford AB. Self-managing Work Teams. Employ Relat Today. 1995;22(4):29–39.

425. Cohen SG, Ledford GEJ. The effectiveness of Self-managing Teams: A Quasi-Experiment. Hum Relations. 1994;47(1):13–42.

426. Fey N, Nordbäck E, Ehrnrooth M, Mikkonen K. How peer coaching fosters employee proactivity and well-being within a self-managing Finnish digital engineering company. Organ Dyn. 2022;51(3).

427. de Bruin J, Doodkorte R, Sinervo T, Clemens T. The implementation and outcomes of self-managing teams in elderly care: A scoping review. J Nurs Manag. 2022;30(8):4549–59.

428. Wheeler AJ, Roennfeldt H, Slattery M, Krinks R, Stewart V. Codesigned recommendations for increasing engagement in structured physical activity for people with serious mental health problems in Australia. Heal Soc Care Community. 2018;26(6):860–70.

429. McKeon G, Steel Z, Wells R, Newby JM, Hadzi-Pavlovic D, Vancampfort D, et al. Mental health informed physical activity for first responders and their support partner: A protocol for a stepped-wedge evaluation of an online, codesigned intervention. BMJ Open. 2019;9(9):1–9.

430. McKeon G, Wells R, Steel Z, Hadzi-Pavlovic D, Teasdale S, Vancampfort D, et al. An online mental health informed physical activity intervention for emergency service workers and their families: A stepped-wedge trial. Digit Heal. 2023;9:1–19.

431. van Hooff MLM, Geurts SAE. Need satisfaction and employees' recovery state at work: A daily diary study. J Occup Health Psychol. 2015;20(3):377–87.

Appendices

Appendix A: Ethical approval

Curtin University

Research Office at Curtin

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12-Nov-2020

Name: Suzanne Robinson
Department/School: School of Public Health
Email: Suzanne.Robinson@curtin.edu.au

Dear Suzanne Robinson

RE: Ethics Office approval
Approval number: HRE2020-0693

Thank you for submitting your application to the Human Research Ethics Office for the project **Exploring health issues associated with rotation work by employing intensive longitudinal assessment methods**.

Your application was reviewed through the Curtin University Low risk review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in the National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007).*

Approval is granted for a period of one year from **12-Nov-2020** to **11-Nov-2021**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Robinson, Suzanne	CI
Kwasnicka, Dominika	Supervisor
Asare, Bernard Yeboah-Asiamah	Student
Powell, Daniel	Supervisor

Approved documents:

Document

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an

amendment is undertaken to eliminate an immediate risk to participants)

4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

It is the responsibility of the Chief Investigator to ensure that any activity undertaken under this project adheres to the latest available advice from the Government or the University regarding COVID-19.

This letter constitutes low risk/negligible risk approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Amy Bowater
Ethics, Team Lead

Appendix B: Related studies

Related study 1. Mental Well-Being during COVID-19: A Cross-Sectional Study of Fly-In Fly-Out Workers in the Mining Industry in Australia

International Journal of
Environmental Research and Public Health

MDPI

Article

Mental Well-Being during COVID-19: A Cross-Sectional Study of Fly-In Fly-Out Workers in the Mining Industry in Australia

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Citation: Asare, B.Y.-A.; Thomas, E.; Affandi, J.S.; Schammer, M.; Brown, P.; Pilbeam, M.; Harris, C.; Ellison, C.; Kwasnicka, D.; Powell, D.; et al. Mental Well-Being during COVID-19: A Cross-Sectional Study of Fly-In Fly-Out Workers in the Mining Industry in Australia. *Int. J. Environ. Res. Public Health* **2021**, *18*, 12264. https://doi.org/10.3390/ijerph182212264

Academic Editor: Paul B. Tchounwou

Received: 2 November 2021
Accepted: 20 November 2021
Published: 22 November 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: Coronavirus disease 2019 (COVID-19) has devastated the world, and its mental health impact has been recognized in the general population. However, little is known about the mental health impact of COVID-19 on fly-in fly-out (FIFO) workers, who are flown to temporarily stay and work in remote areas, during this pandemic. This study examined the mental well-being of FIFO workers in the mining industry during COVID-19 restrictions in Western Australia. An online survey was conducted between May to November 2020 among (N = 842) FIFO workers who underwent COVID-19 screening at a large mining company in Western Australia. The mental well-being score among workers was higher than population norms. One-way ANOVA with Bonferroni post-hoc tests showed significant differences in mental well-being by age, being placed under travel quarantine, undertaking self-isolation, impact of social distance guidelines, and experience of COVID-19 related symptoms. Multiple linear regression analysis showed workers who were younger, placed under travel quarantine and experienced two or more COVID-19 related symptoms were more likely to have worse mental well-being. Acknowledging the negative emotions and distress experiences among the vulnerable groups could help in providing suitable support to help lessen these negative experiences in FIFO workers.

Keywords: COVID-19; fly-in fly-out; FIFO; mental well-being; mental health; mining; Australia

1. Introduction

Coronavirus disease (COVID-19) has devastated lives and economies around the world; since its detection in December 2019 [1]. In March 2020, the World Health Organization (WHO) declared COVID-19 as a pandemic having infected over 118,000 people and caused 4291 deaths in 114 countries [2]. As of 4 October 2021, there were 234,609,003 established COVID-19 cases, and 4,797,368 lives lost around the world [3]. In January 2020, Australia recorded its first COVID-19 case [4], and now has recorded 113,411 confirmed cases with 1344 deaths as of 4 October 2021 [5].

This public health emergency necessitated extraordinary measures to be taken in order to limit the spread or transmission of the virus in the general population across

Related study 2. Multiple health-related behaviours among Fly- In Fly-Out workers in the mining industry in Australia: A cross-sectional survey during the COVID-19 pandemic

PLOS ONE

RESEARCH ARTICLE

Multiple health-related behaviours among Fly-In Fly-Out workers in the mining industry in Australia: A cross-sectional survey during the COVID-19 pandemic

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OPEN ACCESS

Citation: Asare BY-A, Thomas E, Affandi JS, Schammer M, Harris C, Kwasnicka D, et al. (2022) Multiple health-related behaviours among Fly-In Fly-Out workers in the mining industry in Australia: A cross-sectional survey during the COVID-19 pandemic. PLoS ONE 17(10): e0275008. https://doi.org/10.1371/journal.pone.0275008

Editor: Edward Jay Trapido, LSU Health Sciences Center New Orleans: Louisiana State University Health Sciences Center, UNITED STATES

Received: April 29, 2022

Accepted: September 8, 2022

Published: October 27, 2022

Data Availability Statement: Data cannot be shared publicly due to privacy or ethical restrictions. Data are available from the Curtin University Data Access/Ethics Committee (contact via HREC@cutin.edu.au) for researchers who meet the criteria for access to confidential data.

Funding: The study received funding from Mineral Resources Limited (Australia). Mineral Resources Limited provided AUS$ 200 shopping voucher to

Abstract

Background

Fly-In-Fly-Out (FIFO) workers travel to work at isolated locations, and rotate continuous workdays with leave periods at home, and such work practice is common in the offshore oil and gas and onshore mining industry worldwide. The COVID-19 pandemic and accompanying public health actions appear to have had a negative impact on several health-related behaviours among the general population. However, little is known about the impact of the COVID-19 pandemic on the health behaviours of FIFO workers, who have shown higher pre-pandemic rates of risky behaviours than the general population in Australia. This study examined the health-related behaviours of FIFO workers in the mining industry during the COVID-19 pandemic.

Methods

A descriptive cross-sectional study was conducted. FIFO workers from an Australian mining company who underwent COVID-19 screening between May and November 2020 completed an online survey about their regular health-related behaviours. The independent sample t-test and Pearson's chi-square test where appropriate were conducted to examine the differences between males and females for the behavioural outcomes.

Results

A total of 768 FIFO workers (633 males and 135 females) participated in the study. Prevalence of smoking was high (32%). Males smoked more cigarettes per day than females

Appendix C: Supplementary files in Chapter 2

Supplementary information S1. Search strategy for databases

PsycINFO

1. fifo or fly-in fly-out or fly in fly out or drive in drive out or dido or drive-in drive-out or long distance commut* or offshore or rotation shift or rotational work schedule*

2. health or sick* or ill* or wellbeing or psycho* or alcohol or diet or smok* or insomnia or sleep* or physical activit* or exercise or obes* or overweight or fatigue* or stress* or depress* or anxiety or muscul* or cardio* or gastro* or health behavio?r* or health promotion

3. exp Health/ or exp Occupational Stress/ or exp Fatigue/ or exp Sleep/ or exp Well Being/ or exp Sleepiness/ or exp Psychological Stress/ or exp Stress/ or exp Distress/ or exp Mental Health/ or exp Anxiety/ or exp Exercise/ or exp Alcohol Drinking Attitudes/ or exp Alcohol Drinking Patterns/ or exp Binge Drinking/ or exp Alcohol Abuse/ or tobacco smoking/ or "depression (emotion)"/ or exp Health Behavior/ or exp Physical Activity/ or exp Tobacco Smoking/ or exp Health Promotion/ or exp Body Mass Index/ or exp Physical Health/ or exp Cardiovascular Disorders/ or exp Anxiety Disorders/ or exp Musculoskeletal Disorders/

4. 1 AND (2 OR 3)

Medline

1. fifo or fly-in fly-out or fly in fly out or drive in drive out or dido or drive-in drive-out or long distance commut* or offshore or rotation shift or rotational work schedule*

2. health or sick* or ill* or wellbeing or psycho* or alcohol or diet or smok* or insomnia or sleep* or physical activit* or exercise or obes* or overweight or fatigue* or stress* or depress* or anxiety or muscul* or cardio* or gastro* or health behavio?r* or health promotion

3. Fatigue/ or Mental Fatigue/ or Interpersonal Relations/ or Mental Health/ or Mental disorders/ or Sleep Wake Disorders/ or Sleep Initiation Maintenance Disorders/ or Anxiety/ or Anxiety Disorders/ or Depression/ or Health behaviour/ or Work Schedule Tolerance/ or cardiovascular diseases/ or Musculoskeletal diseases/ or Gastrointestinal diseases/ or exp Stress, Physiological/ or Stress, Psychological/ or Occupational stress/ or Occupational health/ or Occupational health/ or Health promotion/

4. 1 AND 2 OR 3

Pubmed

1. (fifo[Text Word] OR fly-in fly-out[Text Word] OR fly in fly out[Text Word] OR drive in drive out[Text Word] OR dido[Text Word] OR drive-in drive-out[Text Word] OR long distance commut*[Text Word] OR offshore [Text Word] OR rotation shift[Text Word] OR rotational work schedule*[Text Word])

2. (((health[Text Word] OR psychological distress[Text Word] OR wellbeing[Text Word] OR alcohol[Text Word] OR insomnia[Text Word] OR diet[Text Word] OR mental health[Text Word] OR physical health[Text Word] OR physical activity[Text Word] OR exercise[Text Word] OR obes*[Text Word] OR overweight[Text Word] OR sleep disorder*[Text Word] OR sleep*[Text Word] OR smoking[Text Word] OR fatigue*[Text Word] OR stress*[Text Word] OR depress*[Text Word] OR anxiety[Text Word] OR muscul*[Text Word] OR cardio*[Text Word] OR psycho*[Text Word] OR gastr*[Text Word] OR sick*[Text Word]))

3. ((Health Behaviour/ ethnology or Alcohol Drinking/ ethnology or Alcohol Drinking/ physiopathology or Alcohol Drinking/ therapy or Overweight/ ethnology or Overweight/ physiopathology or Overweight/ therapy or Smoking/ ethnology or Smoking/ physiopathology or Smoking/ therapy or Sleep Disorders, Circadian Rhythm/ diagnosis or Sleep Disorders, Circadian Rhythm/ ethnology or Sleep Disorders, Circadian Rhythm/ physiopathology or Health Status or Mental Health or Occupational health or Sleep Wake Disorders/ etiology or Fatigue/ etiology or Health behaviour or Adaptation, psychological or Stress, physiological or Stress, psychological or Work Schedule Tolerance/ psychology[MeSH Terms])))

4. 1 AND 2 OR 3

Embase

1. FIFO or fly-in fly-out or fly in fly out or drive in drive out or dido or drive-in drive-out or long distance commut* or offshore or rotation shift or rotational work schedule*

AND

2. health or sick* or wellbeing or psycho* or alcohol or diet or smok* or insomnia or sleep* or physical activit* or exercise or obes* or overweight or fatigue* or stress* or depress* or anxiety or muscul* or cardio* or gastro* or health behavio?r* or health promotion

OR

3. Fatigue/ or Mental Fatigue/ or Interpersonal Relations/ or Mental Health/ or Sleep Wake Disorders/ or Sleep Initiation Maintenance Disorders/ or Anxiety/ or Anxiety Disorders/ or Depression/ or Stress, Physiological/ or Stress, Psychological/ or Work Schedule Tolerance/ or cardiovascular diseases/ or Musculoskeletal diseases/ or Gastrointestinal diseases/ or Health behaviour/ or Occupational stress/ or Occupational health/ or Health promotion/ or Mental disorders/ or Occupational exposure/ or Health status/

CINAHL

1. fifo or fly-in fly-out or fly in fly out or drive in drive out or dido or drive-in drive-out or offshore or long distance commut*

AND

2. health or psycho* or wellbeing or alcohol or insomnia or diet or mental health or physical health or physical activity or exercise or obes* or overweight or sleep disorder* or sleep* or smoking or fatigue* or stress* or depress* or anxiety or

muscul* or cardio* or psycho* or gastr* or sick* or health behaviour* or health promotion

OR

3. (MH "Stress, Physiological+") OR (MH "Stress+") or (MH "Depression+") or (MH "Anxiety Disorders+") OR (MH "Anxiety+") or (MH "Smoking+") or (MM "Mental Fatigue") OR (MM "Fatigue") or (MM "Physical Activity") or (MM "Mental Health") or (MH "Sleep Disorders") OR (MH "Sleep") OR (MM "Sleep Disorders, Circadian Rhythm") or (MH "Alcohol Drinking+") or (MM "Psychological Well-Being") or (MH "Stress, Psychological+") OR (MH "Psychology, Applied+") or (MM "Health")

Scopus

1. Fly in fly out OR FIFO OR offshore OR rotation work shift

2. health or sick* or wellbeing or psycho* or alcohol or diet or smok* or insomnia or sleep* or physical activit* or exercise or obes* or overweight or fatigue* or stress* or depress* or anxiety or muscul* or cardio* or gastro*

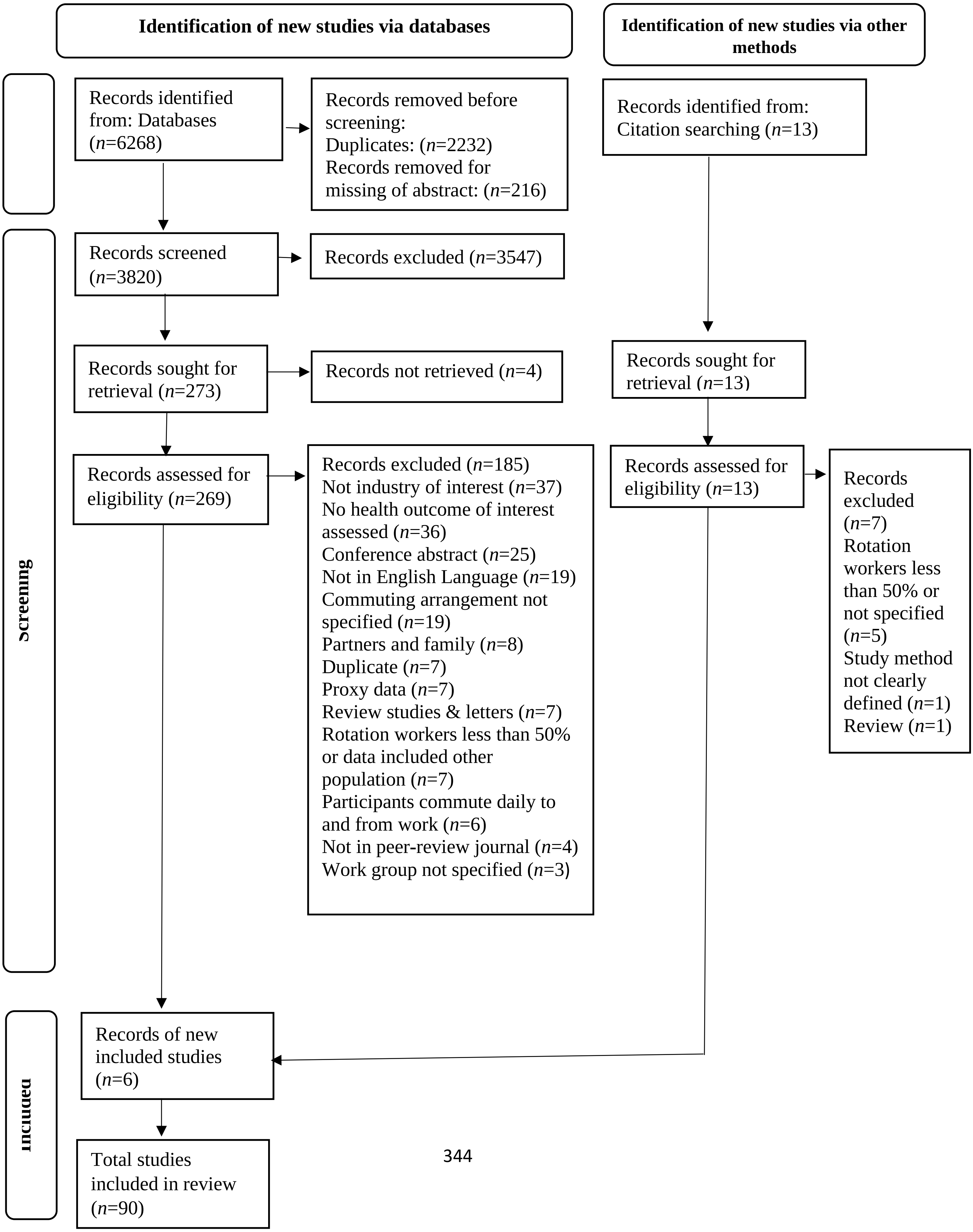
3. 1 AND 2

S1. Extraction form

Domain	Data
Author & year	
Study design	
Aim/objective	
Country & industry	
Participants characteristics (sample size, age, gender)	
Health outcome/phenomenon of interest	
Mode of assessment	
Work-related predictor	
Analysis plan	
Key findings	
Quality rating	

Supplementary information S2. Flow diagram of included studies

Figure S1. Flow diagram of identifying and selecting studies for the systematic review



Supplementary Information S3. Summary of findings from included studies

Table S1. Summary of quantitative studies

Author	Study design	Aim/objective	Study population/study country and industry	Health outcome	Measurements	Summary of findings
Aiken & McCance, 1982(105)	Cross-sectional survey	To examine the drinking habits of offshore workers	213 male workers; Industry; age NR; country/country: UK; industry: Offshore oil/gas	Alcohol intake	Self-reported alcohol intake prior to offshore tour. Analysis plan: Chi-square test and Log t-test	30% consume alcohol above safe limit and more heavy (30%) compared to the general population (10%). Alcohol intake was significantly high among manual workers (37%); manual worker consumed 49.3 units/week compared to an executive worker (29.5 units) ($p<0.004$) and onshore manual industrial workers (21.4 units) ($p<0.005$).
Albrecht & Anglim, 2018(51)	Longitudinal diary survey	To test a model of how day-to-day experiences of job demands and job resources predict day-to-day well-being across the FIFO work cycle	52 FIFO workers; 62.7% male. Country: Australia Industry: Construction	Emotional exhaustion and engagement	Emotional exhaustion, and engagement were measured with items adapted from previously published scales. Analysis plan: Bayesian hierarchical methods	Work engagement declined (-0.07, 95%CI -0.11, 0.03) and emotional demand increased (0.05, 95%CI -0.09, 0.00) over the course of the work cycle. Day-level autonomy ($\beta=0.15$; $p<0.05$) predicted day-level engagement; day-level workload ($\beta=0.16$;$p<0.05$) and emotional demands ($\beta=0.45$;$p<0.05$) predicted emotional exhaustion
Barclays *et al.*, 2016(110)	Cross-sectional survey	To assess the factors associated with well-being of fly-in fly-out (FIFO) workers	60 FIFO geologists; 51.7% males; Mean age 32.2 years Country/country: Australia Industry: Mining	Mental and physical health; sleep problems; BMI	Mental health (Depression, anxiety & stress) measured using DASS-21 (Depression: scores 7-10=moderate, ≥11 severe; Anxiety: 6-7 moderate, ≥8 severe; stress: 10-12 moderate, ≥13 severe); Physical health assessed by self-reported health status. Analysis plan: Descriptive statistics	Depression ($m=6.6\pm7.28$), anxiety ($m=3.69\pm4.20$), stress ($m=8.98\pm7.64$) scores were similar to that of normal population; 10% had severe psychological problem. 45% reported loneliness and isolated. Physical health status was reported good (61.7%) or very good (11.7%); 66.7% reported exercise regularly; 3.3% reported smoking; 46.7% exercise daily or multiple times per week; 25% reported difficulty in sleeping often/most of the time, and 33.3% sometime experience trouble sleeping; 40% were overweight
Bergh *et al.*, 2015(155)	Mixed method study	To present and discuss the auditing	303 offshore employees;	Feeling worn out;	Feeling worn out measured by GWBQ (scores ≥18 on 0-48	Offshore workers ($m=13.8$) were less worn-out compared to the normal population ($m=15.87$).

	(Quantitative data)	tool for a psychosocial work environment	Country: Norway Industry: Offshore oil & gas	musculoskeletal complaints	scale= more worn out). Self-reported musculoskeletal pain in the past year. Analysis plan: Likelihood Ratio/Odds Ratio analysis	Less than 50% of the survey participants reported musculoskeletal pain; headache (36%), shoulder pain (36%), back pain (33%) and neck (27%)
Bergh *et al*., 2018(154)	Mixed method study (Quantitative data)	To explore specific and common psychosocial risks to the oil and gas industry	788 offshore and 1024 onshore workers; Country: Norway Industry: Offshore oil & gas	Worn-out	Work-related stress symptoms were assessed using the worn-out scale of the GWBQ (scores ≥ 18 on 0-48=more worn out). Analysis plan: t-test and correlation analysis	Offshore workers (m=13.82) were less worn-out compared to onshore oil workers (m=15.11) (t=4.658; p<0.001). Increased job demands (r=-0.382; p<0.001) related to poor general well-being. High social support (r=-0.457; p<0.001), clear roles (r=-0.415; p<0.001), and job control (r=-0.472; p<0.001) related to low symptom scores (i.e. better well-being).
Berthelsen *et al*., 2015(114)	Cross-sectional survey	To examine the relationship between psychosocial work exposures and mental distress among onshore- and offshore workers	1471 onshore and offshore workers; 93.2% males; mean age 42.6±10.5yrs; Country: Norway; Industry: Offshore oil & gas	Mental distress (Depression and anxiety)	Anxiety and depression were assessed using Hospital Anxiety and Depression Scale (HADS) (scores ≤7-normal, ≥8=borderline abnormal, ≥11-abnormal case). Analysis plan: Simple and multiple linear regression analyses with block design	Prevalence of anxiety (11.4%) and depression (16.7%) among the offshore workers were lower than the onshore workers (anxiety:13.9%, depression:22.8%); Job demands (β=0.18, 99%CI 0.10-0.26) was associated with more mental distress. Job control (β=-0.11, 99%CI -0.20, -0.03), role clarity (β=-0.15, 99%CI -0.24, -0.06), and fair leadership (β=-0.18, 99%CI -0.29, -0.08) were associated with lower mental distress.
Bjerkan *et al*., 2010(116)	Cross-sectional survey	To examine the relationship between health, safety and work environment	9945 personnel; 89.5% males; 67.1% aged 31 to 50yrs. Country: Norway Industry: Offshore oil & gas	Health complaints	Health complaints were assessed by subjective health complaints in the last 3 months and self-rated General health status. Analysis plan: MANOVA and Bonferroni post hoc test	Perceived general health status was good or very good; Workers in maintenance and modification work groups perceived their general health as poor than other work groups ($F_{7, 8870}$= 7.23, p<0.000); Accommodation personnel reported a significantly higher frequency of ill-health symptoms as compared to the other work groups ($F_{7, 8870}$=12.76, p>0.000).
Bjerkan *et al*., 2011(115)	Cross-sectional survey	To examine the effect of work-related variables on self-reported health complaints among	414 onshore and offshore workers in the maintenance and modification division;	Mental and physical health	Health assessed using the Subjective Health Complaints Inventory (higher mean score on a 0-3 scale =more health complaints). Analysis plan:	Offshore workers reported few physical (mean scores 1.32-1.91) and psychological health (mean scores 1.09-1.40) complaints similar to onshore workers. Job type was related to perceived psychological health [$F_{(7)}$ = 2.94, p = 0.011] and

		Norwegian onshore and offshore oil workers	87.4% male; mean age of 40± 11.19yrs; Country: Norway Industry: offshore oil and gas		MANOVA and Stepwise multiple regression analyses	physical health status ($F_{(14,100)}$= 1.85, p=0.041). Low control of decision (β = − 0.27; p=0.011) and perceived family matters exert negative influence on health (β = -0.24; p=0.020) were negatively associated with psychological health; job demands of repetitive work (β =− 0.23; p=0.042) was negatively associated with physical health
Bowers *et al*., 2018(27)	Cross-sectional survey	To assess the prevalence and correlates of psychological distress	1124 participants (99.6% FIFO) 93.5% males Mean age 37.3±10.7 years Country: Australia Industry: Mining and construction	Psychological distress	Psychological distress assessed by The Kessler Psychological Distress Scale (K10) (scores ≥22 on a scale of 10-50=high/very high distress); Analysis plan: Univariate multinomial regressions and multivariable regression	28% high or very high psychological distress than the general population (10.8%). Stress from fear of stigmatisation for mental health problems (OR=23.5; 95%CI=7.5-73.2), stress caused by immediate supervisory (OR=4.3; 95%CI 1.6-11.3), stress from the remoteness of their living circumstances (OR=3.7; 95%CI=1.6-8.6), financial stress (OR=6.0; 95%CI=2.7-13.1), stress from job tasks (OR=6.2; 95%CI =1.8-21.2), and stress from shift length (OR=2.4; 95%CI=1.2-5.1); and on roster 1 week on/1 week off (OR=1.6; 95%CI=1.0-2.5) and 2 weeks on/2 weeks off (OR=2.4; 95%CI=1.7-3.4) were associated with high distress levels.
Carter *et al*., 2007(72)	Cross-sectional study	To examine the hydration knowledge, perceptions and behaviours; hydration status and needs	180 mining staff; 96% males. Country: Australia. Industry: Mining	Alcohol intake; physical activity	Self-reported alcohol intake (number of standard alcoholic drinks) and number of physical activities. Analysis plan: descriptive statistics	33% consume alcohol; median 3.0(IQR 2.0-6.0) standard drinks per session, and median 3.0(IQR 2.0-6.0) days per week. 50% engage in physical activity at camp; engaged in a median of 3 days per week
Chen, *et al*., 2003(135)	Cross-sectional survey	To examine determinants of perceived occupational stress	561 male workers; mean age was 32.43±8.65yrs; Country: China Industry: Offshore oil & gas	Perceived occupational stress	Occupational stress was measured by the Occupational Stress Scale (OSS). Analysis plan: Hierarchical regression	Lower perceived social support was associated with greater stress from managers (β =0.119; p<0.05), organization structure (β =-0.126; p<0.01) and living environment (β =0.120; p<0.001).
Chen *et al.,* 2005(70)	Cross-sectional study	To examine musculoskeletal pain	561 male workers; mean age	Musculoskeletal problems	Musculoskeletal complaints in the past 12 months using the	56.3% reported musculoskeletal pains in the last 12 months: low back (32.4%), neck (25%), knees

		and occupational stress and other psychosocial factors	32.43±8.65yrs Country: China; Industry: offshore oil and gas		standardised Nordic questionnaire. Analysis plan: multiple forward stepwise logistic regression	(20.1%) and shoulder (20%). Low back pain associated with stress from interface between job and family/social life (OR=1.46; 95%CI=1.18–1.82), safety concerns (OR=1.29; 95%CI=1.05–1.59), physical environment of workplace (OR=1.37; 95%CI=1.11–1.69), and living in environment (OR=1.26; 95%CI=1.02–1.56). Pains in the neck associated with stress from the interface between job and family/social life (OR=1.34; 95%CI=1.05–1.70), safety concern (OR=1.53; 95%CI=1.26–1.93), and physical environment of workplace (OR=1.43; 95%CI=1.14–1.79). Pain in the knees was associated with stress from safety concerns (OR=1.59; 95%CI=1.24–2.06), physical environment of workplace (OR=1.43; 95%CI=1.11–1.85) and managerial role (OR=0.76; 95%C=0.58–0.98). Pain in the shoulder was associated with stress from interface between job and family/social life (OR=1.35; 95%CI=1.02–1.71), safety concerns (OR=1.54; 95%CI=1.20–1.99), and physical environment of workplace (OR=1.32; 95%CI=1.03–1.68). Pain in the wrist/hands was associated with social support (OR=2.44, 95%CI=1.18–5.04).
Chen *et al.*, 2008(138)	Cross-sectional study	To explore the relationship of occupational stress and social support with health-related behaviours	561 male workers; mean age 32.43±8.65yrs; Country: China; Industry: offshore oil and gas	Physical exercise, alcohol intake, smoking.	Self-reported physical exercise (regular exercise after work), alcohol intake (regular intake of alcohol at least one time per week for at least one year), current smoking (regularly smoking of at least one cigarette per day for at least one year). Analysis plan: logistic regression	63.1% did not engage in leisure-time physical exercise. 38.9% current smokers; 22.1% current alcohol consumers. Current smoking was associated with perceived stress from safety concerns (OR=0.74; 95%CI=0.58-0.94) and supervisors’ instrumental support (OR=0.34; 95%CI=0.18-0.65). Current drinking was related to perceived stress from “interface between job and family/social life” (OR=1.32; 95%CI=1.02-1.70) and “Organizational structure” (OR=1.35; 95%CI=1.06-1.74) and emotional support from friends (OR=0.54; 95%CI=0.32-0.96).

						Physical inactivity after work was associated with perceived stress from safety concerns (OR=1.44; 95%CI=1.16-1.79) and lack of support from both supervisors (OR=1.74; 95%CI=1.13-2.65) and friends (OR=1.68; 95%CI=1.06-2.42)
Chen *et al.,* 2009(136)	Cross-sectional study	To explore the association of occupational stress with mental health	561 male offshore workers; mean age was 32.43±8.65yrs; Country: China; Industry: Offshore oil and gas	Mental health	Mental health was measured using the General Health Questionnaire (GHQ-12) (a higher score on a 0-36 scale=worse mental health). Analysis plan: Hierarchical linear regression analysis	Mental health relatively low (mean score=10.17±4.97); Perceived stress from 'management problems and relationships with others at work' (β =0.199; p<0.001), safety concerns (β=0.188; p<0.001), interface between job and family/social life (β=0.197; p<0.001), career and achievement (β=0.181; p<0.001), physical environment of workplace (β=0.130; p<0.001) and organizational structure (β=0.122; p<0.001) were associated with poor mental health
Chen *et al.,* 2009(137)	Cross-sectional survey	To explore the association of mental health with occupational stress, coping styles and their interaction	561 male workers; mean age 32.43±8.65 years; Country: China Industry: offshore oil & gas	Mental health	Mental health was measured using General Health Questionnaire (GHQ)-12 (higher score on a 0-36 scale =worse mental health). Analysis plan: Pearson correlation analysis and hierarchical multiple regression	Mental health level was relatively low (mean score=10.2±5.0). Poor mental health was positively associated with increased perceived occupational stress (β=0.379; p<0.001).
Chen *et al*., 2009(69)	Cross-sectional study	To explore the association of occupational stress and coping styles with ulcer-like symptoms in Chinese male off-shore oil workers	561 male workers; mean age 32.43±8.65yrs Country: China; Industry: offshore oil and gas	Gastric well-being (Ulcer-like symptoms)	Self-reported ulcer-like symptoms; high scores indicating poor gastric well-being. Analysis plan: stepwise multiple regression	Gastric well-being was relatively good, but poor appetite (66.8%) and localized epigastric pain (52.3%) were reported. Increase in occupational stress associated with increased Ulcer-like symptoms (β=0.010; p<0.001).
Cooper & Sutherland, 1987(127)	Cross-sectional survey	To examine the relationships between psychosocial and	218 male offshore workers; age range 20 to 59 yrs;	Mental health; anxiety and depression	Mental health and psychological well-being were assessed by The Crown-Crisp	Offshore workers' mental health (mean score=22.6) was comparable to that normal population & onshore industrial workers (mean

		occupational stressors, and mental health	Country: UK; Industry: Offshore oil/gas		Experiential Index. Analysis plan: A stepwise multiple regression	score=21.1); anxiety levels in offshore workers were significantly higher than normal population; stress from relationships at work and home associated with mental well-being (β=0.626; p<0.001), free-floating anxiety (β =0.574; p<0.001), and depression (β=0.494; p<0.001); stress from living environment associated with anxiety (β=0.596; p<0.001) and poorer mental well-being (β=0.637; p<0.001).
Cooke *et al*., 2019(131)	Cross-sectional survey	To examine the association between pregnant women's report of stress and their partners working fly-in-fly-out	394 families (77 FIFO families); mean age of FIFO workers 32.8±5.83yrs; Country: Australia; Industry: General FIFO	Depression, anxiety and stress	Perceived stress was assessed with the Perceived Stress Scale (scores 0-13=low stress, 14-26=moderate stress, 27-40=high stress); State and trait anxiety was assessed using The Spielberger State-Trait Anxiety Inventory STAI (a higher score on a scale of 20-80 indicates greater anxiety); Depression assessed by Beck Depression Inventory II BDI (scores <14=minimal, ≥14=mild/moderate, ≥29 severe depression). Analysis plan: One-way between subjects ANOVAs	No differences between depression (5.18±5.10 vs 5.28±6.81; p<0.955), anxiety (33.30±9.22 vs 32.37±8.77; p<0.296) and perceived stress (18.77±6.27 vs 19.95±7.17; p<0.607) level among FIFO and non-FIFO regular workers
Dittman *et al.,* 2016(132)	Cross-sectional study	To examine the impact of Fly-In/Fly-Out (FIFO), on children and families	46 FIFO workers and 36 community fathers; Country: Australia; Industry: General FIFO	Depression, Anxiety, Stress, Alcohol	Depression Anxiety Stress Scales-21 (Depression: scores 0-4 normal, 5-6 mild, 7-10 moderate, ≥11 severe; Anxiety: 0-3 normal, 4-5 mild, 6-7 moderate, ≥8 severe; stress: 0-7 normal, 8-9 mild 10-12 moderate, ≥13 severe). Alcohol Use Disorders Identification Test (a high score on a 0-28 scale indicates severe alcohol	Levels of depression (2.58±3.43 vs 3.31±4.39), anxiety (1.31±2.12 vs 1.65±3.04), and stress (3.33±3.27 vs 4.68±4.74) among FIFO fathers were similar to that of non-FIFO fathers (p>0.05). Alcohol use was higher in FIFO workers than non-FIFO workers (5.52±3.97 vs 3.50±2.86, t=-2.68; p<0.05).

					use). Analysis plan: Independent t-test	
Ferguson *et al.,* 2010(53)	Longitudinal diary study	To examine the amount of sleep obtained during off- and work-days	29 participants; 89.7% males Mean age 37.4±6.8yrs; Country: Australia; Industry: mining	Sleep and fatigue	Daily sleep diary and actigraphy. Subjective fatigue was assessed using the Samne Perelli Fatigue Scale for pre- and post-sleep period (for 21 or 28 days). Analysis plan: mixed model ANOVA and pairwise post-hoc	Total sleep time was longer on days off (7.3±1.2 hrs) than on both day-shift (6.1±1.0 hrs) and nightshift (5.7±1.5 hrs) days ($p<0.0001$). Sleep duration was short on night shifts than day shifts ($p<0.01$). Fatigue was higher at pre-sleep periods than post-sleep periods; pre-sleep fatigue was higher on night shifts than both day shifts and days off; post-sleep fatigue was lower on days off than both day and night shifts. Recovery of sleep on both night shift and days off was higher than day shift ($p<0.01$).
Gann *et al*., 1990(101)	Cross-sectional survey	To quantify levels of anxiety and depression	796 employees (403 offshore & 393 onshore); 96.1% males Mean age 40.6 years Country: UK Industry: Offshore oil and gas	Depression and anxiety	Goldberg's Anxiety and Depression Scale; Analysis plan: 2 x 2 contingency table and chi-squared test	15% reported symptoms of Anxiety; 28% reported symptoms of depression; No significant differences in levels of depressive and anxiety symptoms between onshore and offshore staff ($p=0.05$)
Gibson-Smith *et al*., 2018(109)	Cross-sectional survey	To determine the health status, quality of life and mental well-being, and self-care status of offshore workers	776 offshore workers; 66.3% male; mean age 42.9±10.1yrs. Country: UK; Industry: offshore oil & gas	Mental quality of life & mental well-being; physical health; alcohol intake; smoking; diet; physical activity; BMI; sleep	SF-8 assessed physical and mental function (scores >50 indicate a greater quality of life); Warwick Edinburgh Mental Well-being Scale (WEMWBS) (higher scores on a scale: 14-70 indicate greater mental well-being); Fast Alcohol Screening Test (FAST) assessed alcohol in the last 1yr (score ≥3 indicate harmful alcohol intake); Global Adult Tobacco Survey (GATS); diet in 24hrs (≥5	Mental function (median=54.7, IQR 8.1), mental well-being (median score=52.0, IQR=9.0), and physical function (median score=56.1, IQR=4.8) were higher than the normal population (median score 50); 53.4% reported harmful alcohol intake; 20.2% reported smoking, 25.1% were ex-smokers; 5.2% use recreational drugs; 45.1% reported intake of fruit and vegetable below the required guidelines; 70.7% reported physical activity; 67.0% reported poor sleep quality; BMI median 27.5(IQR=4.9); 51.1% were overweight and 23.3% were obese.

					serves of fruit and vegetables per day); Pittsburgh Insomnia Rating Scale-2 (PIRS-2) assessed sleep in 7 days (socres>2 on 0-6 indicated poor sleep quality); Physical activity assessed by IPAQ (≥150/75 minutes moderate/vigorous physical activity); self-reported height and weight (BMI 25-29.9=overweight, ≥30 obese). Analysis plan: Whitney U test	
Hanoa *et al*., 2011(89)	Longitudinal study	To investigate possible changes in health after a voluntary implementation of a new shift schedule	274 in 2006, 307 in 2007 and 312 in 2008 coal company male employees; Mean age 39.1±9.6 yrs. Country: Norway. Industry: Mining	Perceived stress, sleep, pain	Self-reported sleep and stress was assessed using a questionnaire developed by the authors. Analysis plan: Independent t-test	Stress symptoms were rare among 85.5% of workers. Prevalence of sleep problems and pain (1-5%) was low. Stress level at baseline was better for those on 14 days on/14 days off compared to 7 days on /7 days off roster (p=0.006). No differences in stress (p=0.910) and sleep (p=0.992) between 14 days on/14 days off and 7 days on /7 days off roster over 2 year period
Harris *et al*., 2010(90)	Longitudinal study	To study if health, reaction time, and the cortisol rhythm were negatively affected by change in work schedule	19 employees working offshore; mean age was 44 years; 68.4% male. Country: Norway; Industry: offshore oil & gas	Subjective health complaints	Health complaints measured by the Subjective Health Complaints (SHC) inventory in the last 30 days; measured 2 times; 9 months apart). Analysis plan: Paired sample t-tests	73.7% reported very good or good health; 94.7% reported very good or good physical fitness; few subjective health complaints were reported (mean score=6.82±6.40; range 0-87); few musculoskeletal (mean score=3.68±3.51; range 0-24) and few gastric complaints (mean score=1.00±1.60; range 0-24). No change in subjective health complaints between working fixed shift (mean score=6.82±6.40) and swing shift (mean score=5.97±4.36) over 9 months period (p=0.494)
Haward *et al.,* 2009(144)	Longitudinal diary study	To assess the effects of vessel motion on crew performance, and sleep impairment.	47 male crew on a floating vessel; mean 41.5±6.7yrs; Country: UK; Industry: offshore	Sleep and fatigue, depression, anxiety	Daily diaries reporting sleep, and symptoms of fatigue, depression, and anxiety (on 0= none to 4 =severe scale) for 150 days over 6 offshore tours	Fatigue: physical tiredness (*T*=0.147; p<0.01) and mental tiredness (*T*=0.143; p<0.01); Sleep problems: sleep quality (*T*=0.216; p<0.01), sleep duration (*T*=-0.210; p<0.01); depression (*T*=0.121; p<0.01) and anxiety (*T*=0.133; p<0.01) were

			oil & gas		(14 days each). Analysis plan: Kendall rank-order correlation and the Kendall partial rank correlation	related to vessel motion.
Hope *et al.,* 2010(126)	Cross-sectional survey	To examine the relationship between risk perception and safety climate, and sleep quality	9601 employees on 52 offshore oil installations; 90% males; aged 31-50yrs; Country: Norway; Industry: offshore oil and gas	Sleep quality	Self-reported sleep quality (score 1-5: high score indicate high sleep quality). Analysis plan Independent t-tests and one-way ANOVA and Pearson's correlation and hierarchical multiple regression	Subjective sleep quality was relatively good (mean score 3.87±0.74); sleep quality was better in day shift (mean=4.00±0.72) workers than in night (mean=3.72±0.71), fixed (mean=3.68±0.72) and swing (mean=3.81±0.25) shifts (p<0.001). Positive perceived safety climate (β =0.13-0.18; p<0.001) was related to good subjective sleep quality. Risk perception (β=-0.28; p<0.001) was negatively associated with sleep quality.
James *et al*., 2018(29)	Cross-sectional survey	To assess the prevalence of psychological distress and associated demographic, health, and workplace characteristics	1,799 mine workers (85.4% FIFO); 89% males 93.6% aged 25 years and over Country: Australia Industry: Mining	Psychological distress Alcohol intake	Psychological distress was measured by The Kessler Psychological Distress Scale (K10) (score 16-21=moderate, ≥22 indicates high/very high distress on a 10-50 scale). AUDIT (scores >8 indicating risky/high-risk alcohol use); Analysis plan: Chi-square test and multivariate logistic regression	16.9% reported high or very high levels of psychological distress than the general population (7.6%, p<0.001); 49.1% were risky/high-risk alcohol users. 33.8% were illicit drug users in the last month. Increased concerns of losing their job (OR=3.17; 95%CI=1.96-5.16), having shift length longer than 12 hrs (OR=1.61; 95%CI=1.17-2.30) and working for financial reasons (OR=1.34; 95%CI=1.12-1.61) were associated with high distress; increased satisfaction with work (OR=0.33; 95%CI=0.25-0.43) and increased perception of the mine's commitment to mental health (OR=0.69; 95%CI=0.55-0.85) were associated with low distress
Joyce *et al*., 2013(99)	Cross-sectional survey	To examine the association of health behaviours and outcomes with employment type in the West Australian adult population	11,906 adult respondents aged 16 years and above from 2008 to 2010; 524 (4.4%) FIFO workers; 88.5% males; 60.6% aged 25-44yrs; Country: Australia; Industry:	Mental health; Alcohol intake; Smoking; diet, physical activity, BMI	Mental health conditions ever been diagnosed by a doctor. Self-reported alcohol intake (number of drinks per day), smoking status, fruits and vegetable intake (insufficient serves: <5 serves of fruit and vegetables per day), physical activity (insufficient <150/75	FIFO workers had a lower self-reported prevalence of current mental health problems (7.7%; 95%CI=4.4–11.0), consume more alcoholic drinks per day [high risk for short-(29.8%; 95%CI=22.8–36.8) and long-term harm (64.7%; 95%CI= 57.5–71.9)], smoke higher (26.7%; 95%CI=20.5–33.0), and more classified as overweight or obese (79.3%; 95%CI=73.2–85.5) than other work employment (p<0.01). FIFO workers consume

			General FIFO		minutes moderate/vigorous physical activity per week), and height and weight (BMI 25-29.9=overweight, ≥30 obese); Analysis plan: Chi-square test	insufficient fruits (48.9%; 95%CI=41.7–56.1) and vegetables (87.7%; 95%CI=82.9–92.5) intake and undertake insufficient physical activity (40.4%; 95%CI=33.5–47.4) similar to other work employment (p>0.05).
Kalteh *et al*., 2018(108)	Cross-sectional study	To assess the prevalence of musculoskeletal pain and work-related factors	1,157 employees at 229 installations; mean age 40±10.5 yrs; 95.8% males; country: Iran; industry: offshore oil & gas	Musculoskeletal pain; physical activity, Sleep, BMI	Self-reported sleep duration, physical activity and musculoskeletal pain in the last 12 months at the workplace using Standardized Nordic Questionnaire (SNQ); analysis plan: chi-square test	BMI was 25.8±3.3 kg/m^2; musculoskeletal pain (MP) was high; common MP in the last 12 months were knees (47%), neck (38%), low back (37%), shoulder (29%); Workers on drilling, maintenance, operational and tour-scheduling and day-off jobs reported the highest level of musculoskeletal pain (p<0.05). 51.6% engage in exercise twice or more per week. 33.1% reported insufficient sleep duration of less than 5 hours.
Kecklund *et al*., 2001(95)	Longitudinal study	To investigate how double shifts (15.5hrs) affect sleep fatigue and self-rated health	48 male workers (80% LDC); mean age: 41 years; Country: Sweden; Industry: construction.	Health complaints; sleep problem	Self-reported health complaints 3 times over 1 year period: complaint of pains (1 always to 5 never); insufficient sleep (1 always to 5 never); exhaustion (1 always to 5 never). Daily diary 8 times during roster cycle on sleep duration, sleep quality, sleepiness (KSS on 1 very alert to 9 very sleepy); mental fatigue (1inactive to 9 high energy). Analysis plan: ANOVA and t-tests	Complaints of pain in the neck and shoulders (3.8±0.2 vs 3.3±0.2; p<0.05), and back and knees (4.3±0.2 vs 3.9±0.2; p<0.05), insufficient sleep (3.8±0.2 vs 3.3±0.2; p<0.05; range 1-5) and exhaustion on awakening (4.0±0.1 vs 3.4±0.2; p<0.05) significantly increased across 1 year period. Sleepiness (F=2.2; p<0.05) and mental fatigue (F=4.6; p<0.001) increased and accumulated across days and were highest on the last work shift; Sleep duration varied across days (F=15; p<0.001) and was short (approx. 5.5 hrs) during double shifts; Sleep quality was good but varied across days, being poor on last shift (F=9.8; p<0.001); Sleep efficiency was high and show no changes across days (F=0.7; p>0.05)
Lester *et al*., 2015(33)	Mixed method study (Quantitative part)	To explore the parenting patterns of families exposed to the fly-in–fly-out (FIFO) work pattern in raising adolescent children	23 FIFO workers; aged 30 years and above; 87% males ; Country: Australia; Industry: Mining and offshore oil/gas	Psychological distress	Mental health was measured using the K10 scale (score 16-21=moderate, ≥22 indicates high distress on 0-50 scale). Analysis plan: Kruskall–Wallis non-parametric tests	26% of FIFO reported very high levels of psychological distress than the normal population (9.5%); no significant relationship between a FIFO work roster and FIFO workers' psychological distress (p=0.496)

Light & Gibson, 1986 & 1987(96,97)	Cross-sectional survey	To estimate the prevalence of overweightness	419 Caucasian males; mean age 32.5±8.2yrs (range 18-57). Country: UK; Industry: offshore oil & gas	Weightness (BMI)	Objectively measured weight and height; Weightness (BMI) calculated as W/H2 (Kg/m2) (BMI 25-29.9=overweight, ≥30 obese). Analysis plan: chi-square	BMI was 24.80±2.9kg/m^2(range 18.3-33.9); 40.1% were overweight and 5.5% obese; Overweightness was greater in offshore workers than the general population (66.2% vs 50%; p<0.05).
Ljosa *et al*., 2011(71)	Cross-sectional survey	To investigate the association between individual and psychosocial work factors and mental distress among offshore shift workers	1336 employees; 83% males; mean age 45.1±9.6yrs (range 20-64); Country: Norway Industry: Offshore oil & gas	Mental distress; anxiety and depression	Mental distress was assessed by a shortened version of the Hopkins Symptom Checklist (HSCL-5) (score 1-5, a higher score indicates a high level of distress). Analysis plan: Block-wise linear regression	Mental distress symptoms were low (mean score=1.6±0.7); High quantitative demands (β=0.17; 95%CI=0.09-0.26), low social support (β=-0.11; 95%CI=-0.17- -0.16) and high shift work home-interference (β=0.28; 95%CI 0.22-0.34) were associated with high mental distress
Maniscalco *et al*., 1999(106)	Longitudinal interventional study	To examine the effect of a wellness program on the number of back injuries- and positively impact cholesterol, nutrition, and fitness.	147 workers; average age 42 yr; 90% males. Country: USA; Industry: offshore oil & gas	Nutrition/diet	Nutrition score was calculated from 23 items on dietary fat, salt, sugar, and fibreintake between 1992 and 1997 (high on salt, sugar, fat and low fibre= poor nutrition). Analysis plan: Descriptive statistics	From 1992 to 1994; 71% reported poor nutrition; and 63% reported poor fitness level; From 1995 to 1997; 63% reported poor nutrition; and 76% reported poor fitness levels
Mathisen *et al*., 2016(117)	Cross-sectional survey	To investigate psychosocial precursors of action errors and violations	653 oil production workers; Country: Norway; industry: offshore oil & gas	Emotional exhaustion; health complaints	Health complaints in the last 6 months (score 1-2, higher score indicate few complaints); emotional exhaustion was measured by the GWB-Q (scores 1-4, higher score indicates high emotional exhaustion). Analysis plan: descriptive, correlation and regression analyses	Workers reported few health complaints (mean score=1.65±0.33) and low emotional exhaustion (mean score=1.39±0.33); emotional exhaustion predicted action errors (β=0.27; p<0.01) and violations (β=0.26; p<0.01)
Menezes *et al.,* 2004(10)	Cross-sectional survey	To assess the sleep parameters among	202 offshore personnel; 95.5%	BMI, Sleep problems	Self-rated weight and height (BMI 25-29.9=overweight, ≥30	BMI was 26.2±1.2kg/m^2. Shift/night shift workers reported high BMI (26.7±3.7 kg/m2 vs 25.6±3.3

		offshore personnel	males; mean age 36.75±9.5yrs; Country: Brazil; Industry: offshore oil and gas		obese); self-reported sleep duration and quality. Analysis plan: independent t-test and z-test	kg/m^2; p<0.05), poorer sleep quality (20.4% vs. 1.2%; p<0.01), habitual difficulty in falling asleep (15.1% vs. 4.7%; p<0.01) fragmented sleep (45.2% vs. 16.3%, p<0.01), long latency of sleep onset (28% vs. 7%, p<0.01), short sleep duration (6h or less) (44.1% vs. 16.3%; p<0.01), waking up tired (15.1% vs. 3.5%, p<0.01) and habitual napping (35.5% vs. 18.6%; p<0.01) than day-shift workers.
Merkus *et al.*, 2015(146)	Longitudinal diary study	To compare the course of self-reported recovery from work-related fatigue after 2-week 12-hour schedules	61 male employees; mean age 41.5±7.4yrs. Country: Norway; Industry: offshore oil & gas	General health status, sleep and fatigue	Self-perceived general health status; Sleep and fatigue diary for 14 days, and Karolinska Sleep Questionnaire. Analysis plan: Chi-square tests and analysis of variance (ANOVA)	88.6% rated general health status as good or very good; no differences between day (92%), night (75%) and swing (100%) shift workers (p=0.902). Poorer sleep quality in night shift (β=1.41; 95%CI 1.05-1.89) and swing shift (β=1.42; 95%CI 1.03-1.94) workers compared to day shift workers over the leave period. Recovery of sleep quality was similar for night and swing shift workers but different from day workers. Fatigue; feeling rested: night shift (β=1.67; 95%CI 0.74-3.80) swing shift (β=1.56; 95%CI 0.67-3.62); Physical tiredness: night shift (β=1.42; 95%CI 0.91-2.22), swing shift (β=1.52; 95%CI 0.94-2.46); Mental tiredness: night shift (β=1.44; 95%CI 0.85-2.43), swing shift (β=1.01; 95%CI 0.52-1.93) compared to day shift workers.
Merkus *et al.*, 2017(139)	Longitudinal diary study	To explore the pursuit of activities relevant to recovery after an offshore tour	61 male employees; Mean age 41.5±7.4yrs. Country: Norway Industry: offshore oil & gas	General health status; physical activities	Self-perceived general health status. Self-reported daily physical activities and duration for 14 days during a leave period. Analysis plan: Chi-square test and ANOVA	88.6% rated general health status as good or very good; 97% engaged in regular leisure-time physical activities (PA); overall no change in physical activities from the start to the end of a 14-day leave period (p=0.083). Leisure time physical activities did not differ between night-, swing-and day-shift workers on the first day of the free period, but PA decreased over the course of the 14 days in day workers compared to night shift workers (OR 1.10; p=0.029 and swing workers (OR 1.10; p=0.009).

Miller *et al*., 2020(84)	Cross-sectional survey	To examine the association between bullying and psychological distress	580 FIFO personnel 76.3% males Mean age was 35.5±9.1 years Country: Australia Industry: Mining	Depression and hopelessness	Clinical depression was assessed by Beck Depression Inventory-II (BDI-II) (scores 11-16 mild, 17-20 borderline, 21-30 moderate, >30 severe/extreme depression); Hopelessness assessed by Beck Hopelessness Scale (BHS) (score ≥9 on 0-20 indicates elevated suicide risk) Analysis plan: Backward Logistic regression	32.3% of FIFO workers reported moderate or severe depression and 26.7% were at elevated risk of suicide high than the general population; Workplace bullying was associated with increased depression (OR = 2.38; 95% CI =1.40–4.05), and suicide risk (OR =2.70; 95% CI = 1.53–4.76)
Miller *et al*., 2019(32)	Cross-sectional survey	To establish whether clinical depression and increased suicide risk between fly-in, fly-out workers and residential worker	751 Participants (576 FIFO and 175 residential); 76.2% males; mean age 36.5±9.1yrs Country: Australia Industry: Mining	Depression Suicide risk	Depression assessed by Beck Depression Inventory–II (BDI-II) (scores 11-16 mild, 17-20 borderline, 21-30 moderate, >30 severe/extreme depression); Hopelessness (suicide intention and behaviour) assessed by Beck Hopelessness Scale (BHS) (score ≥9 on 0-20 indicate elevated suicide risk). Analysis plan: A General linear model	32.3% of FIFO workers reported moderate or severe depression and 26.7% were at elevated risk of suicide high than the general population. Depression (marginal mean scores 19.7 (17.0–22.4 vs 15.5; 95%CI=14.3–16.6, p=0.01) and hopelessness (27.4% vs 26.7%, p= 0.02) were significantly higher in residential than FIFO workers. Bullying was associated with higher levels of depression (partial η^2=0.11; p=0.001) and hopelessness (partial η^2 = 0.04; p=0.001). Increased social support was associated with lower levels of depression (partial η^2 = 0.13; p=0.001) and hopelessness (partial η^2=0.14; p= 0.001).

Muller *et al*., 2008(98)	Longitudinal diary study	To examine the effects of FIFO operations on self-reported fatigue and performance over a whole FIFO production roster	55 male FIFO; mean age 37yrs; Country: Australia; Industry: Mining	Alcohol, smoking, physical activity, BMI, sleep and fatigue	The Pittsburgh Sleep Diary; Swedish Occupational Fatigue Inventory (SOFI) for 28 days; Diary of self-reported alcohol consumption for 28 days during work and leave periods. Self-reported height and weight, smoking and physical activity. Analysis plan: Bivariate testing	BMI was 28.9 kg/m^2, with 35.3% as obese. >30 min of vigorous exercise was reported on 5 days (3–7) per week at camp and 4 (2–5) days per week off-site. Regular drinking habit: median of 4(2–6) standard drinks per session at camp and 6(3–10) drinks off-site. Daily drinking was highest during off-shift days (1.0-3.5 units/day) than day shift average: 2(1.7-2.8 units/day) and night shifts: average of 1(median 0.6-1.4 units/day). 27.5% were current smokers. Sleep duration was highest on off-shift days (average 8.2h) than on day-shift (average 6.6h) and nigh-shifts (average 6.7h) days. Sleep duration was short before and on day-shift days (5.8h) than on night-shift (7.0h) days. Fatigue increased at concerning levels at the finish of night shifts 1–3 and from day shift 8 onwards
Nielsen *et al*., 2013(130)	Cross-sectional survey	To psychometric properties from a brief self-report measure of safety climate adapted to the petro-maritime organizations	396 offshore workers; 95% males; 64.1% aged 51 years and over. Country: Norway; Industry: Offshore oil & gas	Health complaints	Subjective health complaints were assessed using 14 items of common physical and psychological health issues (mean score 1-4, a higher score indicates more complaints). Analysis plan: Pearson product-moment correlations	Respondents reported low subjective health complaints (mean score 1.39±0.13); Management prioritization (r = -0.21; p< 0.01) and authentic leadership (r=-0.21; p<0.01) negatively and risk perception (r=0.24; p<0.01) positively correlated with health complaints
Nielsen *et al*., 2013(129)	Cross-sectional survey	To examine the relative impact of workplace bullying and risk perception on the mental health among employees in safety-critical organisations.	1017 randomly selected offshore workers; 85.9% males; mean age 44.59±8.9 years; Country: Norway Industry: Offshore oil and gas	Mental health (symptoms of anxiety)	Symptoms of anxiety as indicators of mental health problems, were assessed using six items from the Hopkins symptomschecklist (HSCL) (mean score 1-4, a higher score indicates severe symptoms). Analysis plan: Hierarchical regression analysis	Workers reported low anxiety symptoms (mean score= 1.21±0.29); Workplace bullying (β=0.33; 95%CI=0.28-0.40; p<0.001), and risk perception (β=0.21; 95%CI=0.06-0.11; p<0.001) were predictors of anxiety.
Nielsen *et al*., 2013(145)	Longitudinal study	To examine the prevalence and occupational	1074 offshore employees; 85% male; mean	Psychological distress	Mental health was assessed by Hopkins Symptoms Checklist-25 (HSCL-25) at 2	Prevalence of psychological distress decrease from 9 % at baseline to 8 % after 6 months lower than rates in the general population (13%).

		predictors of psychological distress among offshore workers	age 45±8.6 years (baseline) Country: Norway Industry: Offshore oil and gas		measurements point 6 months apart (mean score ≥1.75 indicate distress case). Analysis plan: logistic regression	Psychological distress at follow-up was associated with laissez-faire leadership (OR = 1.69; 95%CI=1.12–2.54) and workplace bullying (OR = 1.49; 95%CI=1.07–2.10).
Nielsen *et al.*, 2016(128)	Cross-sectional survey	To examine direct and indirect associations between shift work schedules, health complaints, and psychological safety climate	8066 employees; 91% men, aged 31 to 50 years. Country: Norway Industry: Offshore oil and gas	Health complaints; sleep problems	Subjective health complaints were measured on 5 item issues related to physical health (headache, neck-, back-, and knee pain, and problems with hearing) (mean score 1-4, a higher score indicates more complaints). Sleep problems were assessed using Trends in risk-level-Norwegian Shelf (mean score 1-5, a higher score indicates poor sleep quality). Analysis plan: ANOVA and correlation analysis	Health complaints (m=1.58±0.47) and sleep problems (m=2.07±0.73) were relatively low. Safety climate associated with health complaints (β=-0.16; p<0.001) and sleep problems (β =-0.31; p< 0.001). Night shift (β=-0.14; 95%BCaCI=-0.19- -0.09) and swing shift (β=-0.13; 95%BCaCI=-0.15- -0.11) schedules were associated with more sleep problems compared to day shifts.
Oshaug *et al.,* 1992(103)	Cross-sectional survey	To describe the diet among oil workers on selected oil installations	203 workers from 4 installations; 95.6% males; age range 18 to 58 yrs. Country: Norway; Industry: offshore oil & gas	Diet	Food invoice review and self-reported food intake in the last 24h and compared to the Norwegian dietary recommendation	Average daily intake of energy was 12.2MJ of which 44 % from fat and 39 % from carbohydrate, including 8 % from sugar. Compared to the Norwegian dietary recommendation, offshore diet intake was prone to the development of coronary artery disease
Paech *et al.*, 2010(52)	Longitudinal diary study	To assess the work-related factors that influence sleep duration and subjective sleep quality	51 participants; mean age 40.3±10yrs; 98% male; Country: Australia; Industry: Mining	Smoking; sleep duration and quality; BMI	Self-reported weight/height and smoking were measured by General Health Questionnaire (GHQ). Daily sleep diaries and Actigraphy for 15 to 22 days (poor sleep quality: higher score on a 1-5 scale). Analysis plan: Linear mixed-effects models	BMI was 28.7±4.2 Kg/m^2. 47.1% reported smoking; Total sleep time (TST) for days off (7.0±1.9hrs) was longer (p<0.001) than a day (6.0±1.0hrs) and night (6.2±1.6hrs) shifts. TST did not differ across consecutive dayshifts, but TST on the first day of nightshifts were longer (p<0.001) than TST on all other day and nightshifts; Sleep quality did not significantly differ for dayshifts (3.0±1.2), nightshifts (2.8±1.1) or days off (3.1±1.2) [p>0.05] and compared to non-FIFO roster pattern (p>0.05)

Parkes, 1992(120)	Cross-sectional survey	To examine the differences in mental health between onshore and offshore employees	172 male workers (84 offshore works & 88 onshore workers); Mean age 40.9±6.8, range 28-57; Country: UK; Industry: Offshore oil & gas	General mental health; anxiety	General mental health and anxiety were assessed using The General Health Questionnaire (GHQ) (score=0-26, a higher score indicates a high level of poor mental health; poor anxiety: a higher score on a 0-21 scale). Analysis plan: Univariate comparisons and multivariate (multiple regression) analysis	No different between offshore workers' mental health (8.75±3.76) and other work group (8.80±4.02); but significantly higher ($p<0.05$) than that of onshore petroleum workers (7.64±2.94); Anxiety levels among offshore higher than onshore workers (3.62±3.42 vs 2.43±2.18; $p<0.01$); Higher job level (being a supervisor) ($p=0.008$) and working offshore ($p<0.006$) associated with higher anxiety levels
Parkes, 1994(124)	Cross-sectional survey	To compare the sleep patterns of onshore and offshore control-room operators	172 male personnel (84 offshore workers and 88 onshore control-room operators); mean age 42.74±7.21yrs; Country: UK; industry: offshore oil and gas	Sleep duration and quality	Self-rated sleep duration and quality (better sleep quality: higher score on a 0-6 scale). Analysis plan: paired t-tests and repeated-measures analyses of variance	Sleep durations longer on leave periods (7.74±0.81 hrs) than during the day-(6.99±1.18 hrs) and night (7.20±1.34 hrs)-shifts ($p<0.0001$); Night shift sleep duration longer for offshore personnel (7.20±1.34 hrs vs 5.86±1.26 hrs) than those working onshore ($p<0.0001$). Sleep quality was better on leave periods (4.85±1.20) than during day-(3.20±1.84) and night-(3.66±1.52) shifts ($p<0.0001$). Night shift sleep quality was better than day shift ($p< 0.01$). Day shift sleep quality was higher for onshore personnel (4.25±1.35) than for offshore (3.20±1.84) employees ($p<0.001$)

Parkes, 1999(123)	Cross-sectional survey	To examine the combined effects of shift work, objective job categories, and work perceptions on health-related outcomes	1320 male personnel (680 day & 640 shift workers); Mean age 38.9±8.9yr; Country: UK Industry: Offshore oil & gas	Psychological distress; Psychosomatic complaints (headaches, musculoskeletal pain, gastric problems and sleep problems)	Psychological distress was assessed by The General Health Questionnaire (GHQ-12) (scored 0-0-1-1 for case detection purposes and 2-3 cutting points used to identify potential cases). Analysis plan: Logistical regression	Prevalence of health outcomes: psychological distress (14%); headache (38%), musculoskeletal disorders (47%); gastric problems (31%) and sleep problems (45%). Psychological distress was associated with social support (RR=0.76; 95%CI=0.63-0.92, p<0.01). Headaches associated with social support (RR=0.83; 95%CI=0.73-0.94, p<0.01); physical environment (RR=1.14; 95%CI=1.00-1.31, p<0.05); working in management (RR=1.88; 95%CI=1.21-2.91, p<0.01), construction (RR=1.84; 95%CI=1.17-2.89, p<0.01) and drilling (RR=1.64; 95%CI=1.11-2.42, p<0.05). Gastric problems were associated with night/swing shift (RR=1.36; 95%CI=1.00-1.84, p<0.05); social support (RR=0.82; 95%CI=0.72-0.94; p<0.01); physical environment (RR=1.25; 95%CI=1.09-1.44, p<0.01). Musculoskeletal disorders were associated with working in catering (RR=0.50; 95%CI=0.28-0.89, p<0.05) and drilling (RR=1.68; 95%CI=1.14-2.47, p<0.01); physical environment (RR=1.31; 95%CI=1.15-1.50, p<0.001). Sleep problems were associated with night/swing shift (RR=1.81; 95%CI=1.36-2.42, p<0.001); physical environment (RR=1.16; 95%CI=1.01-1.33, p<0.05).

Parkes, 2002(113)	Cross-sectional survey	To examine how individual and environmental factors combine to influence sleep among shift workers	786 (456 offshore and 330 onshore) fixed day and rotation shift male workers; aged 18 to 64 yrs; Country: UK; Industry: offshore oil and gas	Sleep duration and quality; smoking	Self-reported sleep duration and quality (good sleep quality: higher score on 0-6 scale), and smoking Analysis plan: Chi-square test and mixed-model analysis of variance	Sleep duration on day shift (6.84±1.00 vs 6.58±0.96) and night shift (6.57±1.38 vs 5.62±1.33) was higher in offshore workers than onshore workers ($p<0.001$). Sleep duration was better on leave periods than on day- and night shifts ($p<0.001$). Sleep quality on day shift (3.96±1.31 vs 3.87±1.36) and nigh-shifts (3.14±1.49 vs 2.81±1.67) was better in offshore workers than onshore workers ($p<0.01$). Sleep quality ($p<0.001$) was better on leave periods than day and night shifts. Smoking was higher in offshore (33.6%) than onshore (20.6%) workers ($p<0.001$).
Parkes, 2002(112)	Cross-sectional study	To examine the prevalence of BMI and to evaluate the predictors of BMI	1598 male personnel on 17 installations; mean age was 38.7±8.9yrs; Country: UK; Industry: Offshore oil & gas	BMI; Smoking	BMI calculated from self-reported height (m) and weight (kg) (BMI 25-29.9= overweight, ≥30 obese); self-reported smoking status. Analysis plan: descriptive statistics and multiple regression	36% reported smoking; mean BMI was 25.6±2.8kg/m^2; 7.5% were obese and 47.2% were overweight. Shift pattern ($\beta=0.14$; $p>0.05$) not associated with BMI when adjusted for age.
Parkes, 2003(147)	Cross-sectional and longitudinal studies	To examine the prevalence of BMI and to evaluate the predictors of BMI, and 5-year change in BMI	1598 offshore male personnel; mean age was 38.7 ±8.9yrs; Country: UK; Industry: offshore oil & gas	BMI	BMI was calculated from self-reported height (m) and weight (kg) (BMI 25-29.9= overweight, ≥30 obese). Analysis plan: General Linear Model	Over the 5-year period mean BMI significantly increased from 25.6±2.8 to 26.6±2.9kg/m^2 ($p<0.001$); obese rate increased from 9.0 to 14.4%, and overweight from 51.1 to 54.5%. Change of work location (offshore to onshore) was not associated with BMI change.

Parkes, 2015(122)	Cross-sectional survey	To examine the role of overtime in relation to the duration and quality of sleep among North Sea	551 male personnel; Mean age 40.2±8.9, range 20-62 years ; Country: UK; Industry: Offshore oil/gas	Anxiety; sleep duration and quality	Anxiety was assessed using the General Health Questionnaire (score 0-21, a higher score indicates high levels of symptoms). Self-reported sleep duration and sleep quality (good sleep quality: high score on 0-6 scale). Analysis plan: Mixed-model ANCOVA with repeated-measures factor	Low symptoms of anxiety (mean score 4.09±3.63; range 0-21); Sleep duration less during day shift (6.74±0.87hrs) than during leave (7.75±1.00hrs) ($p<0.001$). Working overtime during day shifts was associated with short sleep duration ($\beta=-0.53$; $p<0.001$). Sleep quality was poorer during day shift (3.92±1.29) than during leave (4.83±1.11) ($p<0.001$). Working overtime during day shifts was associated with poorer sleep quality ($p<0.05$)
Parkes, 2015(121)	Cross-sectional survey	To evaluate the association between shift patterns and sleep patterns across the offshore work cycle	1956 personnel working on 24 installations; 99.5% males; mean age 39.9±9.0years; Country: UK; Industry: Offshore oil/gas	Anxiety; sleep duration and quality	Anxiety was assessed using the General Health Questionnaire (score 0-21, a higher score indicates high levels of symptoms). Self-reported sleep duration and sleep quality (good sleep quality: high score on 0-6 scale). Analysis plan: mixed-model ANCOVA	Low symptoms of anxiety (mean score 4.2±3.7; range 0-21); Sleep duration was highest ($p<0.001$) on leave shift (7.9±1.0 hrs) than for day shift (6.9±1.0 hrs) and night shift (6.6±1.4). Sleep duration was longer for fixed-day (6.9 vs 6.57hrs; $\beta=-0.38$, $p<0.001$), and night (6.95 vs 6.59 hrs; $\beta=0.35$, $p<0.01$) shift rosters than swing shift (7N/7D) roster. Working overtime (>16h/week) was related to short sleep duration than working no overtime (6.23 hrs vs 6.72 hrs, $p<0.02$) on night shifts. Sleep quality was better on leave periods (4.9±1.1) than day (3.8±1.3) and night (3.1±1.5) shifts ($p<0.001$). Sleep quality was poorer for swing-shift (7N/7D) roster than fixed-day and night rosters ($p=0.001$).
Parkes, 2015(9)	Cross-sectional survey	To examine the additive and, interactive effects of overtime and work environment characteristics on sleep duration and quality	551 male personnel; Mean age 40.2±8.9; Country: UK; Industry: Offshore oil/gas	Sleep quality and duration	Self-reported sleep duration and sleep quality (good sleep quality: high score on 0-6 scale). Analysis plan: Multivariate regression methods	Sleep duration: working overtime ($p<0.001$) was related to short sleep duration in day shift workers; job demand ($\beta=-0.16$, $p<0.01$) was negatively and supervisor support ($\beta=0.10$, $t=2.71$, $p<0.01$) was positively related to sleep duration in day shift workers working overtime. Sleep quality: supervisor support was associated with higher sleep quality ($B=0.16$; $p<0.005$); working overtime ($B=-0.34$; $p<0.005$) and adverse physical environment ($B=-0.13$; $p<0.05$) was associated with poorer sleep quality.

Parkes, 2016(125)	Cross-sectional survey	To examine how age and measures of the psychosocial/physical work environment combine to predict the duration and quality of sleep	971 male day shift personnel; mean age was 40.8± 8.9yrs. Country: UK; Industry: offshore oil and gas	Sleep duration and quality	Self-rated sleep duration and sleep quality (better sleep quality: a high score on a 0-6 scale). Analysis plan: Hierarchical regression and logistic regression	Sleep duration was shorter (6.74 ± .88 hrs) on day shifts than during leave period (7.73±1.03) ($p<0.001$). High workload ($\beta=-0.162$; $p<0.001$) was associated with short sleep. Social support ($\beta=0.105$; $p<0.001$) was associated with longer sleep duration. Sleep quality was poorer on day shifts (3.87 ± 1.31) than during leave period (4.85±1.08) ($p<0.001$). Job control ($\beta=0.159$; $p<0.001$) and social support ($\beta=0.207$; $p<0.001$) were associated with better sleep quality, and adverse physical environment ($\beta=-0.115$; $p<0.025$) was associated with poor sleep quality.
Pavičić *et al.*, 2019(119)	Cross-sectional survey	To establish the prevalence and stressors of depression and anxiety symptoms among offshore workers	1747 workers in the Middle East; 75% aged 26–45 years; Country: Croatia Industry: Offshore oil and gas	Mental health (depression and anxiety)	Anxiety was assessed by the Generalized anxiety disorder (GAD) questionnaire (score 5-9 mild, 10-14 moderate, ≥15 severe); Depression was assessed using the Patient Health Questionnaire (PHQ)-9 (score 5-9 mild, 10-14 moderate, ≥15 moderately severe/severe); Analysis plan: Ordered logistic regression analysis	15% experience moderate to severe anxiety; 18% experience moderate to severe depression. Working longer rotations/shifts (56 days on/28 days off) was associated with more anxiety symptoms (OR=1.53; 95%CI=1.15–2.04) compared to 28 days on/28 days off roster

Rebar *et al*., 2018(13)	Longitudinal diary study	To compare health behaviours between on-shift and off-shift periods	64 FIFO workers 79.7% male; mean age 40.39±10.34yrs Country: Australia Industry: General FIFO	Chronic mental and physical health conditions; Alcohol intake, smoking, physical activity, relaxation, diet	Self-reported medication for mental problems and physical health condition; Alcohol intake (number of alcoholic drinks), smoking (number of cigarettes smoked), physical activity (minutes taken to exercise), relaxation (minutes taken to relax), diet and sleep quality. Analysis plan: Multilevel models	Mental health medication low (0.08±0.27); no differences between on-shift and off-shift days (γ=1.65; 95%CI=−1.24-4.26). Physical health medication low (m=0.16±0.34); more on on-shift than off-shift days (γ=1.44 (0.36-2.54). Alcohol intake: average 1.05±1.69 per day; intake high on off-shift days than on-shift days (γ=−1.12; 95%CI=−1.48- −0.76). Cigarettes smoked: average 13.22±8.46 per day; smoking high on on-shift days than off-shift days (γ=24.20; 95%CI=0.86-45.88). Daily exercise: average 43.80±58.81mins/day and relaxation (2.78±4.35 hrs/day); less exercise (γ=−10.78; 95%CI=−0.36 to −0.00) and relaxation (γ=−1.22; 95%CI=−1.87- −0.61) on on-shift days than off-shift days. Nutrition quality: modest (0.35±1.01), & poorer on on-shift days than off-shift days (γ=−0.17; 95%CI=−0.33- −0.02). Daily sleep quality: modest (average=0.04±1.04); worse during on-shift compared with off-shift (γ=−0.56; 95%CI=−0.72- −0.40).
Riethmeister *et al*., 2016(88)	Mixed method study (Quantitative part)	To perform a needs assessment to identify the needs of offshore workers with regard to healthy ageing at work	272 offshore workers; 97.3% males; Mean age 44.14±10.7 years. Country: Netherlands Industry: offshore oil & gas	Mental and physical health; Diet; sleep duration and fatigue, BMI	General health was measured with the Short Form-12 (SF-12) (scores >50 on a scale of 0-100 indicate better health). Self-reported sleep, height and weight (BMI 25-29.9= overweight, ≥30 obese), diet (nutritional rating of food), smoking and alcohol intake status. Fatigue assessed by Checklist Individual Strength. Analysis plan: descriptive statistics and t-test	Good mental (m=54.48±5.66) and physical health (m=52.91±4.74) were higher than the normal population (m=50); 7.7% reported musculoskeletal; 82.5% rated their general well-being status as very good to excellent. 38.6% reported smoking (3.04±1.9 mean packs per day); 84.1% reported alcohol consumption; 75% rated food offshore as bad or really bad. BMI was 27±3.7 kg/m^2; 46% were overweight and 21% were obese. 73% reported prolonged fatigue; Sleep duration was shorter on offshore periods (7.18±0.99 hrs) than on days off (7.82±1.01 hrs).

Riethmeister *et al.,* 2018(85)	Longitudinal diary study	To examine the courses of sleep quality and sleepiness in full 2on/2off offshore day shift rotations	42 male offshore workers; mean age 42±12.1yrs; Country: Netherland; Industry: offshore oil & gas	Sleep problems, BMI	Sleep diary and actigraphy for 28 days (7 days pre-, 14 days offshore and 7 days post-offshore); sleep quality (high score on a 1-5 scale indicate better sleep quality). Sleepiness asses by KSS (a higher score on a 1-9 scale indicates a high level of sleepiness). Self-reported height and weight (BMI 25-29.9= overweight, ≥30 obese). Analysis plan: Generalized linear and linear mixed model analyses	BMI was 26.5±3.4kg/m^2; 44% were overweight and 15% were obese; 76% poor sleepers. Total sleep time (TST) was shorter in the offshore work period (389.3±57.9mins) compared to the pre-(420.1±67.5mins) and post-(427.4±100.8mins) offshore work periods (p<0.001). Sleep efficiency: higher during the offshore work period compared to pre-offshore period (OR=1.81; 95%CI=1.26-2.61; p<0.001) and post-offshore period (OR=1.60; 95%CI=1.08 to 2.38; p=0.021). Subjective sleep quality: lower in the offshore work period (3.3±0.8) compared to the pre-offshore period (3.5±0.8; M_{diff}=0.18; 95%CI=0.08-0.29;p=0.001) and post-offshore work periods (3.5±0.8; M_{diff}=0.26; 95%CI=0.14-0.38;p<0.001). Sleepiness: Evening sleepiness was highest during the post-offshore (4.9±2.2) than pre-offshore (4.3±1.9) work periods (p=0.005). Evening sleepiness courses increased during the offshore work period (b =0.06; 95% CI: 0.03–0.08, p<0.001) and decreased during the post-offshore work periods (b= –0.15, 95% CI: –0.25 to –0.08, p=0.004). Morning sleepiness was highest during the offshore (4.0±1.7) than post offshore (3.7±1.6) work periods (p=0.015).
Riethmeister *et al.,* 2018(86)	Longitudinal diary study	To examine daily fatigue scores and changes in circadian rhythm markers over the course of two-week offshore day shift periods	42 offshore day-shift workers; mean age 43.4±11.8 yrs; Country: Netherland; Industry: offshore oil & gas	Fatigue	Daily objective fatigue was measured by reaction times test and Subjective fatigue based on sleepiness was assessed using the Karolinska Sleepiness Scale (KSS) at pre-and post-shift for 14 days (Higher scores on 1-9 scale indicate higher subjective fatigue). Analysis plan: Generalized and linear mixed model	Daily objective fatigue: pre-shift (1.00; 95%CI=0.99–1.00, p=0.045) and post-shift (1.00; 95%CI=0.99–1.00, p=0.329) were stable over the course of the two-week offshore day shifts. Daily subjective fatigue: pre-shift was stable (0.01; 95%CI=-0.01–0.04; p=0.306); post-shift increased by 0.05 points per day (95%CI: 0.02 - 0.08, p=0.004)

Riethmeister *et al.,* 2019(87)	Longitudinal diary survey	To investigate the accumulation of fatigue over a two-week offshore period	42 male offshore day-shift workers; mean age 43.4±11.8yrs; Country: Netherland; Industry: offshore oil & gas	Sleep and fatigue, BMI	Fatigue was assessed by sleepiness using the Karolinska Sleepiness Scale (KSS) (Higher scores on a 1-9 scale indicate higher subjective fatigue); Sleep duration was assessed by actigraph (for 14 work days); Baseline sleep quality by the Pittsburgh sleep quality index (PSQI). Self-reported height and weight Analysis plan: Linear mixed model	BMI was 26.6±3.3 kg/m^2; Sleep quality was poor. Sleep duration was short (6:28±0:52hrs) per day on offshore period; acute sleep loss was 1.32±0.52hr (95%CI: 88.6–94.9), no change over 2 week work period (b=-0.19; 95%CI=1.12-0.73; p=0.679) and chronic sleep loss was 21.20±8.10hrs Fatigue: Pre-shift (3.9±1.6) lower than post-shift (4.5±1.8) fatigue (M_{diff}=−0.32; 95%CI: 0.63-0.01; p=0.042). Post-shift fatigue accumulation was faster than pre-shift fatigue (M_{diff} score increased by 0.03 points per day (95%CI: 0.00–0.07; p=0.037).
Sadeghniiat-Haghighi *et al*., 2018(111)	Cross-sectional survey	To assess the sleep quality and the effect of different shift schedules on the sleep quality of offshore oil workers	192 offshore workers; gender NR; mean age 37.0±9.3 yrs; Country: Iran; Industry: Offshore oil & gas	Smoking; sleep duration and quality	Subjective sleep assessed by Pittsburg Sleep Quality Index (PSQI) (sores ≥5 on a 0-21 scale indicate poor sleep quality); Self-reported smoking status. Analysis plan: Descriptive statistics	17.7% reported smoking; short sleep duration (6.73±3.61hrs) and 69.0% had poor/impaired sleep quality; Fixed night shift workers (83.3%) were more likely to report impaired sleepquality than fixed day shift (66.1%) and swing (66.6%) shift (p=0.34).

Sadeghniiat-Haghighi *et al.*, 2019(140)	Cross-sectional survey	To evaluate the effect of shift work and different shift schedules on sleep quality and duration of sleep	43 participants; 100% male; mean age was 35.9±7.9 years Country: Iran Industry: Offshore oil & gas	Depression; sleep problems, BMI	Depression: Beck Depression Inventory (scores 0-13 (minimal), 14-19 mild depression, 20-28 moderate depression, 29-63 severe depression); Epworth Sleepiness Scale (scores ≥10 on 0-24 scale indicate excessive daytime sleepiness); Insomnia by Insomnia Severity Index (scores ≥8 on 0-28 indicate insomnia); sleep quality assessed by Pittsburgh Sleep Quality Index (sores ≥5 on 0-21 scale indicate poor sleep quality); Changes in sleep patterns over time (for 14 days) by actigraphy. Self-reported height and weight. Analysis plan: Independent t-test and one-way ANOVA	BMI was 22.7±2.4 kg/m^2. Depression symptoms were minimal (m=9.05±8.5); 27% had shift work disorder; 51.2% had less than six mean sleep hours per 24 hours; 72% had poor sleep quality and 67% reported insomnia; Sleep duration (Total Sleep Time) was short for swing shift (7days /7 nights) workers during the second working week than first week (340±42 vs 370±58mins; p=0.018). Sleep efficiency is high (85±5.1%).
Saksvik *et al.,* 2011(141)	Longitudinal diary study	To investigate how sleep in offshore workers change from day to day pre-, during- and post-work period	19 processing workers; mean age 44.4±8.6 yrs; 68.4% male; Country: Norway; Industry: offshore oil and gas	Sleep problems	Daily sleep diary and actigraphy for 4 weeks (sleep quality: a high score on a 1-5 scale indicates good quality). Analysis plan: Repeated measure ANOVAs	Sleep efficiency: higher in day shift than night (93% vs 88%; p<0.001) and swing (93% vs 88%; p<0.05) shifts across the working week; but higher when working swing shift than night (p<0.01) and day (p<0.05) shifts the first week of work. Sleep quality was better during swing than regular day (3.40±0.49 vs 3.37±0.61; p<0.05) and night (3.40±0.49 vs 3.32±0.63; p<0.05) shifts for first week of work. Subjective sleep duration was longer on day shifts (431±34.24 vs 417±44.57mins; p<0.05) and night (431±47.01 vs 417±44.57mins; p<0.01) shifts than swing shifts across the 2 work weeks.

Sellenger *et al*., 2017(28)	Cross-sectional survey	To examine the prevalence of psychological distress	105 FIFO workers; 44.8% male Country: Australia Industry: Construction	Psychological distress	Psychological distress was measured by the K10 scale (16-21 moderate, 22-29 high, 30-50 very high distress). Analysis plan: Kendall tau correlation and Pearson correlation	High (17.1%; 95%CI=15.9-18.3) and very high (8.6%; 95%CI=6.4-10.8) psychological distress compared to the general population (5.8% and 2.4% respectively); feeling socially isolated (r^2= 0.61), and workplace bullying (r^2= 0.31) positively correlated with high psychological distress
Sneddon *et al*., 2013(107)	Cross-sectional survey	To examine the influence of stress and fatigue upon work situation awareness	185 drilling personnel; mean age group was 35–44 years; Country: UK Industry: Offshore oil & gas	Perceived job stress, sleep and fatigue	Job stress was measured using the offshore stress scale (a higher score on 0-160 scale indicates high stress). Fatigue and sleep disruption were assessed by the Australian Maritime Safety Authority scale (a higher score indicated greater sleep disruption (on a 14-70 scale) and fatigue (on a 13-65 scale). Analysis plan: Correlations (Pearson's Product Moment) and regression analyses	Stress level was relatively low (m=57.23±26.24); sleep disruption (m=30.66±7.11) and fatigue (m=31.03±7.49) levels were minimal. Stress (β=-0.34; p<0.01) was negatively associated with work situation awareness.
Stewart *et al.,* 2016(133)	Cross-sectional survey	To provide information on body dimensions for the civilian UK male offshore workforce	404 male offshore workforce; mean age 41.4±10.07yrs; Country: UK; Industry: offshore oil & gas	BMI	Objective measurement of Weight (kg) and Height (m). Analysis plan: mean score	BMI was 28.7±4.0 kg/m^2. Workers with less BMI pass egress test simulating the smallest helicopter window emergency exit size (p<0.0001).
Stewart *et al.,* 2017(134)	Cross-sectional survey	To determine the prevalence of overweight and obesity, and compare data with the national population	588 male offshore workers; mean age 40.6±10.7yrs. country: UK; Industry: offshore oil & gas	BMI	Objective measurement of stature (cm) and weight (kg), and 3D body scanning; BMI calculated as kg/m^2 (BMI 25-29.9= overweight, ≥30 obese). Analysis plan: Chi-square, univariate analysis of variance and post hoc tests	BMI was 28.3±4.0kg/m^2 increased from 24.9kg/m^2 in 1984; 52% were overweight and 30% were obese; an increase in prevalence overweight by 6% and obesity by 24%. BMI was higher than the Scottish normal population (p=0.021).

Sutherland, 1993(104)	Cross-sectional survey	To examine the sources of stress and the link between stress, personal factors, and accident occurrence	310 males working on 97 drilling and production installations; age range 21 to 60 yrs; Country: UK Industry: Offshore oil & gas	Mental health Smoking; alcohol intake	Psychological well-being assessed by The Crown Crisp experiential index (CCEI)	Mental health (mean score=23.1) was poor compared to onshore/normal industrial workers (mean score=21.1); 34% reported tobacco smoking status; 16% reported consuming more than 21 units (safe level) of alcohol per week
Sutherland & Copper, 1991(92)	Longitudinal study	To examine the relationships between stress, personality and accident involvement	310 male drilling and production workers; age range 21 to 60 yrs Country: UK Industry: Offshore oil and gas	Psychological well-being;	Psychological well-being assessed by the Crown Crisp Experiential Index (CCEI) (3 measurement points 6 months apart) Analysis plan: multiple regression	Poor mental well-being predicted by stress from home/work interface (β=0.27; t=3.04, p<0.002), safety and insecurity concerns (β=0 17, t=2.67, p< 0.01), and job dissatisfaction (β=-0.10; t=-2.28, p<0.05)
Thorne *et al.*, 2008(142)	Longitudinal diary study	To evaluated sleep on shift schedules differing by only 1 h in work start and finish time	17 offshore night shift male workers; mean age 41±12 yrs. Country: UK; Industry: offshore oil & gas	Sleep duration, BMI	Sleep diaries and actigraphy for the last 7 days of offshore work period. BMI measurement NR. Analysis plan: two-way RM-ANOVA	BMI was 27.25±2.95kg/m^2. Night shift schedule with an early start at 18:00h associated with long sleep duration (6.60±0.30hrs vs 5.71±0.27hrs) than late start schedule at 19:00h ($F_{(1,12)} = 6.20$; p<0.05)
Thorne *et al.,* 2010(143)	Longitudinal diary study	To investigate the effects of timed bright light treatment on sleep and circadian adaptation in offshore night-shift workers	14 offshore night male shift workers; mean age 47.5±9 yrs. Country: UK; Industry: offshore oil & gas.	Sleep duration, BMI	Sleep diaries and actigraphy for the last 7 days of offshore work period. BMI measurement NR. Analysis plan: descriptive statistics	BMI was 28.25±2.30kg/m^2. Sleep duration was short (5.89±0.65hrs) and sleep efficiency was lower (82.7±6.3%) during the last 7 days of work period.

Waage *et al*., 2009(93)	Cross-sectional survey	To examine Shift Work Disorder among shift workers in the North Sea	103 workers in the North Sea; 95.1% men; mean 39.8±10.2yrs	Health complaints, sleep problems	Subjective Health Complaint Inventory (SHC); Sleep problems by Pittsburgh Sleep Quality Index (PSQI) (sores >5 on 0-21 scale indicate poor sleep disorders); Bergen Insomnia Scale (BIS) (higher score on 0-42 indicate insomnia); Epworth Sleepiness Scale (scores >10 on 0-24 scale indicate excessive sleepiness); Shift Work Disorder diagnosed based on ICSD-2 minimal criteria (yes on 3 items). Analysis plan: Independent t-test and chi-square tests	23.3% had shift work disorder (SWD); self-rated physical health was good/very good in workers with SDW (87.5%) and non-SWD (88.6%) ($p=0.917$). Poorer sleep quality ($p<0.001$) and more subjective health complaints ($p<0.001$) in SWD workers (100%) than non-SWD workers (89.9%) (more musculoskeletal (90.9% vs 69.6%, $p=0.04$), and gastric problems (87% vs 50.6%, $p<0.01$) in workers with SWD during the last 30 days). 79.4% experience sleep problems during the offshore period; sleep problems was more in workers with SWD ($p=0.003$). 96.1% had sufficient sleep during the non-work period high than during work periods (65%).
Waage *et al*., 2010(94)	Cross-sectional survey	To examine the relationship between shift type, and morningness and sleep/health problems in oil rig shift workers	199 purposively selected workers; 96.6% males; mean age was 42.9 years. Country: Norway; Industry: offshore oil & gas	Subjective health complaints; sleep duration, BMI	Subjective health complaints were assessed by the Subjective Health Complaint Inventory (SHC) (high scores indicate more complaints). Self-reported height and weight; Sleep was measured by the Pittsburgh Sleep Quality Index (PSQI) (sores >5 on a 0-21 scale indicate sleep disorders); Analysis plan: Multiple linear regressions, and post hoc analysis	BMI was 26 kg/m^2; 81% of workers described their health as very good or good; Workers reported some subjective health complaints (mean score 7.10±6.16; range 0-87); more musculoskeletal complaints among workers aged >50 years compared to younger workers (16.93±45.19 vs 1.75±5.61; range 0-24, $p<0.001$), low gastrointestinal complaints (1.36±5.70; range 0-24). Swing shift workers reported longer sleep duration than day shift workers ($\beta=0.18$; $p=0.01$).

Waage *et al.*, 2012(156)	Longitudinal diary survey	To investigate sleepiness in the same shift workers during three different shift schedules	28 workers in a processing area; mean age was 44yrs; 68.4% men; Country: Norway; industry: offshore oil & gas	Sleepiness	Sleep and wake diaries of KSS hourly (higher scores on a 1-9 scale indicate higher subjective fatigue) and the Accumulated Time with Sleepiness (ATS) once a day for 4 weeks (2 waves 9 months apart). Analysis plan: ANOVA with separate post hoc tests	Sleepiness was highest during the first days of night and swing shifts (range p=0.01 to 0.03), and also in the middle of the swing shift work period (range p=0.02 to 0.03). Workers reported more subjective sleepiness after the night shift than after day (p<0.01) or swing shifts (p=0.01) on leave periods. No differences in objective ($F_{2,18}$ = 0.61, p=0.27) and subjective ($F_{2,28}$ = 0.14, p>0.05) sleepiness between different shift types.
Waage *et al.*, 2013(91)	Longitudinal study	To examine and compare the workers' subjective health before after a four week leave period and following a two week work period at the oil rig.	188 oil rig workers; mean age 42.9±10.6yrs; 97.3% male. Country: Norway; Industry: offshore oil & gas	Health complaints; sleep quality, insomnia, smoking	Subjective health complaints measured by the Subjective Health Complaints Inventory (SHC) in the last 30 days (measured 2 times, 2 weeks apart) (high scores a on 0-87 indicate more complaints); Sleep problems by Pittsburgh Sleep Quality Index (PSQI) (sores >5 on 0-21 scale indicate poor sleep disorders); Bergen Insomnia Scale (BIS) (higher score on 0-42 scale indicate insomnia). Self-reported smoking status. Analysis plan: Paired samples t-test and 2 × 2 ANOVA	81.5% self-reported physical health as good or very good; 23% reported smoking. Swing shift workers (89.3%) reported better health than day shift workers (73.4%) (p=0.02). Poor sleep quality (5.7±2.7 vs 4.5±2.6; p<0.0005) and more complaints of insomnia (12.5±12.9 vs 7.5±6.4; p<0.0005) at the end than start of the work period. Swing shift workers reported poorer sleep quality (5.9±2.8 vs 4.5±2.9; p<0.0005) and more complaints of insomnia (13.8±9.6 vs 7.1±6.8; p<0.0005) at the end compared to the start of the work period. No differences between day shift workers and swing shift workers for sleep quality at the start (27.8% vs 26.9%, p=0.96) and end (33.3% vs 44.1%, p=0.09) of the work period. Daily smoking in day shift workers (23.3%) was similar to swing shift (22.6%) workers (p=0.65). No differences in SHCs at the start to the end of the work period (7.2±6.2 vs 6.7±5.5; p=0.12)

Ulleberg *et al.*, 1997(118)	Cross-sectional survey	To examine the relationship between job stress, job dissatisfaction, social support, absenteeism and strain	1137 employees; 91% male; mean age 40 yrs. Country: Norway; Industry: Offshore oil & gas	Strain, sleep and gastric problems	Strain assessed by self-reported problems with sleeping and stomach trouble (mean score 1-5, a higher score indicates a high level of strain). Analysis plan: Stepwise multiple regression analysis	Workers report low to moderate levels of strain (1.84±0.70); more sleep difficulties (mean score=2.17±1.13) and low stomach problems (mean score=1.66±0.99). Stress from physical workload (β=0.15; p<0.001), communication and participation in work decisions (β=0.10; p=0.012) and perception of risk: disasters and accidents (β=0.19; p<0.001), satisfaction with employee relations (β=0.23; p<0.001) and extrinsic satisfaction with working condition (β=0.11; p=0.019) were associated with high strain; high social support from supervisor (β=-0.09; p=0.015) was associated with less strain
Vojnovic & Bahn, 2015(73)	Cross-sectional study	To examine the relationship between demographic information and mental health among FIFO workers	629 FIFO workers; 83% male Mean age 36.80±10.35 (ranged 18–65yrs). Country: Australia Industry: mining and oil & gas	Mental health (depression, anxiety and stress)	Depression, anxiety and stress were assessed by self-report using The Depression Anxiety Stress Scale (DASS-21) (scores on DASS-21 multiplied by 2; Depression: scores 0-9 normal, 10-13 mild, 14-20=moderate, ≥21 severe/extremely severe; Anxiety: 0-7 normal, 8-9 mild, 10-14 moderate, ≥15 severe; stress: 0-14 normal, 15-18 mild, 19-25 moderate, ≥26 severe).	28.3% experienced depression symptoms, 22.3% reported anxiety symptoms and 19.4% reported stress symptoms; 36.31% of participants experienced psychological distress symptoms above the clinical cut-off levels.

Table S2. Summary of qualitative studies

Author	Study design	Aim/objective	Study population/study country and industry	Phenomenon	Data collection methods/ Analysis plan	Summary of findings
Carter & Kaczmarek, 2009(153)	Qualitative study	To explore the psychological impact offshore FIFO employment has on Gen Y	10 male; aged 18-28yrs; Country: Australia; Industry: offshore oil and gas	Psychological well-being	Semi-structured interviews. Analysis plan: Thematic analysis	Workers reported financial rewards, long leave periods to engage in social activities to improve their well-being, and a sense of social belonging at the workplace. Workers reported feelings of depression prior to returning to work and during the first day at work due to missing out on social events. Workers reported difficulty with forming and maintaining personal relationships
Devine *et al.,* 2008(148)	Qualitative study	To identify staff perceptions of the types and sources of occupational health and safety hazards at a remote fly-in-fly-out minerals extraction and processing plant	23 to 53 staff purposive sample. Gender: NR; age: NR; Country: Australia. Industry: mining	Fatigue	Focus group discussion lasting 60-90mins. Thematic analysis	Workers reported concerns about high levels of fatigue due to roster and sleep difficulties; fatigue improved after a change of roster 7N/7D/7L to 8D/6L/8N/6L
Ebert & Strehlow, 2017(151)	Qualitative study	To examine the 24/7 on-site chaplain's service impact on the health and well-being of FIFO personnel	29 employees; 69% male; age 20–60yrs; Country: Australia Industry: mining	Mental well-being	Semi-structured interviews. Analysis plan: Thematic analysis	Workers reported mental distress from anxiety, depression and home/work interference issues; Workers reported on-site chaplaincy provided social support and made effective promotion of the mental health of FIFO personnel working at a remote mine site; chaplains provided active outreach, effective trust building and the on-site availability were identified as central to the service being accessed and overcoming barriers embedded in mining culture and masculinity

Gardner *et al.,* 2018(15)	Qualitative study	To investigate how workers and their partners negotiate the impact of FIFO on their mental health and well-being	34 FIFO workers; 79% male; mean age 41±11yrs; Country: Australia; Industry: General FIFO	Mental health and well-being	Open-ended questions via email. Analysis plan: Thematic analysis	Workers reported FIFO work imposes the sense of living two lives, which comes with the difficulties of adjusting to the differences and pace of the domestic and work lives. Workers reported being trapped in undesired jobs by high wages; absence from family put a strain on relationships with partners due to physical and psychological distance which causes tension and distrust; Some reported feelings of isolation and loneliness due to prolonged absence from their families and impeded communication which manifested in anxiety or depression. Some reported feeling guilty for delegating everyday domestic duties and responsibilities to their partners. Workers indicated the lack of support from employers and the general population for FIFO workers to deal with mental health issues, reluctant to seek help for health or well-being issues due to masculinity, stigma, and fear of losing jobs
Gibson-Smith *et al.,* 2018(100)	Qualitative study	To identify self-care behaviours perceived to require behaviour change within the offshore workforce, and explore perceived potential behavioural determinants	16 offshore workers; 93.8% males; aged 28–57 yrs. Country: Australia; Industry: offshore oil & gas	Health behaviour	Semi-structured one-on-one interviews via telephone. Analysis plan: Deductive and Thematic analysis	Workers identified behaviours requiring change including reducing alcohol use and smoking, eating healthily and increasing physical activity. Workers indicated eating behaviour was influenced by ''…. availability of healthy/unhealthy food options offshore ''. Workers reported physical activity influenced by ''…increasing the number of opportunities for workers to exercise and improving gym facilities offshore''.
Perring *et al.,* 2014(149)	Qualitative study	To investigate how facilities located within on-site mining camps support the everyday life of FIFO mining workers	7 FIFO workers; 6 males; Aged 20-59 years. Country: Australia; Industry: Mining	Physical activities	In-depth semi-structured interview	Workers reported engaging in sporting activities more than once a week. Some stated time constraints due to long shift hours and travel times to and from work sites, fatigue and management (not proactive) and not well-maintained facilities limit creational activities and influence engagement in physical activity. Most participate in alcohol drinking (culture of drinking).

Pirotta, 2009(150)	Qualitative study	To explore the experiences of women working at mine sites on a Fly In, Fly Out (FIFO)	20 women working FIFO; mean age 31.2yrs (23-49); Country: Australia; Country: Mining	Psychological well-being	Semi-structured interviews. Analysis plan: Thematic analysis	FIFO workers reported financial rewards, long leave periods, and a sense of community living at camps. Workers reported social life disruptions; difficulties developing friendships and intimate relationships. Workers reported a sense of isolation and loneliness. Workers reported feelings of depression, anxiety and physical exhaustion due to long work hours
Rodrigues *et al.,* 2001(102)	Qualitative study	To evaluate how offshore drilling workers perceived shift work on the high seas and its impacts on their life and working conditions	51 male workers on mobile drilling; mean age of 37.6yrs; Country: Brazil; Industry: offshore oil & gas	Psychosomatic symptoms	Psychosomatic symptoms were assessed through a comprehensive interview. Analysis plan: Thematic analysis	Conflicts related to social and domestic arrangements were considered high; "pre-boarding stress syndrome" characterised by anxiety, sleepiness, bad mood and other psychosomatic symptoms in the last days off was reported. Workers reported poor sleep during the first and the last 2-3 days of the leave periods. Workers reported concerns about sleepiness during the day after night shifts.
Riethmeister *et al.,* 2016(88)	Mixed method study (qualitative aspect)	To perform a needs assessment to identify the needs of offshore workers with regard to healthy ageing at work	19 supervisors (14 males) & 49 offshore workers; age 22-67yrs. Country: Netherlands Industry: offshore oil & gas	Sleep, fatigue, nutrition	Semi-structured interviews of supervisors and Focus group discussions with workers	Workers identified being far away from home, work-home/family conflicts, worries of lack of privacy (sharing cabins), and lack of flexible work arrangements influence their health and social life. Workers experience mental exhaustion (due to long shift hours). Workers reported a culture of masculinity with the mentality of 'no get sick'. Food and nutrition were identified as major health concerns; criticized the easy access to unhealthy food and the unhealthy eating behaviours of offshore workers. Workers reported issues of fatigue (due to long shift hours), and sleep disturbances (due to environmental stressors such as motion and noise of platforms, and accommodation arrangements);
Torkington *et al.,* 2011(39)	Qualitative study	To explore how FIFO/DIDO mining affects the psychosocial well-being of miners	11 current/former FIFO/DIDO workers; 81.8% male; aged 20-59 years. Country: Australia. Industry: mining	Psychosocial well-being, alcohol, fatigue	Semi-structured interviews. Analysis plan: Thematic analysis	Workers indicated being satisfied with their jobs and life; '… enjoy the work environment and interact with colleagues and have enough days off to be with family and friends; Workers expressed minimal mood but worries about missing out on family events, and difficulties maintaining social life. Workers reported of 'culture of drinking'; enjoyed by some and non-drinkers do not fit in socially. Some workers reported fatigue due to tiredness and sleep disturbance.

Wright & Griep, 2019(152)	Qualitative study	To understand how working in the petroleum industry affects oil workers' psychosocial health and well-being	14 individuals (12 males, 2 females) Country: Canada Industry: Petroleum	Psychological health and well-being; musculoskeletal problem	Semi-structured interviews. Analysis plan: Thematic analysis	Workers reported stigmatization or discrimination as working dirty work and substance abusers from their communities. Workers reported mental strain/emotional difficulties in maintaining relationships or work-family relationships, especially among those with young children, and families not appreciative of their work; face with adopting behaviours and bullying to fit into work social environment; workers are faced with a culture of hard work and intolerance for weakness which leads to working while sick. Workers reported difficulty in balancing work and social lifestyle (having to switch off work brain and put on the social brain); workers lack control over their jobs; Workers experienced physical pain regularly: common are muscle and joint pains, neck and back pains, and leg and feet pains

Appendix D: Data collection tools
Rotation Work and Economic Survey (in workers)

We would like to learn more about FIFO workers' health and well-being. To help us understand it better, please complete this survey (10-15 minutes).
You will be entered into a draw at the end of the study, to win a AUS$200 shopping voucher for participating in the study.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number 2020-0693)

Thank you for taking time to participate in this study

Read more about the study

Q1 Do you give consent to participate in this study?

○ Yes, I have read the information statement and I understand its contents, and I voluntarily consent to take part in this research project.

○ No, I do not consent to take part in the research project

Skip To: End of Survey If Do you give consent to participate in this study? = No, I do not consent to take part in the research project

Thanks for participating in the study. All information you provide will be kept confidential. Thank you for your time.

Demographic and work characteristics
We would like to learn more about you; please provide your personal and work details below

Q2 Please indicate the country where you are?

○ Australia

○ UK

Q3 How old are you (in years)?

▼ 18 ... 75

Q4 What is your gender?

- ◯ Male
- ◯ Female
- ◯ Other (Please specify) ____

Q5 What is your ethnic background?

- ◯ Caucasian/White
- ◯ Aboriginal/Torres Strait Islander
- ◯ African Descent
- ◯ Caribbean
- ◯ Arab Descent
- ◯ Asian Decsent
- ◯ Mixed race
- ◯ Other (Please specify) ____

Q6 What is your relationship status?

- ◯ Single/ never married
- ◯ Married
- ◯ Divorced
- ◯ Separated
- ◯ Widowed
- ◯ Civil partnership
- ◯ De-facto/co-habiting
- ◯ Other (Please specify) ____

Q7 Do you have children?

- ◯ Yes
- ◯ No

Skip To: Q9 If Do you have children? = No

Q8 How many children do you have?

▼ 1 ... 10

Q9 What is your highest level of education attained?

- ◯ No formal education
- ◯ Primary education
- ◯ Secondary education
- ◯ O GCSE/O-level or equivalent
- ◯ A-levels or equivalent
- ◯ Trade/Apprentice
- ◯ TAFE/College/Diploma
- ◯ Bachelor degree
- ◯ Postgraduate degree
- ◯ Other (Please specify) ____

Q10 What is your current occupational role at work?

- ◯ Management
- ◯ Professional
- ◯ Maintenance/Technician
- ◯ Catering
- ◯ Production
- ◯ Drilling/construction
- ◯ Machinery operator and driver
- ◯ Labourer
- ◯ Administration/services
- ◯ Other (Please specify) ____

Q11 How long (in years) have you worked in FIFO/rotation/offshore work?

▼ less than 1 year ... 50

Q12 What is the rotating shift pattern you normally work on?

- ◯ Rotation shift (mixture of day/night shifts)
- ◯ Regular shift (fixed day)
- ◯ Regular shift (fixed night)
- ◯ Stand-by shift
- ◯ Other (Please specify?) ____

Q13 On a common shift, how many hours would you work per day?

▼ 1 ... 20

Q14 What is your typical number of consecutive days on shift?

▼ 1 ... 90

Q15 What is the typical number of consecutive days off you would have between shifts?

▼ 1 ... 90

Q16 What is income from paid FIFO work per annum? (This refers to the amount you actually receive from your current FIFO work. We are interested only in your income, i.e. exclusive of, if present, your partner's income)

▼ A$50-60k ... A$181k and above

Sleep and health-related behaviour

We would like to ask some questions about your sleep patterns, diet, alcohol use, smoking, and lifestyle.

Q17 **We would like to know your weight and height to calculate for your BMI**
What is your weight in kgs/stones/Ibs? (Please select one that is suitable for you)

kgs	▼ 20 ...
stones	▼ 20 ...
Ibs	▼ 20 ...

Q18 What is your height in meters, cm, or feet/inches? (Please select one that is suitable for you)

meters	▼ 1.0 ... 5.0
cm	▼ 1.0 ... 5.0
feet	▼ 1.0 ... 5.0

Sleep patterns
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

Q19 How many hours of actual sleep did you get at night **during on-shift days**? *(This may be different from the number of hours you spent in bed)*

▼ 1 ... 30

Q20 How many hours of actual sleep did you get at night **during off-shift days**?

▼ 1 ... 30

Q21 During the past month, **during on-shift days**, how would you rate your sleep quality overall?

○ Very good

○ Fairly good

○ Fairly bad

○ Very bad

Q22 During the past month, **during off-shift days**, how would you rate your sleep quality overall?

○ Very good

○ Fairly good

○ Fairly bad

○ Very bad

Fruits and vegetable intake
The following questions are about your usual consumption of fruits and vegetables, including fresh, frozen and tinned fruits and vegetables, during on-shift and off-shift days. Please answer all questions.

Q23 How many serves of vegetables do you usually eat each day during **on-shift day**? *(one serving equals one of leafy green or raw salad vegetables)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat vegetables

Q24 How many serves of vegetables do you usually eat each day during **off-shift days**? *(one serving equals one of leafy green or raw salad vegetables)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat vegetables

Q25 How many serves of fruit do you usually eat each day during **on-shift days**? *(one serving equals one cup canned fruits)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat fruits

Q26 How many serves of fruit do you usually eat each day during **off-shift days**? *(one serving equals one cup canned fruits)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat fruits

Alcohol consumption and smoking status

Q27 How often do you have a drink containing alcohol?

- ◯ Never
- ◯ Monthly or less
- ◯ 2–4 times a month
- ◯ 2–3 times a week
- ◯ 4 or more times a week

Skip To: Q32 If How often do you have a drink containing alcohol? = Never

Q28 **When on-shift,** how many standard drinks containing alcohol do you have on a typical day when drinking?

- ◯ 0
- ◯ 1 or 2
- ◯ 3 or 4
- ◯ 5 or 6
- ◯ 7 to 9
- ◯ 10 or more

Q29 When off-shift, how many standard drinks containing alcohol do you have on a typical day when drinking?

- ◯ 0

- 1 or 2
- 3 or 4
- 5 or 6
- 7 to 9
- 10 or more

Q30 **When on-shift,** how often do you have six or more standard drinks on one occasion?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

Q31 **When off-shift,** how often do you have six or more standard drinks on one occasion?

- Never
- Less than monthly
- Monthly
- Weekly
- Daily or almost daily

Q32 Do you smoke?

- Yes
- No

Skip To: Q34 If Do you smoke? = Yes

Q33 If no, have you ever smoked?

- Yes
- No

Skip To: Q36 If If no, have you ever smoked? = No

Q34 How many cigarettes do you smoke per day **when on-shift**?

▼ 1 ... 100

Q35 How many cigarettes do you smoke per day **when off-shift**?

▼ 1 ... 100

Physical activity

Think about only those physical activities that you did for at least 10 minutes at a time.

Q36 How many days per week did you do **vigorous physical activities** (like heavy lifting, digging, or aerobics) **when on-shift**?

▼ None ... 7

Q37 How much time did you usually spend doing **vigorous physical activities** on one of those days when on-shift? (Specify in minutes)

▼ 0... 500

Q38 How many days per week did you do **vigorous physical activities** (like heavy lifting, digging, or aerobics) and moderate when off-shift?

▼ None ... 7

Q39 How much time did you usually spend doing **vigorous physical activities** on one of those days **when off-shift**? (Specify in minutes)

▼ 0... 500

Q40 How many days per week did you do **moderate physical activities** (like carrying light loads, bicycling at a regular pace, or doubles tennis) **when on-shift**?

▼ None ... 7

Q41 How much time did you usually spend doing **moderate physical activities** on one of those days when **on-shift**? (Specify in minutes)

▼ 0 ... 500

Q42 How many days per week did you do **moderate physical activities** (like carrying light loads, bicycling at a regular pace, or doubles tennis) when off-shift?

▼ None ... 7

Q43 How much time did you usually spend doing **moderate physical activities** on one of those days when off-shift? (Specify in minutes)

▼ 0 ... 500

Q44 How many days per week did you do **mild physical activities** (e.g. walking at work, walking from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure) **when on-shift**?

▼ None ... 7

Q45 How much time did you usually spend doing **mild physical activities** on one of those days **when on-shift**? (Specify in minutes)

▼ 0 ... 500

Q46 How many days per week did you do **mild physical activities** when off-shift?

▼ None ... 7

Q47 How much time did you usually spend doing **mild physical activities** on one of those days **when off-shift**? (Specify in minutes)

▼ 0 ... 500

Physical Health status
We would like to you know about your physical health status. Please select the answer that is correct for you.

Q48 Overall, how would you rate your health during the past 4 weeks?

○ Excellent

○ Very good

○ Good

○ Fair

○ Poor

○ Very poor

Q49 During the past 4 weeks, how much did physical health problems limit your usual physical activities (such as walking or climbing stairs)?

○ Not at All

○ Very Little

○ Could Not Do Physical Activities

○ Somewhat

○ Quite a Lot

Q50 During the past 4 weeks, how much difficulty did you have doing your daily work, both at home and away from home, because of your physical health?

- Not at All
- A Little Bit
- Could Not Do Daily Work
- Some
- Quite a Lot

Q51 How much bodily pain have you had during the past 4 weeks?

- None
- Very Mild
- Mild
- Moderate
- Severe
- Very Severe

Q52 **Psychological distress status**

These questions relate to how you've been feeling over the past **four weeks**. Please select the answer that is correct for you. About how often did you...

	None of the time	A little of the time	Some of the time	Most of the time	All of the time
feel tired out for no good reason?	○	○	○	○	○
feel nervous?	○	○	○	○	○
feel so nervous that nothing could calm you down?	○	○	○	○	○
feel hopeless?	○	○	○	○	○
feel restless or fidgety?	○	○	○	○	○
feel so restless you could not sit still?	○	○	○	○	○

feel depressed?	○	○	○	○	○
feel that everything was an effort?	○	○	○	○	○
feel so sad that nothing could cheer you up?	○	○	○	○	○
feel worthless?	○	○	○	○	○

Work productivity

We would like to know about the effect of your health problems on your ability to work and perform regular activities. By health problems we mean any physical or emotional problem or symptom.

Q53 During the past four weeks, how many hours did you miss from work because of your health problems? *Include days you missed on sick days, times you went in late, left early, etc., because of your health problems.*

▼ 0 ... 300

Q54 During the past four weeks, how many hours did you actually work?

▼ 1 ... 500

Q55 During the past four weeks, how much did your health problems affect your productivity while you were working? ***Rank 0 (Health problem had no effect on my work) to 10 (Health problem completely prevented me from working)***

	0	1	2	3	4	5	6	7	8	9	10
0											

Q56 Would you like to tell us more about your health? Take part in a short daily diary surveys (not more than 5 mins) for 28 consecutive days that will help us understand your health profile. You will be asked about your day, including your feelings (e.g. mood, anxiety, stress), sleep, lifestyle (e.g. alcohol use), and work-related characteristics (e.g. workload & support). You will receive a personalised report that can help you learn a bit more about your health. You will also help us understand changes in FIFO workers' health and wellbeing.

○ Yes

○ No

Skip To: Q60 If Would you like to tell us more about your health? Take part in a short daily diary surveys (not m... = No

Read more about the daily diary study

Q57 I understand that I will be contacted regularly during the study to complete further questionnaires.

○ Yes

○ No

Q58 Do you give consent to participate in the daily study?

○ Yes, I have read the information statement and I understand its contents, and I voluntarily consent to take part in this research project.

○ No, I do not consent to take part in the research project

Skip To: Q60 If Do you give consent to participate in the daily study? = No, I do not consent to take part in the research project

Q59 Please enter your mobile number you may wish to be contacted on for follow-up questionnaires *(This mobile number will be stored in a separate dataset so it is impossible to link to your data)*

____

Q60 Please enter your email address if you would like to be included in a raffle draw? *(This email address will be stored in a separate dataset so it is impossible to link to your data)*

____

Rotation work and Health: Survey for Partners

We would like to learn more about the partners of FIFO workers and their health and well-being. To help us understand it better, please consider completing this 10-minute survey.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number 2020-0693)

Thank you for taking time to participate in this study

Read more about this study

Do you give consent to participate in this study?

☐ Yes, I have read the information statement and I understand its contents, and I voluntarily consent to take part in this study

☐ No, I do not consent to take part in the research project

Thanks for participating in the study. You will now be asked some questions about you ahead of the daily diary part of the study. Please answer all the questions. Thank you for your time.

Q1 How old are you?

▼ 18 ... 70

Q2 What is your gender?

○ Male

○ Female

○ Other (Please specify) ____

Q3 What is your ethnic background?

○ Caucasian/white

○ Aboriginal/Torres Strait Islander

○ African Descent

○ Caribbean

○ Arab Descent

○ Asian Descent

○ Mixed race

○ Other (Please specify) ____

Q4 What is your relationship status?

- ◯ Married
- ◯ Civil partnership
- ◯ De-facto/co-habiting
- ◯ Other (Please specify) ____

Q5 How long (in years) have you been in this relationship with your partner?

▼ less than 1 year ... 60

Q6 Do you have children?

- ◯ Yes
- ◯ No

Skip To: Q9 If Do you have children? = No

Q7 How many?

▼ 1 ... 30

Q8 What is the age of your youngest child?

▼ less than 1year ... 59

Q9 What is the your highest level of education attained?

- ◯ No formal education
- ◯ Primary education
- ◯ Secondary education
- ◯ O GCSE/O-level or equivalent
- ◯ A-levels or equivalent
- ◯ Trade/Apprentice
- ◯ TAFE/College

○ Bachelor degree

○ Postgraduate degree

○ Other (Please specify) ____

Q10 What is your current employment status?

○ Undertaking house duties

○ Working full-time

○ Working part-time

○ Self-employed

○ Student

○ Other (Please specify) ____

Q11 What is your partner's current occupational role at work?

○ Management

○ Professional

○ Maintenance/Technician

○ Catering

○ Production

○ Machinery operator and driver

○ Drilling/construction

○ Labourer

○ Administration/services

○ Other (Please specify) ____

Q12 What is your partner's usual rotation shift pattern?

○ Rotation shift (mixture of day/night shifts)

○ Regular shift (fixed day)

◯ Regular shift (fixed night)

◯ Stand-by shift

◯ Other (Please specify) ____

Q13 What is the number of hours of your partner's normal shift per day?

▼ 1 ... 30

Q14 What is your partner's number of consecutive days away at work?

▼ 1 ... 120

Q15 What is your partner's number of consecutive days at home?

▼ 1 ... 120

Q16 How long (in years) has your partner worked rotation work (FIFO) during the course of your relationship?

▼ Less than 1 year ... 70

Health and lifestyle status
We would like to know about your health and lifestyle. *Your answers will remain confidential. Please select the answer that is correct for you.*

Sleep patterns The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

Q17 How many hours of actual sleep did you get at night during your partner's **on-shift days**? *(This may be different from the number of hours you spent in bed)*

▼ 1 ... 30

Q18 How many hours of actual sleep did you get at night during partner's **off-shift days**?

▼ 1 ... 20

Q19 During the past month, during your partner's on-shift days, how would you rate your sleep quality overall?

◯ Very good

◯ Fairly good

◯ Fairly bad

◯ Very bad

Q20 During the past month, during your partner's off-shift days, how would you rate your sleep quality overall?

◯ Very good

◯ Fairly good

◯ Fairly bad

◯ Very bad

Q21 **We would like to know your weight and height to calculate for your BMI**
What is your weight in kgs/stones/Ibs? (Please select one that is suitable for you)

kgs	▼ 20 ...
stones	▼ 20 ...
Ibs	▼ 20 ...

Q22 What is your height in meters, cm, or feet/inches? (Please select one that is suitable for you)

meters	▼ 1.0 ... 5.0
cm	▼ 1.0 ... 5.0
feet	▼ 1.0 ... 5.0

Alcohol and smoking status

Q23 How often do you have a drink containing alcohol?

◯ Never

◯ Monthly or less

◯ 2-4 times per month

◯ 2-3 times per week

◯ 4 or more times per week

Skip To: Q27 If How often do you have a drink containing alcohol? = Never

Q24 How many hours of actual sleep did you get at night during your partner's on-shift days? (This may be different from the number of hours you spent in bed)
Q25 During your partner's off-shift days, how many standard drinks containing alcohol do you have on a typical day when drinking?

- ○ 0
- ○ 1-2
- ○ 3-4
- ○ 5-6
- ○ 7-9
- ○ 10 or more

Q26 How often do you have six or more standard drinks on one occasion in the last year?

- ○ Never
- ○ Less than monthly
- ○ Monthly
- ○ Weekly
- ○ Daily or almost daily

Q27 Do you smoke?

- ○ Yes
- ○ No

Skip To: Q29 If Do you smoke? = Yes
Q28 If no, have you ever smoked?

- ○ Yes
- ○ No

Skip To: Q31 If If no, have you ever smoked? = No

Q29 If you do currently smoke, how many cigarettes do you smoke per day during your partner's on-shift days?

▼ 1 ... 100

Q30 How many cigarettes do you smoke per day during your partner's off-shift days?

▼ 1 ... 100

Q31 How many serves of vegetables do you usually eat each day during partner's **on-shift day**? *(one serving equals one of leafy green or raw salad vegetables)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat vegetables

Q32 How many serves of vegetables do you usually eat each day during partner's **off-shift days**? *(one serving equals one of leafy green or raw salad vegetables)*

- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more
- ◯ Less than one serve
- ◯ Don't eat vegetables

Q33 How many serves of fruit do you usually eat each day during partner's **on-shift days**? *(one serving equals one cup canned fruits)*

- ◯ 1 serve

- 2 serves
- 3 serves
- 4 serves
- 5 serves
- 6 serves or more
- Less than one serve
- Don't eat fruits

Q34 How many serves of fruit do you usually eat each day during partner's **off-shift days**? *(one serving equals one cup canned fruits)*

- 1 serve
- 2 serves
- 3 serves
- 4 serves
- 5 serves
- 6 serves or more
- Less than one serve
- Don't eat fruits

Q35 How many minutes per day do you usually do vigorous or moderate physical activities outside of work for at least 10 minutes at a time partner's on-shift days?

▼ 0 ... 500

Q36 How many minutes per day do you usually do vigorous or moderate physical activities outside of work for at least 10 minutes at a time during your partner's off-shift days?

▼ 0 ... 500

Public Health status

We would like to you know about your physical health status. Please select the answer that is correct for you.

Q37 Overall, how would you rate your health during the past 4 weeks?

- Excellent
- Very good
- Good
- Fair
- Poor
- Very poor

Q38 During the past 4 weeks, how much did physical health problems limit your usual physical activities (such as walking or stairs)?

- Not at all
- Very little
- Could not do physical activities
- Somewhat
- Quite a lot

Q39 During the past 4 weeks, how much difficulty did you have doing your daily work, both at home and away from home, because of your physical health?

- Not at all
- A little bit
- Could not do daily work
- Some
- Quite a lot

Q40 How much bodily pain have you had during the past 4 weeks?

- None
- Very mild
- Mild
- Moderate

○ Severe

○ Very Severe

Q41 **Psychological distress.** These questions relate to how you've been feeling over the past four weeks. Indicate box next to each question that best reflects your thoughts, feelings and behaviourIn the past 4 week, about how often did you:

	None of the time	A little of the time	Some of the time	Most of the time	All of the time
Feel tired out of no good reason?	○	○	○	○	○
Feel nervous?	○	○	○	○	○
Feel so nervous that nothing could calm you down?	○	○	○	○	○
Feel hopeless?	○	○	○	○	○
Feel restless or fidgety?	○	○	○	○	○
Feel so restless you could not sit still?	○	○	○	○	○
Feel depressed?	○	○	○	○	○
Feel that everything was an effort?	○	○	○	○	○
Feel so sad that nothing could cheer you up?	○	○	○	○	○
Feel worthless?	○	○	○	○	○

Q42 Would you like to tell us more about your health? Take part in short daily surveys (not more than 5 mins) for 28 consecutive days that will help us understand your health profile. You will be asked about your day, including your feelings (e.g. depression, anxiety, stress), sleep, lifestyle (e.g. alcohol use), and work-related characteristics (e.g. workload & support).You will receive a personalised report of your health profile over 28 consecutive days. You will also help us understand changes in FIFO partners health and well-being.

- ○ Yes
- ○ No

Skip To: End of Survey If Would you like to tell us more about your health? Take part in short daily surveys (not more than... = No

Q43 I understand that I will be contacted regularly during the study to complete further questionnaires.

- ○ Yes
- ○ No

Skip To: End of Survey If I understand that I will be contacted regularly during the study to complete further questionnaires. = No

Q44 Please enter your mobile number for the follow-up daily surveys *(This mobile number will be stored in a separate dataset so it is impossible to link to your data)*

____

Rotation work and Health: a daily diary (Worker)

This survey collects information about your daily experience, work and health issues. Thank you very much for taking part!

Q1 Please enter your given study ID (stated in the text message).

____

Q2 Is today your..........?

- ◯ work day (on-shift)
- ◯ non-work day (off-shift)

Skip To: Q5 If Is today your..........? = non-work day (off-shift)

We would ask you set of questions that relate to your work demands and the available job support in the last 24 hour.

Q3 Today, **my Supervisor was supportive**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Somewhat disagree
- ◯ Neither agree nor disagree
- ◯ Somewhat agree
- ◯ Agree
- ◯ Strongly agree

Q4 Today, **I felt my organisation provided enough 'on the job' resources so I could do my job effectively.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Somewhat disagree
- ◯ Neither agree nor disagree
- ◯ Somewhat agree
- ◯ Agree
- ◯ Strongly agree

Q5 Today, **I felt others were supportive**

- ◯ Strongly disagree

- Disagree
- Somehow disagree
- Neither agree or disagree
- Somewhat agree
- Agree
- Strongly agree

Q6 Today, I had autonomy to decide on the order in which things were done

- Strongly disagree
- Disagree
- Somehow disagree
- Neither agree nor disagree
- Somehow agree
- Agree
- Strongly agree

Q7 Today, **I had autonomy in making decisions on what I did**

- Strongly disagree
- Disagree
- Somehow disagree
- Neither agree nor disagree
- Somehow agree
- Agree
- Strongly agree

Q8 Today, **my workload was too heavy**

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree

- Agree
- Strongly agree

Q9 Today, **I did not have enough time to do my work to the best of my ability**

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Q10 Today, **my tasks were simple and uncomplicated**

- Strongly disagree
- Disagree
- Somehow disagree
- Neither agree or disagree
- Somewhat agree
- Agree
- Strongly agree

Sleep pattern, mood and lifestyle

We ask some questions about your sleep pattern, mood, diet, use of alcohol and smoking, and lifestyle in the last 24 hours.

Q11 Last night, how would you rate your sleep quality overall?

- Very good
- Fairly good
- Fairly bad
- Very bad

Q12 How **happy** did you feel today?

- Not at all
- A little

- Moderately
- Quite a bit
- Extremely

Q13 How **excited** did you feel today?

- Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Q14 How **nervous** did you feel today?

- Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Q15 How **worried** did you feel today?

- Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Q16 How **sad** did you feel today?

- Not at all
- A little
- Moderately
- Quite a bit
- Extremely

Q16 How **lonely** did you feel today?

- Not at all

- A little
- Moderately
- Quite a bit
- Extremely

Q17 How many standard alcohol drinks did you consume today?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 or more

Q18 How many cigarettes did you smoke today?

▼ 0 ... 100

Q19 How many minutes did you do moderate or vigorous physical activities outside of work for at least 10 minutes at a time today?

▼ 0 ... 500

Q20 How many serves of vegetables did you consume today? *(one serving equals one of leafy green or raw salad vegetables)*

- I don't eat vegetables
- Less than one serve
- 1 serve
- 2 serves
- 3 serves
- 4 serves
- 5 serves
- 6 serves or more

Q21 How many servings of fruits did you consume today? *(one serving equals one half cup)*

- I don't eat fruits
- Less than one serve
- 1 serve
- 2 serves
- 3 serves
- 4 serves
- 5 serves
- 6 serves or more

Rotation work and Health: A daily diary (Partner)

This survey collects information about your daily experience and health. Thank you very much for taking part!

Please enter your given study ID (stated in the text message)

Sleep pattern and lifestyle

We ask some questions about your sleep pattern, mood, diet, use of alcohol and smoking, and lifestyle in the last 24 hours.

Q1 Is your partner.............today?

- ◯ away at work (on-shift)
- ◯ present at home (off-shift)

Q2 Last night (today), how would you rate your sleep quality overall?

- ◯ Very good
- ◯ Fairly good
- ◯ Fairly bad
- ◯ Very bad

Q3 How **happy** did you feel today?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

Q4 How **excited** did you feel today?

- ◯ Not at all
- ◯ A little
- ◯ Moderately
- ◯ Quite a bit
- ◯ Extremely

Q5 How **nervous** did you feel today?

○ Not at all

○ A little

○ Moderately

○ Quite a bit

○ Extremely

Q6 How **anxious** did you feel today?

○ Not at all

○ A little

○ Moderately

○ Quite a bit

○ Extremely

Q7 How **worried** did you today?

○ Not at all

○ A little

○ Moderately

○ Quite a bit

○ Extremely

Q8 How **sad** did you feel today?

○ Not at all

○ A little

○ Moderately

○ Quite a bit

○ Extremely

Q9 How **lonely** did you feel today?

○ Not at all

○ A little

○ Moderately

○ Quite a bit

○ Extremely

Q10 How many standard alcohol drinks did you consume today?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7 or more

Q11 How many cigarettes did you smoke today?

▼ 0 ... 100

Q12 How many minutes did you do vigorous or moderate physical activities outside of work for at least 10 minutes at a time today?

▼ 0 ... 500

Q13 How many serves of vegetables did you consume today? *(one serving equals one of leafy green or raw salad vegetables)*

- ◯ I don't eat vegetables
- ◯ Less than one serve
- ◯ 1 serve
- ◯ 2 serves
- ◯ 3 serves
- ◯ 4 serves
- ◯ 5 serves
- ◯ 6 serves or more

Q14 How many servings of fruits did you consume today? *(one serving equals one half cup)*

- ◯ I don't eat fruits
- ◯ Less than one serve
- ◯ 1 serve
- ◯ 2 serves

○ 3 serves

○ 4 serves

○ 5 serves

○ 6 serves or more

We would ask you set of questions that relate to your work demands and the available job support in the last 24 hour.Q15 Today, my workload was too heavy

○ Strongly disagree

○ Disagree

○ Somewhat disagree

○ Neither agree nor disagree

○ Somewhat agree

○ Agree

○ Strongly agree

Q16 Today, I did not have enough time to do things to the best of my ability

○ Strongly disagree

○ Disagree

○ Somewhat disagree

○ Neither agree nor disagree

○ Somewhat agree

○ Agree

○ Strongly agree

Q17 Today, my tasks were simple and uncomplicated

○ Strongly disagree

○ Disagree

○ Somewhat disagree

○ Neither agree nor disagree

○ Somewhat agree

○ Agree

- Strongly agree

Q18 Today, I had autonomy to decide on the order in which things are done

- Strongly disagree
- Disagree
- Somehow disagree
- Neither agree nor disagree
- Somehow agree
- Agree
- Strongly agree

Q19 Today, I had autonomy in making decisions on the task I did

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Q20 Today, I felt others were supportive

- Strongly disagree
- Disagree
- Somehow disagree
- Neither agree nor disagree
- Somehow agree
- Agree
- Strongly agree

Q21 Please write down your feelings and experiences over the day *(Include all that you would want us to know about your day as a FIFO partner, e.g., how FIFO lifestyle affects you, behaviour of your partner, available support, how you would want to be supported etc).*

____

Appendix E: Supplementary files in Chapter 4

Supplementary information S4. Differences between included and excluded study samples

Table S3. Differences between included and excluded study samples

Characteristics	Included sample (n=216)	Excluded sample (n=83)	p-value
Age (in years)	39.9±11.6	39.3±12.2	0.710
Sex			0.334
Male	143(66.2)	50(60.2)	
Female	73(33.8)	33(39.8)	
Ethnicity			0.658
Caucasian/White	183(84.7)	72(86.8)	
Other	33(15.3)	11(13.2)	
Marital status			0.999
Single/never married	43(19.9)	16(19.3)	
Married	93(43.1)	36(43.4)	
Divorced/separated/widowed	25(11.6)	10(12.1)	
De-facto/co-habiting/ other	55(25.5)	21(25.3)	
Educational status			0.850
Secondary education/A-Levels/O GCSE/O-level or equivalent	67(31.0)	21(31.3)	
Trade/Apprentice	45(20.8)	17(25.4)	
TAFE/College/Diploma	60(27.8)	16(23.9)	
University degree/Other	44(20.4)	13(19.4)	
FIFO role			0.694
Management	33(15.3)	8(11.9)	
Professional	27(12.5)	12(17.9)	
Maintenance/Technician	39(18.1)	13(19.4)	
Catering	10(4.6)	6(9.0)	
Production/Drilling/Construction	36(16.7)	9(13.4)	
Machinery operator and driver	35(16.2)	9(13.4)	
Labourer	9(4.2)	4(6.0)	
Administration/services/Other	27(12.5)	6(9.0)	
Shift pattern (n=283)			0.920
Rotation shift (mixture of day and night shifts)	121(56.0)	38(56.7)	
Regular shift/Other	95(44.0)	29(43.3)	
Shift length			0.688
<12 hrs	30(13.9)	12(18.2)	
12	129(59.7)	37(56.1)	
>12	57(26.4)	17(25.8)	

Supplementary Information S5. Differences in work productivity loss measures between the risk of health conditions

Table S4a. Mann-Whitney analysis of the differences in absenteeism for the risk of health conditions

Health conditions	Percent absenteeism due to health				
	High risk	Low risk	Excess	z	p-value
Poor sleep condition	2.07	1.04	1.03	-1.555	0.120
Risky alcohol use	1.75	1.68	0.07	0.015	0.988
Current Smoking	1.99	1.60	0.39	-1.510	0.131
Poor diet	1.77	0.07	1.70	-0.709	0.479
Weight problems	1.77	1.51	0.26	-0.348	0.728
Insufficient physical activity	2.73	1.32	1.41	-2.322	0.020
Poor physical health	4.23	1.46	2.77	-2.453	0.014
Psychological distress	3.08	1.01	2.07	-2.959	0.003

Table S4b. Mann-Whitney analysis of the differences in presenteeism for the risk of health conditions

Health conditions	Percent presenteeism due to health				
	High risk	Low risk	Excess	*z*	p-value
Poor sleep condition	4.64	2.40	2.24	-2.390	0.017
Risky alcohol use	4.12	3.70	0.42	-0.524	0.601
Current Smoking	5.70	3.18	2.52	-2.609	0.009
Poor diet	3.92	1.88	2.04	-1.011	0.312
Weight problems	4.02	3.32	0.70	-0.528	0.597
Insufficient physical activity	5.13	3.37	1.76	-1.910	0.056
Poor physical health	11.71	3.08	8.63	-5.000	<0.001
Psychological distress	7.01	2.26	4.75	-6.069	<0.001

Table S4c. Mann-Whitney analysis of the differences in total productivity loss for the risk of health conditions

Health conditions	Percent total productivity loss due to health				
	High risk	Low risk	Excess	*z*	p-value
Poor sleep condition	6.43	3.36	3.07	-2.220	0.026
Risky alcohol use	5.71	5.14	0.57	-0.877	0.380
Current Smoking	7.37	4.61	2.77	-2.183	0.029
Poor diet	5.47	1.94	3.53	-1.164	0.244
Weight problems	5.56	4.69	0.86	-0.421	0.674
Insufficient physical activity	7.52	4.54	2.98	-2.114	0.035
Poor physical health	15.11	4.40	10.71	-4.554	<0.001
Psychological distress	9.64	3.19	6.45	-5.432	<0.001

Supplementary Information S6. Differences in work productivity loss measures between multiple health risks

Table S5a: Kruskal-Wallis test of differences in work productivity loss measures between multiple health risk groups

	Multiple health risks	Productivity loss (%)	X^2(df)	*p*-value
Absenteeism			10.643(2)	0.005*
	Low	0.81		
	Medium	1.47		
	High	2.99		
Presenteeism			25.391(2)	<0.001*
	Low	1.82		
	Medium	3.02		
	High	7.45		
Total productivity loss			23.943(2)	<0.001*
	Low	2.57		
	Medium	4.32		
	High	10.03		

*significant at p<0.05

Table S5b: Dunn's test with Bonferroni adjustment nonparametric pairwise multiple comparisons of work productivity loss measures between multiple health risk groups

	Multiple health risks	Excess productivity loss (%)	*p*-value
Absenteeism			
	Medium vs low	0.66	0.711
	High vs low	2.18	0.005*
	High vs medium	1.52	0.007*
Presenteeism			
	Medium vs low	1.20	0.120
	High vs low	5.63	<0.001*
	High vs medium	4.43	<0.001*
Total productivity loss			
	Medium vs low	1.75	0.137
	High vs low	7.46	<0.001*
	High vs medium	5.71	<0.001*

*significant at p<0.05

Supplementary Information 7. Examining the health and work-related predictors of loss productivity measures

Table S6a. Health and work-related predictors of any absenteeism (based on logistic regression using the total study sample) and percent absenteeism (based on least squares regression limited to study sample with positive percent absenteeism)

Parameters	Logistic regression of any absenteeism (N=216)		Least square regression of percent absenteeism (n=44)	
	OR(95%CI)	p-value	β(95%CI)	p-value
Age in years				
<35	1		Ref	
35-44	0.58 (0.21, 1.61)	0.293	-0.41(-2.03, 1.21)	0.619
45-54	0.28(0.07, 1.20)	0.087	-0.88(-3.06, 1.30)	0.430
55+	0.09(0.01, 0.73)	0.024	1.14(-2.25, 4.53)	0.510
Sex				
Male	1		Ref	
Female	1.86(0.75, 4.65)	0.183	-0.98(-2.31, 0.35)	0.149
FIFO role				
Management	1		Ref	
Professional	1.05(0.21, 5.21)	0.951	2.09(-0.22, 4.40)	0.076
Maintenance/Technician	2.62(0.59, 11.54)	0.204	0.57(-1.78, 2.91)	0.637
Production/Drilling/Construction/Labourer	4.14(1.09, 15.74)	0.037	1.53(-0.63, 3.68)	0.165
Machinery operator and driver	4.29(1.00, 18.37)	0.050	1.21(-1.03, 3.44)	0.290
Catering/Other	1.59(0.20, 12.69)	0.661	2.31(-0.72, 5.34)	0.135
FIFO duration in years				
5	1		Ref	
5-9	0.79(0.28, 2.25)	0.661	0.03(-1.38, 1.45)	0.965
10+	0.37(0.12, 1.15)	0.085	1.88(-0.03, 3.79)	0.053
Shift pattern				
Regular shift	1		Ref	
Rotation shift/other	1.15(0.47, 2.82)	0.763	0.62(-0.78, 2.02)	0.388
Shift hours				
12 hrs	1		Ref	
12 hrs and more	1.78(0.43, 7.36)	0.424	1.11(-1.10, 3.33)	0.325
Consecutive days spent at work				
8	1		Ref	
8-14 days	0.67(0.23, 1.91)	0.452	-1.05(-2.48, 0.38)	0.149

15+ days	0.27(0.03, 2.76)	0.272	1.81(-1.49, 5.11)	0.283
Consecutive days spent at home				
8 days	1		Ref	
8-14 days	0.69(0.15, 3.26)	0.638	-1.29(-3.90, 1.31)	0.330
Poor sleep condition	1.68(0.52, 5.46)	0.387	-0.47(-2.08, 1.15)	0.571
Risky alcohol use	0.95(0.32, 2.80)	0.922	0.05(-1.48, 1.58)	0.1949
Smoking	0.71(0.21, 2.42)	0.588	-1.28(-3.02, 0.46)	0.149
Poor diet	3.80(0.31, 46.94)	0.298	2.22(-1.95, 6.40)	0.297
Weight problems	1.50(0.46, 4.93)	0.500	-2.48(-4.69, -0.26)	0.028
Insufficient physical activity	2.94(1.02, 8.48)	0.046	-0.57(-2.41, 1.26)	0.541
Poor physical health	8.25(1.88, 36.14)	0.005	0.49(-1.29, 2.27)	0.591
Psychological distress	1.76(0.55, 5.60)	0.340	-0.20(-1.69, 1.29)	0.790
-2 Log likelihood or regression *F* statistic	-82.914		F(26, 17)=0.90	
P value for -2 log-likelihood or regression *P* value	0.002		0.610	
Pseudo R^2 or adjusted R^2	0.241		-0.068	

Adjusted for age, sex and co-occurrence of multiple health risks

Table S6b. Health and work-related predictors of any presenteeism (based on logistic regression using the total study sample) and percent presenteeism (based on least squares regression limited to study sample with positive percent presenteeism)

Parameters	Logistic regression of any presenteeism (N=216)		Least square regression of percent presenteeism (n=116)	
	OR(95%CI)	p-value	β(95%CI)	p-value
Age in years				
<35	1		Ref	
35-44	0.81(0.36, 1.83)	0.610	-0.14(-0.49, 0.22)	0.451
45-54	1.03(0.36, 2.93)	0.959	-0.13(-0.55, 0.28)	0.532
55+	0.51(0.16, 1.58)	0.243	-0.02(-0.55, 0.51)	0.939
Sex				
Male	1		Ref	
Female	0.99(0.47, 2.11)	0.985	-0.01(-0.33, 0.31)	0.955
FIFO role				
Management	1		Ref	
Professional	1.81(0.62, 5.29)	0.280	0.17(-0.30, 0.65)	0.471
Maintenance/Technician	2.21(0.79, 6.19)	0.130	0.07(-0.37, 0.52)	0.745
Production/Drilling/Construction/Labourer	1.49(0.59, 3.78)	0.404	0.07(-0.34, 0.49)	0.725
Machinery operator and driver	1.74(0.60, 5.05)	0.312	0.21(-0.25, 0.68)	0.365
Catering/Other	1.69(0.44, 6.55)	0.447	0.13(-0.48, 0.73)	0.677
FIFO duration in years				
5	1		Ref	
5-9	0.87(0.37, 2.02)	0.744	-0.00(-0.35, 0.35)	0.996
10+	0.50(0.22, 1.18)	0.113	-0.13(-0.49, 0.23)	0.485
Shift pattern				
Regular shift	1		Ref	
Rotation shift/other	1.55(0.77, 3.12)	0.223	0.13(-0.15, 0.41)	0.357
Shift hours				
12 hrs	1		Ref	
12 hrs and more	1.20(0.42, 3.46)	0.733	0.10(-0.34, 0.55)	0.649
Consecutive days spent at work				
8	1		Ref	
8-14 days	1.43(0.60, 3.41)	0.414	-0.08(-0.46, 0.29)	0.665
15+ days	060(0.13, 2.74)	0.511	-0.19(-0.89, 0.51)	0.589

Consecutive days spent at home				
8 days	1		Ref	
8-14 days	1.29(0.48, 3.47)	0.613	-0.01(-0.44, 0.43)	0.966
Poor sleep condition	1.06(0.42, 2.67)	0.906	0.42(0.06, 0.78)	0.024
Risky alcohol use	1.12(0.47, 2.68)	0.801	0.24(-0.09, 0.57)	0.159
Smoking	1.23(0.48, 3.15)	0.672	0.13(-0.24, 0.49)	0.495
Poor diet	1.92(0.34, 10.92)	0.460	0.39(-0.49, 1.27)	0.385
Weight problems	0.97(0.39, 2.45)	0.954	0.30(-0.09, 0.70)	0.131
Insufficient physical activity	1.50(0.64, 3.48)	0.351	0.32(-0.02, 0.66)	0.062
Poor physical health	5.17(1.18, 22.54)*	0.029	0.82(0.38, 1.26)	<0.001
Psychological distress	4.14(1.55, 11.08)**	0.005	0.50(0.12, 0.87)	0.010
-2 Log likelihood or regression *F* statistic	-126.347		F(26, 89)=1.99	
P value for -2 log-likelihood or regression P value	0.010		0.001	
Pseudo R^2 /adjusted R^2	0.153		0.184	

Adjusted for age, sex and co-occurrence of multiple health risks

Table S6c. Health and work-related predictors of any total productivity loss (based on logistic regression using the total study sample) and percent total productivity loss (based on least squares regression limited to study sample with positive total productivity loss)

Parameters	Logistic regression of any total productivity loss (N=216)		Least square regression of percent total productivity loss (n=121)	
	OR(95%CI)	p-value	β(95%CI)	p-value
Age in years				
<35	1		Ref	
35-44	0.60(0.26, 1.38)	0.230	-0.03(-0.46, 0.41)	0.909
45-54	0.73(0.25, 2.08)	0.553	-0.14(-0.66, -0.38)	0.602
55+	0.38(0.12, 1.17)	0.092	-0.02(-0.69, 0.65)	0.952
Sex				
Male	1			
Female	1.03(0.48, 2.20)	0.943	-0.03(-0.43, 0.36)	0.879
FIFO role				
Management	1		Ref	
Professional	1.50(0.51, 4.41)	0.458	0.36(-0.22, 0.95)	0.226
Maintenance/Technician	2.00(0.71, 5.58)	0.188	0.30(-0.25, 0.85)	0.287
Production/Drilling/Construction/Labourer	1.75(0.69, 4.42)	0.239	0.24(-0.26, 0.75)	0.348
Machinery operator and driver	2.25(0.76, 6.59)	0.142	0.29(-0.27, 0.85)	0.314
Catering/Other	1.70(0.43, 6.67)	0.445	0.16(-0.59, 0.91)	0.677
FIFO duration in years				
5	1		Ref	
5-9	0.93(0.40, 2.18)	0.872	-0.27(-0.69, 0.16)	0.217
10+	0.48(0.21, 1.12)	0.091	-0.30(-0.75, 0.15)	0.195
Shift pattern				
Regular shift	1		Ref	
Rotation shift/other	1.41(0.70, 2.85)	0.334	0.19(-0.15, 0.53)	0.274
Shift hours				
12 hrs	1		Ref	
12 hrs and more	1.40(0.48, 4.06)	0.535	0.14(-0.41, 0.70)	0.616
Consecutive days spent at work				
8	1		Ref	
8-14 days	1.38(0.58, 3.29)	0.471	-0.22(-0.68, 0.24)	0.357
15+ days	0.65(0.15, 2.89)	0.574	-0.20(-1.05, 0.65)	0.643
Consecutive days spent at home				

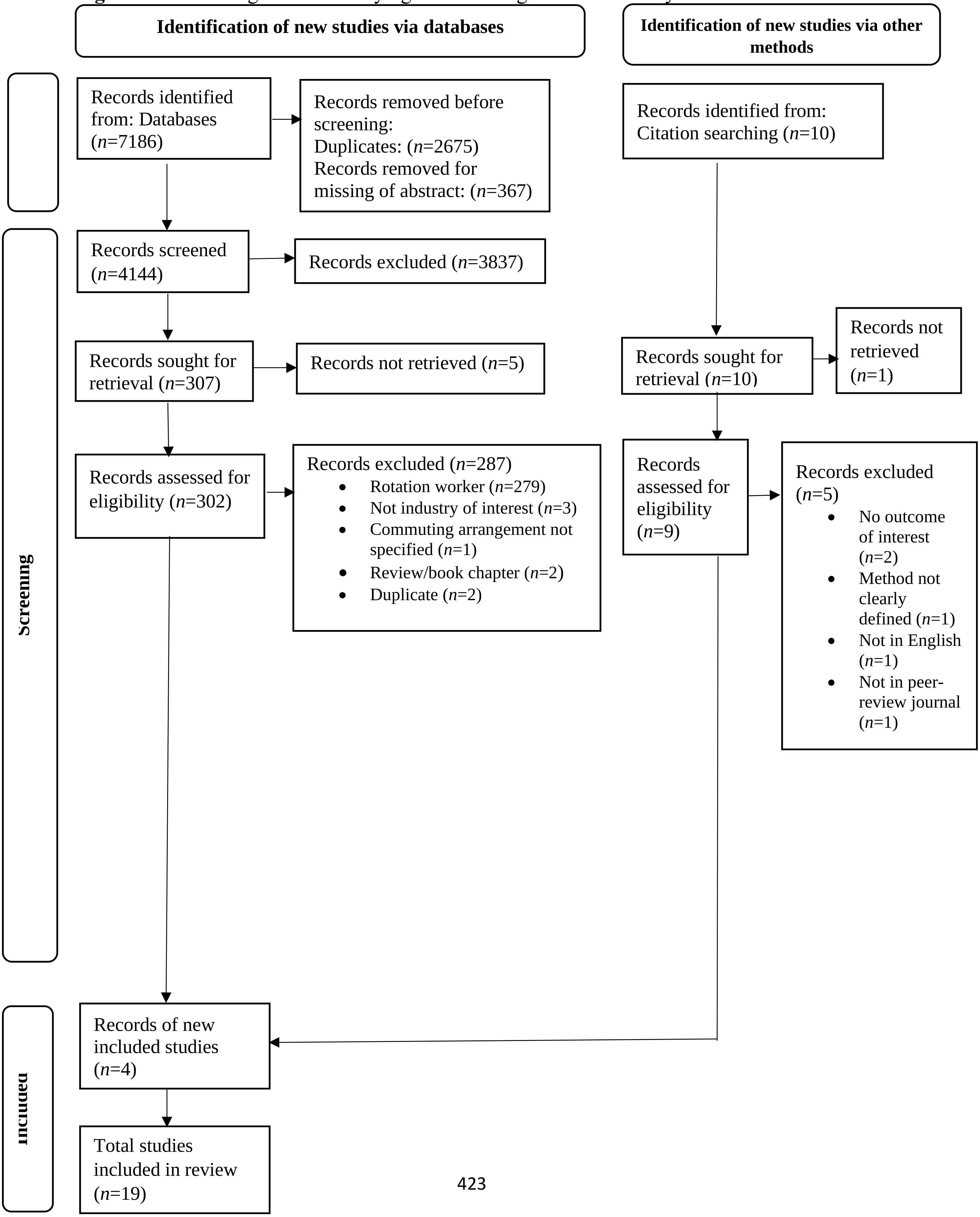
8 days	1		Ref	
8-14 days	1.31(0.49, 3.52)	0.589	-0.06(-0.60, 0.48)	0.834
Poor sleep condition	1.06(0.42, 2.69)	0.897	0.41(-0.05, 0.87)	0.080
Risky alcohol use	1.03(0.43, 2.48)	0.945	0.27(-0.14, 0.69)	0.199
Smoking	0.85(0.33, 2.20)	0.737	0.13(-0.32, 0.58)	0.576
Poor diet	2.19(0.40, 12.13)	0.370	0.64(-0.48, 1.75)	0.262
Weight problems	0.90(0.36, 2.26)	0.820	0.24(-0.25, 0.74)	0.337
Insufficient physical activity	1.34(0.57, 3.13)	0.501	0.46(0.04, 0.89)	0.034
Poor physical health	4.02(0.94, 17.20)	0.061	0.87(0.32, 1.43)	0.002
Psychological distress	2.85(1.07, 7.57)	0.035	0.54(0.08, 1.00)	0.021
-2 Log likelihood or regression *F* statistic	-126.048		F(26, 94)=1.62	
P value for -2 log-likelihood or regression P value	0.014		0.049	
Pseudo R^2 or adjusted R^2	0.149		0.118	

Adjusted for age, sex and co-occurrence of multiple health risks

Appendix F: Supplementary files in Chapter 5

Supplementary information S8. Flow diagram of included studies

Figure S2. Flow diagram of identifying and selecting studies for the systematic review



Supplementary Information S9. Summary findings from included studies

Table S7. Summary of studies characteristics and quantitative findings for partners

Author (methodological quality)	Funding source	Study design	Aim/objective	Study population/ setting and industry	Health outcomes/ Phenomenon	Measurements/analysis plan	Summary of findings	Take away message
Cooke *et al.,* 2018(131) (High)	None Declared	Cross-sectional survey	To compare the levels of stress experienced by pregnant women whose partners FIFO and whose partners did not work away.	394 families in a pregnancy cohort; 77 FIFO families; 100% female; mean age 29.79±5.10yrs Country: Australia Industry: General FIFO	Depression, anxiety and stress; Alcohol	Beck Depression Inventory II BDI; Spielberger State-Trait Anxiety Inventory STAI; Perceived Stress Scale; List of Threatening Experiences checklist. Analysis plan: ANOVA	No difference between women with FIFO partners and women with non-FIFO partners (regular and irregular schedules) for depression (8.41±4.64 vs 7.37±4.33 & 8.09±4.57; p=0.169), anxiety (35.55±11.04 vs 34.79±10.17 & 36.08±10.59; p=0.955), perceived stress (23.13±8.64 vs 21.10±7.27 & 22.10±8.00; p=0.137), and alcohol/drug problems (11% vs 6% & 12%; p=0.188). Women's perceived stress was high when partners worked FIFO (β=-1.944; 95%CI=-3.51, -0.38, p=0.015).	Partners of rotation work showed similar levels of depression, anxiety and stress and alcohol use as partners of non-rotation workers.
Dittman *et al.,* 2016(132) (High)	University/research institution	Cross-sectional survey	To examine the impact of Fly-In/Fly-Out (FIFO), on children and families	232 FIFO partners & 294 non-FIFO partners; mean age 36.32±6.13 years. Country: Australia; Industry: General FIFO	Depression, Anxiety, stress; Alcohol	DASS-21; Alcohol AUDIT; Analysis plan: ANCOVA; Pearson's correlations and Hierarchical multiple	Depression (3.63±4.57 vs 2.48±3.67; p<0.001), anxiety (2.00±3.12 vs 1.37±2.35; p<0.01), stress (5.69±4.90 vs 4.52±4.03; p<0.01), and worries about partner's well-being (2.45±2.12 vs 1.81±1.92; p<0.001) higher in FIFO partners than non-FIFO partners. No difference in alcohol use between FIFO partners and non-FIFO partners.	Partners of rotation work showed higher levels of depression, anxiety and stress than partners of non-rotation work, but alcohol use was similar in both groups.

Lester *et al.*, 2015(33) (Medium)	Western Australian Health Promotion Foundation (Healthway)	Mixed method study (Cross-sectional study)	To explore the parenting patterns of families exposed to the fly-in–fly-out (FIFO) work pattern in raising adolescent children,	23 at-home parents with FIFO partners, and 23 FIFO workers; Aged 30 years and over. Country: Australia; Industry: General FIFO	Mental health	assessed by K10 assessed partner's mental health; Analysis plan: Kruskall–Wallis non-parametric tests	More FIFO partners (32%) had very high levels of psychological distress than the general population (2.6%). FIFO partners' psychological distress was not related to the FIFO work roster (p=0.093).	Partners showed high levels of psychological distress.
Morrice *et al.*, 1985a(303) (Low)	Social Science Research Council	Mixed method study (Cross-sectional study)	To examine the prevalence of Intermittent Husband Syndrome	200 offshore wives and 103 on-shore wives; mean age 31.7 yrs. Setting: UK Industry: offshore oil and gas	General health; Anxiety, depression and intermittent husband syndrome	General Household Survey (GHS) Symptom lists and Zuckerman Adjective Checklist. Analysis plan: NR	Partners self-reported general health was good and similar to onshore wives and the general population. Anxiety and depression were higher when the husbands are absent (10 cases) than present (2 cases); 10% presented with ''Intermittent Husband Syndrome'' characterized by a change in mood and behaviours	Partners show good general health status but showed high cases of anxiety/depression in the absence of workers
Parkes *et al.*, 2005a(305) (Medium)	UK Health and Safety Executive	Mixed method study (Cross-sectional survey)	To explore spouses' perceptions of offshore lifestyles	245 respondents; aged 22 to 59 yrs. Setting: UK; Industry: offshore oil and gas	Psychological well-being	Self-develop questionnaire. Analysis plan: descriptive statistics (t-test)	Large proportion of partners (58.5%) reported problems including concerns/worries about workers' safety (84.4%), loneliness (66.4%), difficulties adjusting to intermittent absence (58.9%), and coping with domestic emergencies (57.4%).	A large proportion of partners have high levels of anxiety, loneliness and difficulties adopting/coping with the absence of workers.

Rebar *et al.,* 2018(13) (High)	LIVIN Australia	Longitudinal diary study	To compare health behaviours between on-shift and off-shift periods	42 FIFO partners; mean age 38.58±9.22 years Country: Australia; Industry: General FIFO	Health behaviours and well-being (sleep and nutrition quality, alcohol intake, smoking, physical activity and relaxation time, and medication for physical and mental problems)	Self-developed online diary for 7 consecutive days each on- and off-shift. Analysis plan: Multilevel models	Partners tended to have poorer nutrition (γ=−0.17 (−0.33 to −0.02), sleep quality (γ=−0.56; 95%CI=−0.72 to −0.40), less exercise time (γ=−10.78; 95%CI=−0.36 to −0.00) and less relaxation time (γ=−1.22; 95%CI=−1.87 to −0.61) during on-shift days than off-shift days. Partners drank significantly less alcohol than workers (γ=−0.91; 95%CI=−1.50 to −0.26) and drink less alcohol during on-shift than off-shift days (γ=−1.12; 95%CI=−1.48 to −0.76). Partners smoke significantly more during on-shift than off-shift days (γ=24.20; 95%CI=0.86 to 45.88). Medication use for mental and physical health impairments was not common, but partners took more physical health medication during on-shift days than off-shift days (γ=1.44; 95%CI=0.36 to 2.54).	Partners show poorer nutrition and sleep quality, less exercise and relaxation time, and smoked more in the absence of workers; but drink more in the presence of workers.
Taylor *et al.,* 1985(304) (Low)	Social Science Research Council	Cross-sectional survey	To examine the psycho-social effects on wives of their husbands' intermittent absence on offshore oil rigs	200 wives of offshore oil workers; mean age 31.7 years. Country: UK; industry: offshore oil and gas	Anxiety and depression; Perceived health status, perceived sleep pattern	The Zuckerman Adjective Checklist, General Household survey checklist. Analysis plan: Not reported	Self-reported health status was good (61%) and similar to onshore wives (59%) and the general population. Similar proportions of offshore wives and wives in the general population (18% vs 16%) reported nervy, tense and depressed symptoms. Higher anxiety 'caseness' in offshore wives when partners are away (10 cases) than in onshore wives (0 cases). High stress in offshore wives was associated with being married for less than 5 years ($p<0.05$), wife working outside the home ($p<0.01$), having no	Partners' general health status was good but showed high cases of anxiety in the absence of the workers.

							previous experience of husband absence ($p<0.05$), having at least one preschool child ($p<0.05$) and irregular work pattern of husband ($p<0.05$).	
Wilson *et al.,* 2020(34) (High)	None Declared	Cross-sectional survey	To describe and compare partners' sleep problems and loneliness when the FIFO/DIDO workers were at home and away	199 partners of the FIFO/DIDO Workers; 74.9% aged 18-44yrs; Country: Australia; Industry: mining	Sleepiness, sleep duration and quality, and loneliness	The Epworth Sleepiness Scale; The Pittsburgh Sleep Quality Index (PSQI) (score>5= poor sleep quality); UCLA Loneliness Scale. Analysis plan: Repeated-measures ANCOVA	Sleep quality was poorer when the worker is away than present at home (8.8 ± 3.1 vs 7.8 ± 3.3; $p=0.001$). No difference in partners' sleep duration ($m=7.2\pm1.5$ vs 6.9 ± 1.6; $p=0.486$) and sleepiness ($m=15\pm4.1$ vs 15.4 ± 4.6; $p=0.960$) when workers are at home than when workers are away. High loneliness when workers are away than at home ($m=27.9\pm6.4$ vs 22.2 ± 6.2; $p<0.001$). Short sleep duration, poor sleep quality, excessive sleepiness and extreme loneliness in FIFO partners than the general population.	Partners showed shorter sleep duration, poorer sleep quality, excessive sleepiness and extreme loneliness in FIFO partners than the general population whether the workers are present at home or away

Table S8. Summary of studies characteristics and qualitative findings for partners

Author (methodological quality)	Funding source	Study design	Aim/objective	Study population/ setting and industry	Health outcomes/ Phenomenon	Measurements/analysis plan	Summary of findings	Take away message
Gardner *et al.*, 2018(15) (High)	LIVIN (Australia)	Qualitative study	To investigate how workers and their partners negotiate the impact of fly-in fly-out (FIFO) on their mental health and well-being	26 conveniently selected partners of FIFO workers; mean age 40±9 yrs; Country: Australia Industry: General FIFO	Mental health and well-being	Open-ended questions via email. Analysis plan: Thematic analysis	FIFO work imposes the sense of living two lives, which comes with the difficulties of adjusting to the differences and pace of the domestic and work lives, and creates tension and frustrations; Some partners indicated being trapped in an undesired job by high wages. Partners reported worries about sole parenting and the absence of FIFO workers on the well-being of children; FIFO puts strain on relationships due to physical and psychological distance leading to disconnect and tension; Partners feel emotional strains and worried about workers' physical and mental health	Rotation work impact was generally described as having a negative impact on the psychological well-being of at-home partners
Mayes, 2020(302) (Medium)	None declared	Qualitative study	To examine how FIFO workers' rhythms of physical absence and presence in family life shape the everyday mobilities and temporalities of their emplaced spouses	20 women FIFO partners; aged 22-59 years. Country: Australia. Industry: mining	Psychological well-being	In-depth, semi-structured interviews	Partners experience "living two separate lifestyles" with disruption to routine life leading to recurrent tension. Increase the burden of sole parenting in the absence of workers, limiting the social mobility of partners with young children. Some partners experience weekends in the absence of workers as 'depressing' and 'lonely' and tended to social isolate by avoiding places (e.g. parks, homes of non-FIFO families). Some partners without children get free time to socialise with others in the absence of the workers.	Partners show a negative impact of rotation work on their psychological well-being
Morrice *et al.*, 1985b(303) (Low)	Social Science Research	Mixed method study	To explore the nature of the stresses and the	30 wives and 17 Husband; Country: UK	Intermittent Husband Syndrome	Extensive interview. Analysis plan: Thematic analysis	Some wives have adapted successfully to their husband absence lifestyle and found it a preferable way of life; take advantage	Partners show a mixed impact of

	Council	(Qualitative study)	adaptation in Intermittent Husband Syndrome	Industry: offshore oil and gas			of their husband's absences to increase their competence and to enlarge their network of relationships. Other partners experienced distress and felt miserable; Partners reported feeling loneliness when their husband is away; overburdened by single parenting and domestic chores; intermittent readaptation to home life by workers brings tension and domestic conflict; experience worries/anxiety before husband leaves for work tour; disruption of family life as partners feel neglected and separated from husband when at home	rotation work on their psychological well-being
Parkes, 2005b(305) (Medium)	UK Health and Safety Executive	Mixed method study (Qualitative study)	To examine the perceptions, attitudes, and concerns of the spouses of offshore workers	39 telephone interviews; aged 22 to 59 yrs. Country: UK; Industry: offshore oil and gas	Psychological well-being	Telephone interview, and self-reported measure. Thematic analysis	Difficulties adjusting to the lifestyle of presence and absence of workers (''living two lives'') characterised by irritation and tension; intermittent absence and presence lead to role conflicts and disruption to 'single life' leading to tension and irritation; experience of anxiety and tension prior to worker leaving home (stressfulness caused by a sense of worker leaving home for work); experience loneliness and anxiety associated with bringing up children alone. Partners develop greater independence, personal confidence, and coping ability; becoming self-reliant in the absence of workers.	Partners show a mixed impact of rotation on their psychological well-being.

Pini & Mayers, 2012(306) (Medium)	None declared	Qualitative study	To explore the emotional life of fly-in fly-out (FIFO) workers and their families	513 posts on *Mining Families Matters* website from February 2010 to December 2011; Age: NR Country: Australia Industry: General FIFO	Psychological well-being	Posts on Mining Families Matters website. Analysis plan: Thematic analysis	Feeling 'independent, resourceful, strong and sometimes unemotional' by long/experienced FIFO partners. FIFO provides the chance to make new friends and increase social networks. Some partners experienced emotions of sadness, 'loneliness and despair'. Emotional experiences of 'loss, loneliness and uncertainty' was linked to having younger children and being new to the FIFO lifestyle. Tensions between women's expression of pride in their emotional strength and the need to temper this capacity when FIFO men returned home. Anxiety about becoming 'too independent' among new FIFO partners	Partners showed a mixed impact of rotation on their psychological well-being
Silva-Segovia & Salinas-Meruane, 2016(301) (High)	Comisión nacional de investigación Científica y Tecnológica; Fondecyt projects	Qualitative study	To explore the emotional adjustments and imbalances experienced by female partners of Chilean mining workers	Six women between the ages of 30 and 56, with 1–4 children. Country: Chile Industry: Mining	Emotional adjustments and imbalances	In-depth interview. Analysis plan: Thematic analysis with Critical Discourse Analysis	Family modify daily routines to suit worker's routine of working, resting or recreational times, creating tension and feelings of frustration, resentment, and unsatisfied demands in the family. Partners experience tension caused by suspicion of infidelity and disruption to sexual intimacy	Partners experienced a negative impact of rotation on their emotional well-being
Whalen & Schmidt, 2016(307) (High)	None declared	Qualitative study	To explore the lived experiences of women whose partners commute to the Alberta oil sands for work	8 partners of LDC workers; age 37-50yrs; Country: Canada; Industry: mining/petroleum	Psychological well-being;	Interviews; Analysis plan: Thematic analysis	Partners reported increased workload of looking after children and working outside of home, feelings of loneliness and loss of companionship in the absence of workers; some partners expressed nervousness about workers' job security; some partners develop a sense of control and empowerment regarding family decision-making. Some partners indicated the sense of high financial rewards helped them cope with rough patches in the absence of workers.	Partners and children experienced a mixed impact of rotation work on their psychological well-being

Table S9. Summary of studies characteristics and quantitative findings for children

Author (methodological quality)	Funding source	Study design	Aim/objective	Study population/ setting and industry	Health outcomes/ Phenomenon	Measurements/analysis plan	Summary of findings	Take away message
Dittman *et al.,* 2016(132) (High)	University/ research institution	Cross-sectional survey	To examine the impact of Fly-In/Fly-Out (FIFO), on children and families	232 FIFO partners & 294 non-FIFO partners; mean age 36.32±6.13 years. Country: Australia; Industry: General FIFO	Children's behaviour and Emotional difficulties	Child Adjustment and Parent Efficacy Scale (CAPES) Analysis plan: ANCOVA; Pearson's correlations and Hierarchical multiple	No difference in behavioural (19.83±11.84 vs 18.36±9.88) and emotional (3.25±2.60 vs 2.87±2.61) difficulties between children in FIFO families and children in non-FIFO families (p>0.05). Poor parental emotional adjustment (β=0.22; p<0.01), lower weekly work hours (β=-0.16; p<0.01) and perceived rotation work lifestyle negative impact on family (β=0.18; p<0.01) predicted children's behaviour problems in FIFO families. Poor parental emotional adjustment (β=0.19; p<0.001) and perceived rotation work lifestyle negative impact on family (β=0.34; p<0.01) predicted emotional problems	Children of rotation work showed similar levels of behaviour and emotional difficulties as children in non-FIFO families. Parent worker's long working hours and poor emotional adjustment were associated with children's emotions and behaviours
Kaczmarek & Sibbel, 2008(275) (High)	None declared	Cross-sectional survey	To examine the effects of employment-related father absence on children's psychological well-being and perceptions of family functioning	90 primary school-aged children and their mothers (30 FIFO children & mothers; mean age 10.16±1.29 years. Country: Australia; Industry: General FIFO	Depression; Anxiety	Children's Depression Inventory (CDI); Children's Manifest Anxiety Scale (RCMAS). Analysis plan: ANOVA	No difference between children of FIFO families and children from non-FIFO families for depression [M=7.60±5.60 vs 5.00±3.66; F(2,81)=03.68, p=0.02], anxiety [M=11.00±6.77 vs 8.12±6.07; F(2,81)=.76, p=0.18] and general functioning [M=1.87±0.42 vs 1.82±0.38; F(2,81)=0.91, p=0.41]; were within the healthy functioning limits.	Children of rotation work showed healthy levels of depression, anxiety and general functioning similar to children of non-rotation workers.

Lester *et al.*, 2015(33) (Medium)	Western Australian Health Promotion Foundation (Healthwa y)	Mixed method study (Cross-sectional study)	To explore the parenting patterns of families exposed to the fly-in–fly-out (FIFO) work pattern in raising adolescent children,	41 adolescent children of FIFO parents; Age: 0-24; Country: Australia; Industry: General FIFO	Mental health	Strengths and Difficulties Questionnaire (SDQ) to assess adolescent mental health. Analysis plan: Kruskall–Wallis non-parametric tests	Few adolescents from FIFO homes (2%) showed mental health concerns, compared to Australian norms (10%). Adolescent mental health was not related to FIFO parent's work roster ($p=0.507$). 73% of adolescents reported no emotional difficulties	Adolescent children showed low levels of mental health and emotional difficulties
Lester *et al.*, 2016(308) (High)	None declared	Cross-sectional study	To explore the mediation of parental presence and family connectedness on the association between fly-in fly-out employment and adolescent well-being	618 students; Age: NR; Country: Australia Industry: General FIFO	Depression; Emotional and Behavioural difficulties	DASS-21; Strengths and Difficulties Questionnaire (SDQ). Analysis plan: Multilevel mediation	More adolescents of FIFO parents reported significantly mild (7.4% vs 6.2%), moderate (9.1% vs 6.9%) and severe (3.0% vs 2.8%) depressive symptoms ($p=0.02$) and emotional and behavioural difficulties (9.6% vs 7.5%; $p=0.02$) compared to adolescent from non-FIFO families. Greater parental presence predicted lower depressive symptoms ($\beta=-0.16$; $p<0.01$) and emotional and behavioural problems ($\beta=-0.17$; $p<0.01$). Greater family connectedness predicted lower depressive symptoms ($\beta=-0.11$; $p<0.01$) and emotional and behavioural problems ($\beta=-0.11$; $p<0.01$)	Adolescent children of rotation workers had higher levels of depressive symptoms and emotional and behavioural difficulties than children of non-rotation workers.

Robinson *et al.,* 2017(312) (Low)	None declared	Cross-sectional survey	To examine the relationships between the working arrangements of mineworkers and behavioural issues in their children	1961 partners and 1798 mineworkers Age: NR Country: Australia Industry: Mining	Child's emotions and behaviours	SDQ assessed parent perception of child's emotions and behaviours. Analysis plan: Pearson correlation	Parents working excessive hours related to hyperactivity behaviour (r=0.108; p<0.001), emotional (r=0.128; p<0.001), conduct (r=0.108; p<0.01) and peer problems (r=0.090; p<0.001). Parental emotional exhaustion was related to hyperactivity behaviour (r=0.109; p<0.001), emotional (r=0.174; p<0.001), conduct (r=0.116; p<0.01) and peer problems (r=0.158; p<0.001). Parental tiredness associated with hyperactivity behaviour (r=0.115; p<0.001), emotional (r=0.141; p<0.001), conduct (r=0.080; p<0.01) and peer problems (r=0.106; p<0.001). Parental sleep disruption associated with emotional (r=-0.147; p<0.01), conduct (r=-0.079; p<0.05) and peer problems (r=-0.080; p<0.05).	Parent workers' long working hours, emotional exhaustion, and sleep disruption were associated with children's emotions and behaviours. However, all associations were small in size.
Zargham-Boroujeni *et al.,* 2015(311) (High)	None declared	Cross-sectional survey	To assess anxiety in children of offshore staff	160 students (64 offshore staff's children; mean age 9.83±0.16yrs. Country: Iran; Industry: offshore oil and gas	Anxiety	Revised Children's Manifest Anxiety Inventory. Analysis plan: t-test and logistic regression tests	Offshore staff's children significantly experienced anxiety (56.2%) than based staff's children (32.3%) (p=0.03). Parents working offshore increased children's anxiety by 2 times (AOR=2.140; 95%CI=1.001-4.576, p=0.049)	Children of rotation workers show higher anxiety than children of non-rotation workers

NR=not reported

Table S10. Summary of studies characteristics and qualitative findings for children

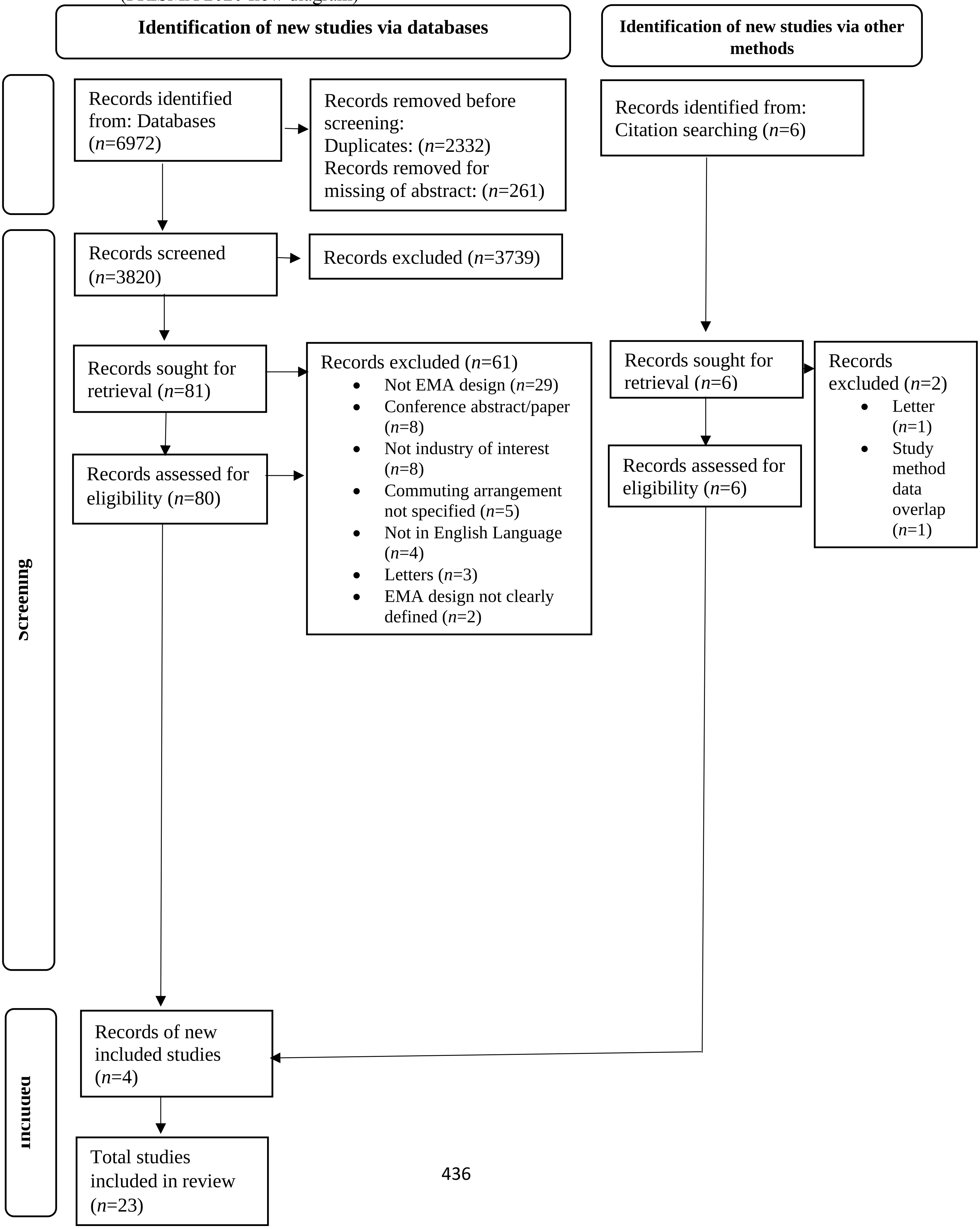
Author (methodological quality)	Funding source	Study design	Aim/objective	Study population/ setting and industry	Health outcomes/ Phenomenon	Measurements/analysis plan	Summary of findings	Take away message
Macbeth *et al.,* 2012(309) (High)	None declared	Qualitative study	To understand the lived experiences of adolescent boys whose fathers were currently employed in a FIFO	8 adolescent males, aged 13 to 21 years Country: Australia Industry: General FIFO	Psychological Well-being	Semi-structured interviews. Thematic analysis	FIFO provide high financial benefits and enough free days to spend and socialised with Dad during the leave period. Adolescents expressed feeling relaxed and less stressed when dad is away as they have the freedom and can have friends come over	Rotation work impact was generally positive on the psychological well-being of adolescent males
Mauthner *et al.,* 2000(310) (Medium)	Economic and Social Research Council	Qualitative study	To explore children's accounts of parental work and the work± family interface	33 children (10 from offshore families & 23 onshore families); aged 8-12 yrs; 22 girls. Country: UK Industry: oil and gas	Children's behaviour and emotions	Focus group discussion; Thematic analysis	Children reported getting annoyed seeing their mothers do their father's house chores and also getting upset by their father missing special family events and feeling hurt by their parent's absence. Some children worry/are anxious about the safety of their father when away at work. Children sometimes feel happy being able to avoid parents taking out their frustration on them or punishment in the absence of their fathers. Offshore children reported seeing their fathers more (during leave days) than onshore office workers' children, but miss their fathers when away at work and would want to see them more often	Children show mixed psychological well-being, and behaviour and emotions
Parkes, 2005b(305) (Medium)	UK Health and Safety Executive	Mixed method study (Qualitative study)	To examine the perceptions, attitudes, and concerns of the spouses of offshore workers	39 telephone interviews; aged 22 to 59 yrs. Country: UK; Industry: offshore oil and gas	Psychological well-being	Telephone interview, and self-reported measure. Thematic analysis	Children get to spend enough time with their parents during leave periods. Some children become independent and resilient whereas some develop emotional strain and rejection behaviour toward workers (missing parent and feeling upset by the absence of parent)	Rotation work showed a mixed impact on the behaviour and emotions of children

Whalen & Schmidt, 2016(307) (High)	None declared	Qualitative study	To explore the lived experiences of women whose partners commute to the Alberta oil sands for work	8 partners of LDC workers; age 37-50yrs; Country: Canada; Industry: mining/petroleum	Children's behaviour and emotional	Interviews; Analysis plan: Thematic analysis	Partners reported children exhibit no severe behavioural or emotional issues, but children experience sadness and loneliness at the beginning of their father's commuting job	Children experienced a mixed impact of rotation work on their psychological well-being

Appendix G: Supplementary files in Chapter 7

Supplementary Information S10. Flow diagram of included studies

Figure S3: Flow diagram of identifying and selecting studies for the systematic review (PRISMA 2020 flow diagram)



Supplementary Information S11. Summary of findings from included studies

Table S11. Characteristics of EMA studies on health and related behavioural outcomes/predictors in rotation workers

Author and Year	Setting and country	Sample size	Analytical sample	Age; mean(SD)	Study type	Outcomes	Predictors
Albrecht and Anglim, 2018 (51)	Construction Australia	79	52	NR	Observational	Emotional exhaustion, engagement	Workload, emotional demand, social support, job autonomy
Bhuanantanondh et al., 2021(353)	Oil and gas Thailand	38	38	36.1(7.8)	Observational	Fatigue, sleep duration (hours)	Start and end of shift; day (day and night shift)
Bjorvatn et al., 1998 (357)	Offshore oil and gas Norway	7	6	38.9	Observational	Sleepiness; Sleep patterns	Day, work phase (on-shift and off-shift)
Bjorvatn et al., 1999 (354)	Offshore oil and gas Norway	7	6	38.9	Interventional	Sleepiness; Sleep patterns	Light, day, work phase (on-shift and off-shift)
Bjorvatn et al., 2007(355)	Offshore oil and gas; Norway	38	17	42	Interventional	Sleepiness; sleep patterns	Light, melatonin, day
Ferguson et al., 2010(53)	Mining Australia	42	29	37.4(6.8)	Observational	Sleep duration and fatigue	Shift type (day, night, day off)
Ferguson et al., 2011(165)	Mining Australia	111	35	40.3(10)	Observational	Fatigue, sleep	Fatigue: roster type, test time and sleep
Haward et al., 2009(144)	Offshore oil and gas UK	47	37	41.5(6.7)	Observational	Sleep problems (sleep quality, sleepy feeling, not enough sleep), tiredness, motion sickness symptoms (depression, anxiety, headache, dizziness, aches and pains, vomiting)	Motions (x-,y-,z-axes direction) of platform

Table S11. Characteristics of EMA studies on health and related behavioural outcomes/predictors in rotation workers (cont'd)

Author and Year	Setting and country	Sample size	Analytical sample	Age; mean(SD)	Study type	Outcomes	Predictors
Merkus et al., 2015(146)	Offshore oil and gas Norway	104	61	41.5(7.2)	Observational	Sleep quality, feeling rested, physical tiredness, mental tiredness, energy for activities	Shift type (day, night and swing shifts)
Merkus et al., 2015(356)	Offshore oil and gas Norway	52	29	43.5(9.8)	Observational	Smoking, Alcohol	Shift type (day and night shifts)
Merkus et al., 2017(139)	Offshore oil and gas Norway	104	61	41.5(7.2)	Observational	Leisure time physical activity	Shift type (day, night and swing shifts)
Muller et al., 2008(98)	Mining Australia	52	48	37	Observational	Fatigue, sleep duration and quality, and alcohol intake	*Fatigue*: sleep duration, alcohol consumption, shift type (day 7-night shift)
Ots et al., 2021(344)	Offshore oil and gas Netherlands	50	36	44.3(11.1)	Observational	Physical activity, sleepiness	Roster phase (pre-, offshore and post-offshore phases). Sleepiness: PA, sleep quality
Paech et al., 2010(52)	Mining Australia	111	51	40.3(10)	Observational	Sleep (total sleep time and sleep quality)	Roster, shift type (day and night, off days))
Rebar et al., 2018(13)	General FIFO Australia	64	64	40.39(10.34)	Observational	Sleep quality, exercise, nutrition quality, relaxation, alcohol intake, smoking, mental and physical impairments	Work phase (days on vs days off)

Table S11. Characteristics of EMA studies on health and related behavioural outcomes/predictors in rotation workers (cont'd)

Author and Year	Setting and country	Sample size	Analytical sample	Age; mean(SD)	Study type	Outcomes	Predictors
Riethmeister et al., 2018(85)	Offshore oil and gas Netherlands	60	42	42(12.1)	Observational	Sleep quality and sleepiness	Work phase (days on vs days off)
Riethmeister et al., 2018(86)	Offshore oil and gas Netherlands	60	42	42(12.1)	Observational	Fatigue (sleepiness), time in bed (sleep quality)	Time (pre-and post-shift)
Riethmeister et al., 2019(87)	Offshore oil and gas Netherlands	60	42	43.4(11.8)	Observational	Fatigue (Sleepiness), sleep duration and loss	Time (pre-and post-shift), days
Sadeghniiat-Haghighi et al., 2019(140)	Offshore oil and gas Iran	42	42	35.9(7.9)	Observational	Sleep duration and quality	Time (first week vs second week of a 2-week work period), shift type (fixed day, fixed night, swing: 7d/7n, standby
Saksvik et al., 2011(141)	Offshore oil and gas Norway	28	19	44.4(8.6)	Observational	Sleep (sleep duration, efficiency, and quality)	Shift type (day shift, night shift, and swing shift), day
Thorne et al., 2008(142)	Offshore oil and gas UK	17	16	43.5(11.0)	Observational	Sleep duration and quality	Night shift start time (18:00–06:00 h and 19:00–07:00 h)
Thorne et al., 2010(143)	Offshore oil and gas UK	14	10	47.5(9.0)	Interventional	Sleep duration and quality	Night shift start time (18:00–06:00 h and 19:00–07:00 h)
Waage et al., 2012(156)	Offshore oil and gas Norway	28	15	44	Observational	Sleepiness	Shift type (day shift, night shift, and swing shift), day, time

Table S12. Methodological characteristics of the EMA studies on health and related behavioural outcomes in rotation workers

Author and Year	EMA design/ approach	Method for EMAs delivery	*Monitoring periods; *Study duration/days	*Compliance rate; *Compliance enhancer (incentive)	*Assessment frequency (outcome); *prompts (frequency)	*Assessment period	Outcomes measures; Validity	Analysis method
Albrecht & Anglim, 2018(51)	Daily diary	Website/online diaries	1; NR	NR; NR	Daily-Every 3 days; Yes (once)	On-shift days	Self-report; Multiple items; precedent	Multilevel models
Bhuanantanondh et al., 2021(353)	Daily diary Interval contingent	Hand-held device (tablet)	1;14 days	NR;NR	Once daily (sleep duration), 2 times per day (fatigue); NR	On-shift days	Self-report and monitoring-Reaction response Time (RRT); precedent	Repeated measure ANOVA
Bjorvatn et al., 1998(357)	Daily diary Interval contingent	Paper and pencil (Not specified)	1; 21 days	NR; Yes (none)	Hourly (sleepiness), Daily (accumulated sleepiness and sleep)	On-and off-shift days	Sleepiness: self-report; single item. sleep pattern: multiple items; precedent	Repeated measure ANOVA
Bjorvatn et al., 1999(354)	Daily diary Interval contingent	Paper and Pencil	2; 42 days	NR; Yes (none)	Hourly (sleepiness); Daily (accumulated sleepiness and sleep); NR	On-and off-shift days	Sleepiness: self-report; single item. Sleep pattern: multiple items; precedent	Repeated measure ANOVA

ANOVA=Analysis of variance; CR=compliance rate; NR=not reported; PR=participation rate; *Assessment period: work roster cycle phase during which assessment was done; *Assessment frequency: number of times per day participants were assessed; *Compliance enhancer: measure undertaken to increase compliance to assessment schedules; *Compliance rate: the percentage of scheduled assessments to which participants completed; *Method of EMA delivery: method of administration of EMAs; * Monitoring periods: number of waves of data collection used in the study; *Study duration: the total number of assessment days each monitoring period lasted.; *Participation or response rate: the percentage of participants who completed the predetermined number of assessment; *Prompts frequency: number of times participants are alerted to answer assessment schedules

Table S12. Methodological characteristics of the EMA studies on health and related behavioural outcomes in rotation workers (cont'd)

Author and Year	EMA design/ approach	Method for EMAs delivery	*Monitoring periods; *Study duration/days	*Compliance rate; *Compliance enhancer (incentive)	*Assessment frequency (outcome); *prompts (frequency)	*Assessment period	Outcomes measures; Validity	Analysis method
Bjorvatn et al., 2007(355)	Daily diary Interval contingent	Wrist-worn device (Actigraph), handheld computer, paper and pencil	1; 14 days	NR; Yes (none)	Hourly and daily (sleepiness) Daily and Continuous (sleep); NR	On-shift days	Sleepiness: Self-report and objective measure; single item. Sleep pattern: multiple items; precedent	ANOVA
Ferguson et al., 2010(53)	Daily diary Interval contingent diary	Wrist-worn device (Actiwatch) and Paper and pencil	1;21-28 days	NR; NR	Daily and continuous (sleep); 2 times per day (fatigue); NR	On-and off-shift days	Sleep: Self-report and monitoring; multiple items. Fatigue: self-report; single item; precedent	Mixed model ANOVA
Ferguson et al., 2011(165)	Daily diary Interval contingent	Paper and pencil; Wrist-worn device (Actigraph); Hand-held device (Palmpilot)	1; 15-22 days	NR;NR	2 times daily (fatigue) Continuous (sleep)	On-and off-shift days	Reaction Response time (RRT) and monitoring	Linear mixed model
Haward et al., 2009(144)	Daily diary	Paper and pencil	6; 84 days	PR:66-78%; NR	Daily; NR	On-shift days	Self-report; single-item; precedent	ANOVA and correlation

ANOVA=Analysis of variance; CR=compliance rate; NR=not reported; PR=participation rate. *Assessment period: work roster cycle phase during which assessment was done. *Assessment frequency: number of times per day participants were assessed. *Compliance enhancer: measure undertaken to increase compliance to assessment schedules. *Compliance rate: the percentage of scheduled assessments to which participants completed. *Method of EMA delivery: method of administration of EMAs. * Monitoring periods: number of waves of data collection used in the study. *Study duration: the total number of assessment days each monitoring period lasted. *Participation or response rate: the percentage of participants who completed the predetermined number of assessments; *Prompts frequency: number of times participants are alerted to answer assessment schedules

Table S12. Methodological characteristics of the EMA studies on health and related behavioural outcomes in rotation workers (cont'd)

Author and Year	EMA design/ approach	Method for EMAs delivery	*Monitoring periods; *Study duration/days	*Compliance rate; *Compliance enhancer (incentive)	*Assessment frequency (outcome); *prompts (frequency)	*Assessment period	Outcomes measures; Validity	Analysis method
Merkus et al., 2015(146)	Daily diary	Paper and pencil	1; 14 days	NR; NR	Daily; NR	On-shift days	Self-report; single-item; precedent	Generalized Estimating Equations
Merkus et al., 2015(356)	Daily diary	Paper and pencil	1; 11days	NR;NR	Daily; NR	Off-shift days	Self-report; NR	Mann–Whitney U tests
Merkus et al., 2017(139)	Daily diary	Paper and pencil	1;14 days	CR:80.3%; NR	Daily; NR	Off-shift days	Self-report; multiple items; precedent	Generalized Estimating Equations
Muller et al., 2008(98)	Daily diary Interval contingent diary	Paper and pencil	1;28 days	CR:87%, PR:95%; NR	Daily (sleep); 2 times per day (fatigue); NR	On-and off-shift days	Self-report; multiple items; precedent	t-tests and ANOVA; standardized parametric regression
Ots et al., 2021(344)	Interval contingent diary	Website/online ; wrist-worn device (Actigraph)	1;28 days	NR; NR	2 times per day (sleepiness) Continuous (physical activity, sleep quality)	On-and off-shift days	Self-report; single item (sleepiness); monitoring (PA, sleep quality)	Linear mixed models

ANOVA=Analysis of variance; CR=compliance rate; NR=not reported; PR=participation rate. *Assessment period: work roster cycle phase during which assessment was done. *Assessment frequency: number of times per day participants were assessed. *Compliance enhancer: measure undertaken to increase compliance to assessment schedules. *Compliance rate: the percentage of scheduled assessments to which participants completed. *Method of EMA delivery: method of administration of EMAs. * Monitoring periods: number of waves of data collection used in the study. *Study duration: the total number of assessment days each monitoring period lasted. *Participation or response rate: the percentage of participants who completed the predetermined number of assessments; *Prompts frequency: number of times participants are alerted to answer assessment schedules

Table S12. Methodological characteristics of the EMA studies on health and related behavioural outcomes in rotation workers (cont'd)

Author and Year	EMA design/ approach	Method for EMAs delivery	*Monitoring periods; *Study duration/days	*Compliance rate; *Compliance enhancer (incentive)	*Assessment frequency (outcome); *prompts (frequency)	*Assessment period	Outcomes measures; Validity	Analysis method
Paech et al., 2010(52)	Daily diary	Wrist-worn device (Actigraphy) and Paper and pencil	1;15-22 days	NR; NR	Daily; NR	On-and off-shift days	Self-report and monitoring; multiple items; precedent	Linear mixed models
Rebar et al., 2018(13)	Daily diary	Website/online diaries	2; 14 days	NR; Yes (feedback)	Daily; NR	On-and off-shift days	Self-report; Single items; NR	Multilevel model
Riethmeister et al., 2018(85)	Interval contingent diary	Wrist-worn device (Actigraphy) and website/online diaries	1; 28 days	NR; Yes (monitoring)	2 times per day (sleep and sleepiness), continuous (sleep); NR	On-and off-shift days	Sleep: Self-report and objective measure; multiple items. Sleepiness: single item; precedent	Generalised linear and linear mixed models
Riethmeister et al., 2018(86)	Interval contingent diary	Wrist-worn device (Actigraph), Handheld device (iPad), and website/online diaries	1; 14 days	NR; NR	2 times per day (fatigue); continuous (sleep); NR	On-shift days	Fatigue/sleepiness : self-report and objective measure (RRT); Time in bed: single-item and objective measure; precedent	Generalised linear and linear mixed models

ANOVA=Analysis of variance; CR=compliance rate; NR=not reported; PR=participation rate. *Assessment period: work roster cycle phase during which assessment was done. *Assessment frequency: number of times per day participants were assessed. *Compliance enhancer: measure undertaken to increase compliance to assessment schedules. *Compliance rate: the percentage of scheduled assessments to which participants completed. *Method of EMA delivery: method of administration of EMAs. * Monitoring periods: number of waves of data collection used in the study. *Study duration: the total number of assessment days each monitoring period lasted. *Participation or response rate: the percentage of participants who completed the predetermined number of assessments; *Prompts frequency: number of times participants are alerted to answer assessment schedules

Table S12. Methodological characteristics of the EMA studies on health and related behavioural outcomes in rotation workers (cont'd)

Author and Year	EMA design/ approach	Method for EMAs delivery	*Monitoring periods; *Study duration/days	*Compliance rate; *Compliance enhancer (incentive)	*Assessment frequency (outcome); *prompts (frequency)	*Assessment period	Outcomes measures; Validity	Analysis method
Riethmeister et al., 2019(87)	Interval contingent diary	Wrist-worn device (Actigraph) and website/online diaries	1;14 days	NR; NR	2 times per day (fatigue); Continuous (sleep); NR	On-shift days	Fatigue/sleepiness : self-report and objective measure (RRT); single-item. Sleep quality: objective measure; precedent	Linear mixed models
Sadeghniiat-Haghighi et al., 2019(140)	Daily diary	Wrist-worn device Paper and pencil	1; 14 days	NR; NR	Daily, Continuous; NR	On-shift days	Self-report and objective measure; multiple items; NR	ANOVA
Saksvik et al., 2011(141)	Daily diary	Wrist-worn device (Actigraph) and Paper and pencil	2; 56 days	PR:67.8%; NR	Daily, Continuous; NR	On-and off-shift days	Self-report and objective measure; multiple items; precedent	ANOVA
Thorne et al., 2008(142)	Daily diary	Wrist-worn device (Actigraph) and Paper and pencil	1; 7 days	NR; NR	Daily Continuous; NR	On-shift days	Self-report and objective measure; single-item; NR	ANOVA
Thorne et al., 2010(143)	Daily diary	Wrist-worn device (Actigraph)	1; 7 days	NR; NR	Daily Continuous; NR	On-and off-shift days	Self-report and objective measure; single-	ANOVA

		and Paper and pencil					item; NR	
Waage et al., 2012(156)	Daily diary and Interval contingent diary	Hand-held computer and Paper and pencil	2; 56 days	NR; Yes (monitoring and end-of-day diary collection)	Hourly, Daily; Yes (to start completing diaries)	On-and off-shift days	Self-report and objective measure; single-item; precedent	ANOVA

ANOVA=Analysis of variance; CR=compliance rate; NR=not reported; PR=participation rate. *Assessment period: work roster cycle phase during which assessment was done. *Assessment frequency: number of times per day participants were assessed. *Compliance enhancer: measure undertaken to increase compliance to assessment schedules. *Compliance rate: the percentage of scheduled assessments to which participants completed. *Method of EMA delivery: method of administration of EMAs. * Monitoring periods: number of waves of data collection used in the study. *Study duration: the total number of assessment days each monitoring period lasted. *Participation or response rate: the percentage of participants who completed the predetermined number of assessments; *Prompts frequency: number of times participants are alerted to answer assessment schedules

Appendix H: Sample of daily survey personal report


What will you learn?
In this report we give you a summary of your data
Your sleep quality
Your alcohol intake
Your physical activity and diet
Your emotions


What is Mental Health?
Is it a state of mind?

Defining Mental Health

Mental health includes our emotional, psychological, and social well-being. It affects how we think, feel, and act.

It also helps determine how we handle stress, relate to others, and make choices.
Work (FIFO) can affect mental health in positive and in negative way.

More than a State of Mind

Having good mental health is more than the absence of illness.
Rather, it's a state of holistic well-being.

More Common than You Think

1 in 5 adults

experienced a mental health concern in the past year.

Our recent study demonstrated that FIFO work can be associated with poorer mental health outcomes.
Some FIFO workers report poor sleep, problems with smoking and drinking alcohol.
FIFO partners' health can also be affected by the rotation work.

Mental Health is Integral

When we are mentally healthy, we can realize our abilities, cope with stress, work productively, and contribute to society.

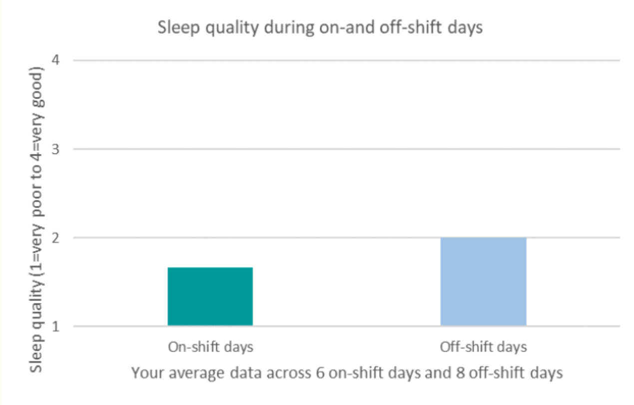
In this report, we want to provide you with insights to your own health and wellbeing.
We are also looking at more people like you.
The overall program of research is likely to impact industry and policy.

Your sleep quality

FIFO work can have an impact on the quality and quantity of your sleep.

Here is what we've learnt about you and your sleep during the study.

- You typically reported 'fairly bad' sleep quality over the study period
- Your sleep quality was a bit better on off-shift days than on on-shift days

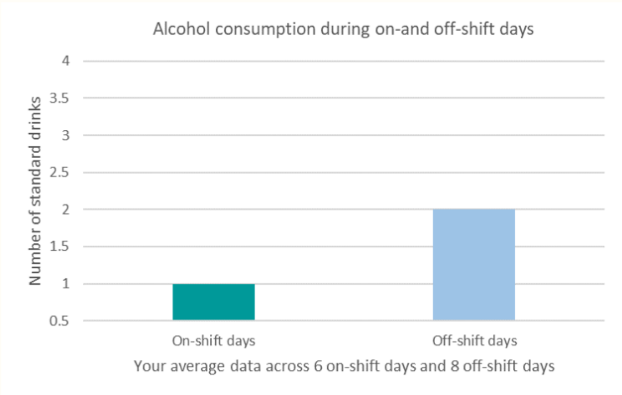


Alcohol

We know that FIFO work can be challenging.

Here is what we've learnt about you!

- You drunk on average 1.6 standard drinks per day
- You drunk many alcoholic drinks on off-shift days (2 standard drinks) than on-shift days (1 standard drink)

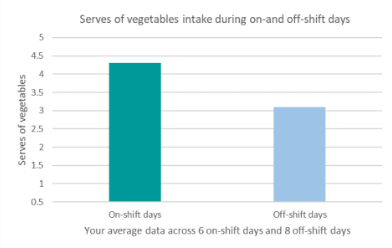


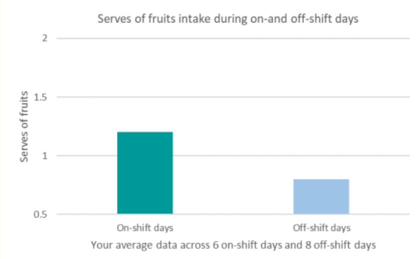
Your diet & physical activity

To maintain good mental and physical health, good quality diet and exercise are very important!

Here is what we've learnt about you!

- You seemed to eat higher amount of fruits and vegetables during on-shift days than on off-shift days.
- Recommended serves per day are: veg (5 serves) and fruits (2 serves)



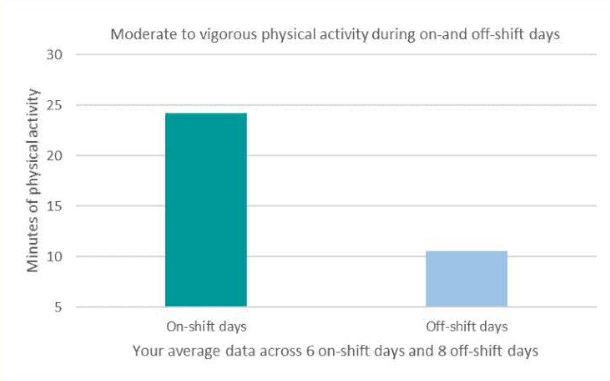


Your diet & physical activity

To maintain good mental and physical health, good quality diet and exercise are very important!

Here is what we have learnt about you!

- On average, you reported doing 16.4 mins of physical activity per day.
- Your reports suggested you do higher physical activity on on-shift days (24.2 mins) than on off-shift days (10.6 mins).

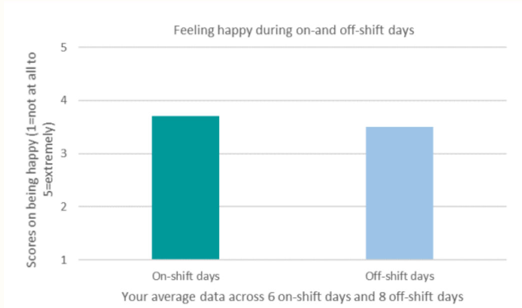


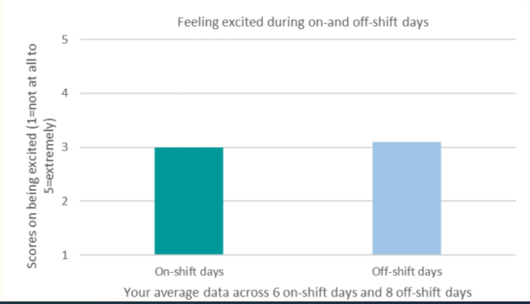
Positive emotions

Sometimes your diet and physical activity levels correspond with your happiness. People often report feeling happier if they eat well and exercise.

Here is what we have learnt about you!

- You seemed to be happy and excited at similar levels on off-shift days and on-shift days



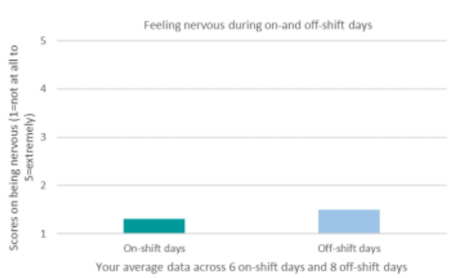


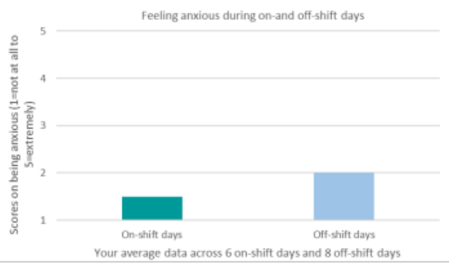
Negative emotions

Work can impact on several issues, including how nervous or anxious you feel or how sad and lonely you get. We all experience that sometimes and FIFO work can make things worse (both for workers but often also for their partners).

Here is what we have learnt about you!

- You reported feeling 'a little' nervous and anxious over the study period
- You tended to be nervous and anxious at similar levels during on-and off-shift days



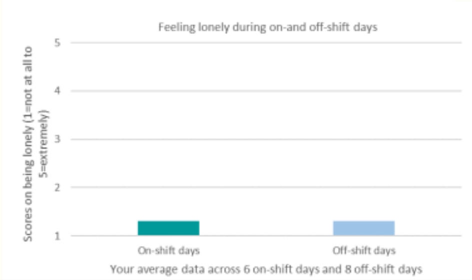


Negative emotions

Work can impact on several issues, including how nervous or anxious you feel or how sad and lonely you get. We all experience that sometimes and FIFO work can make things worse (both for workers but often also for their partners).

Here is what we have learnt about you!

- You reported feeling 'a little' sad and lonely over the study period
- You reported feeling sad at higher levels during off-shift days than on-shift days



Do not hesitate to seek professional help.

We care about our hearts, so why can't we care for our minds?

Develop Coping Skills

Take a deep breath, then relax.

Everyone has a different way to manage stress, consider the one that works best for you!

Embrace the relationships.

It's easier to deal with daily challenges, if you surround yourself with people who you can trust and who support you.

Speak up if things are not going well.

If things are not going in a right direction, speak up and seek support! You can contact: **Lifeline WA on 131114**

Thank you!

We have learnt a lot from you.
Thank you for your time.
Email us if you have any questions or comments: fifo@curtin.edu.au

Appendix I: Supplementary files in Chapter 8

Supplementary Information S12. Sample panel plots of daily data over assessment days among FIFO workers.

Figure S4. Daily standard drink intake

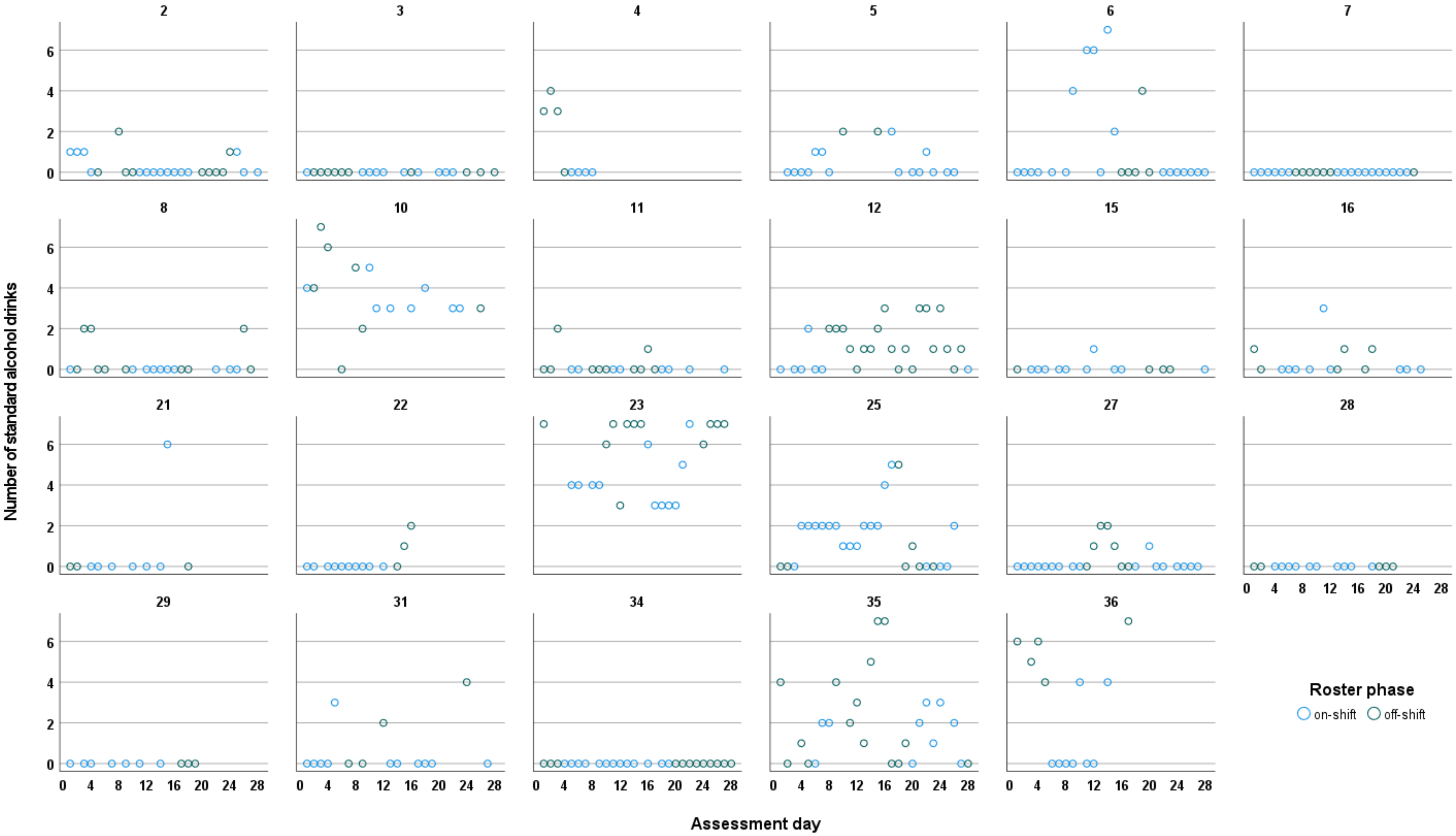


Figure S5. Daily number of cigarettes smoked

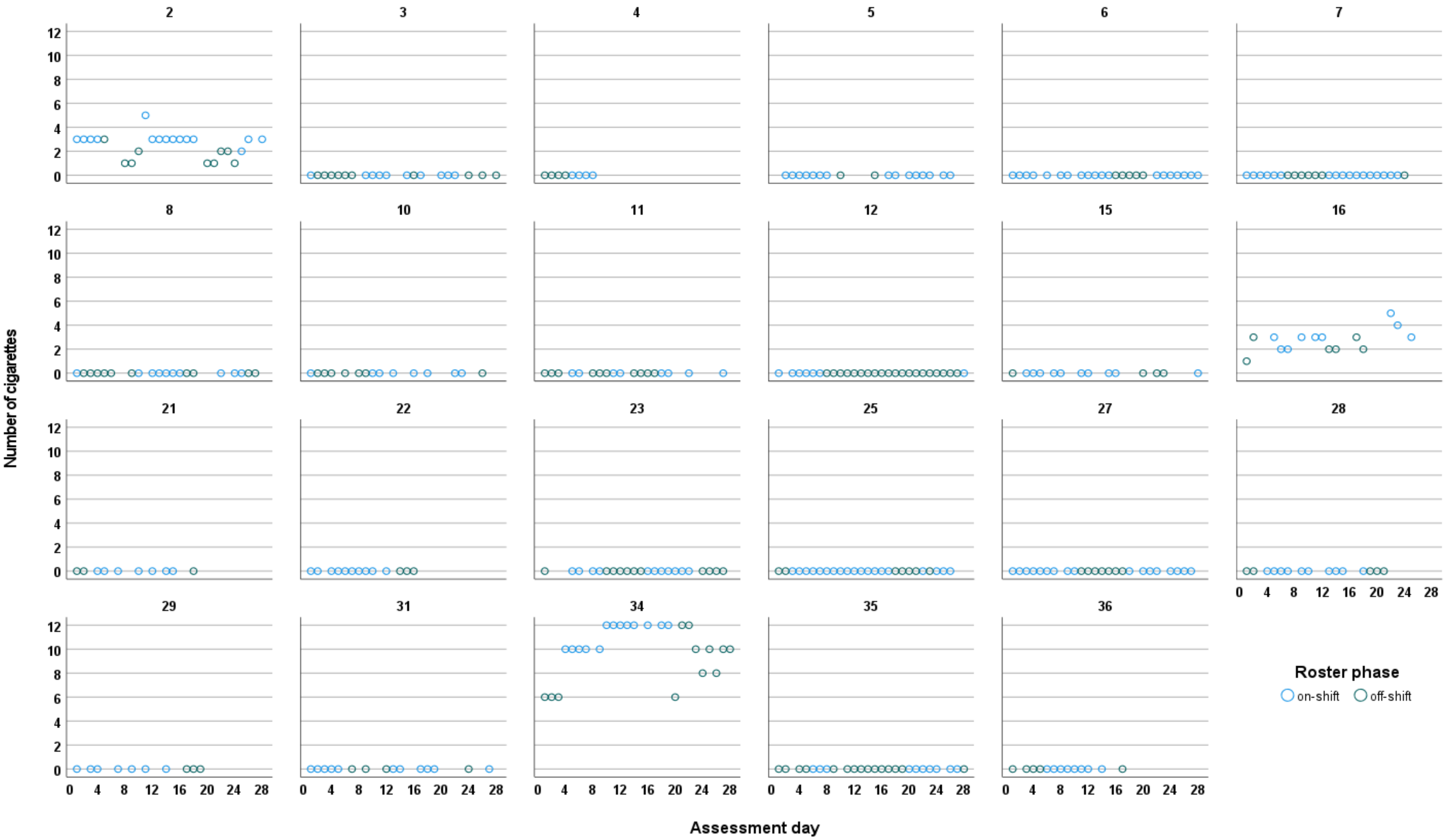


Figure S6. Daily minutes of moderate to vigorous physical activity

Figure S7. Daily serves of fruits and vegetable intake

Figure S8. Daily sleep quality

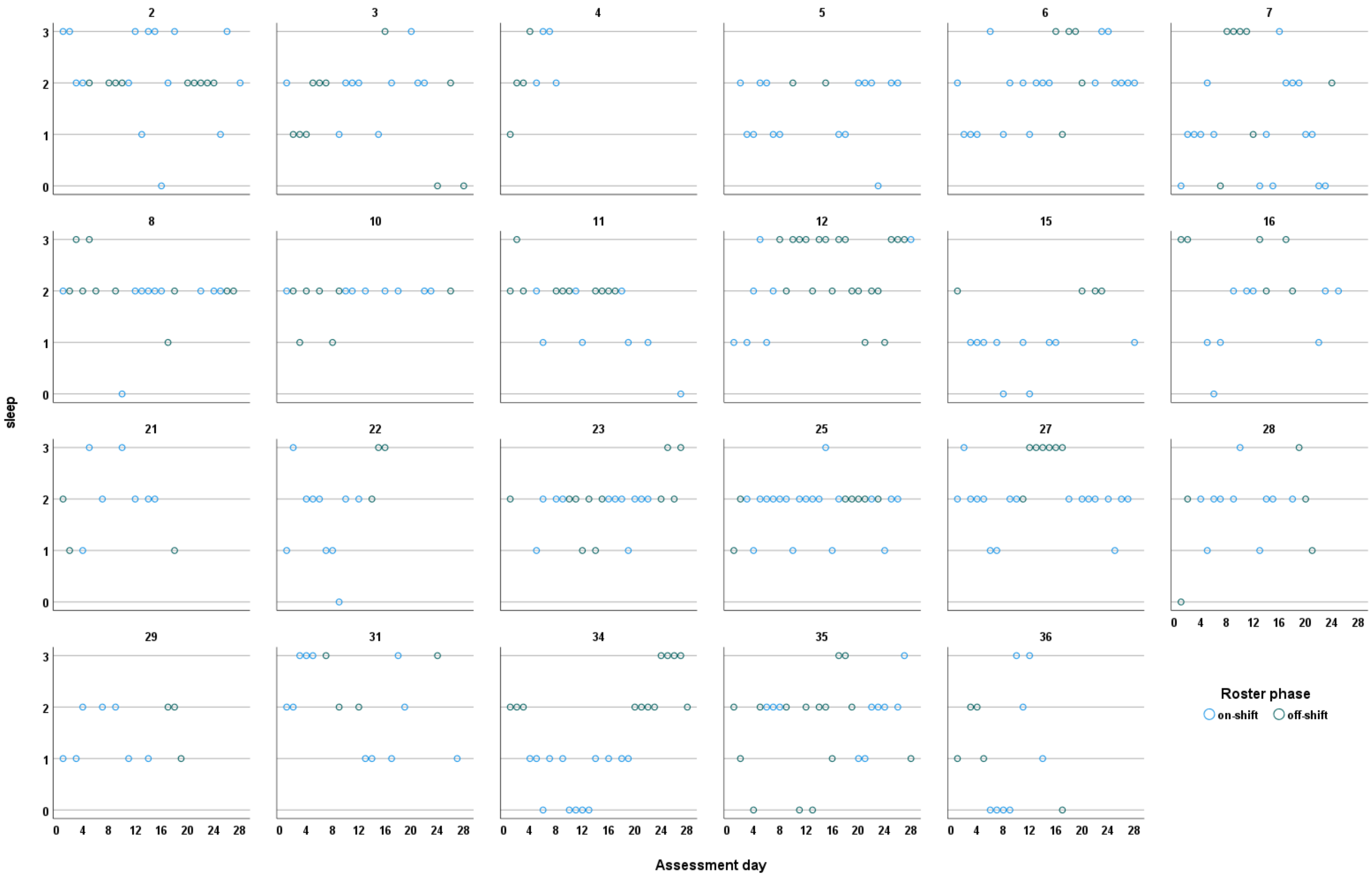


Figure S9. Daily positive affect

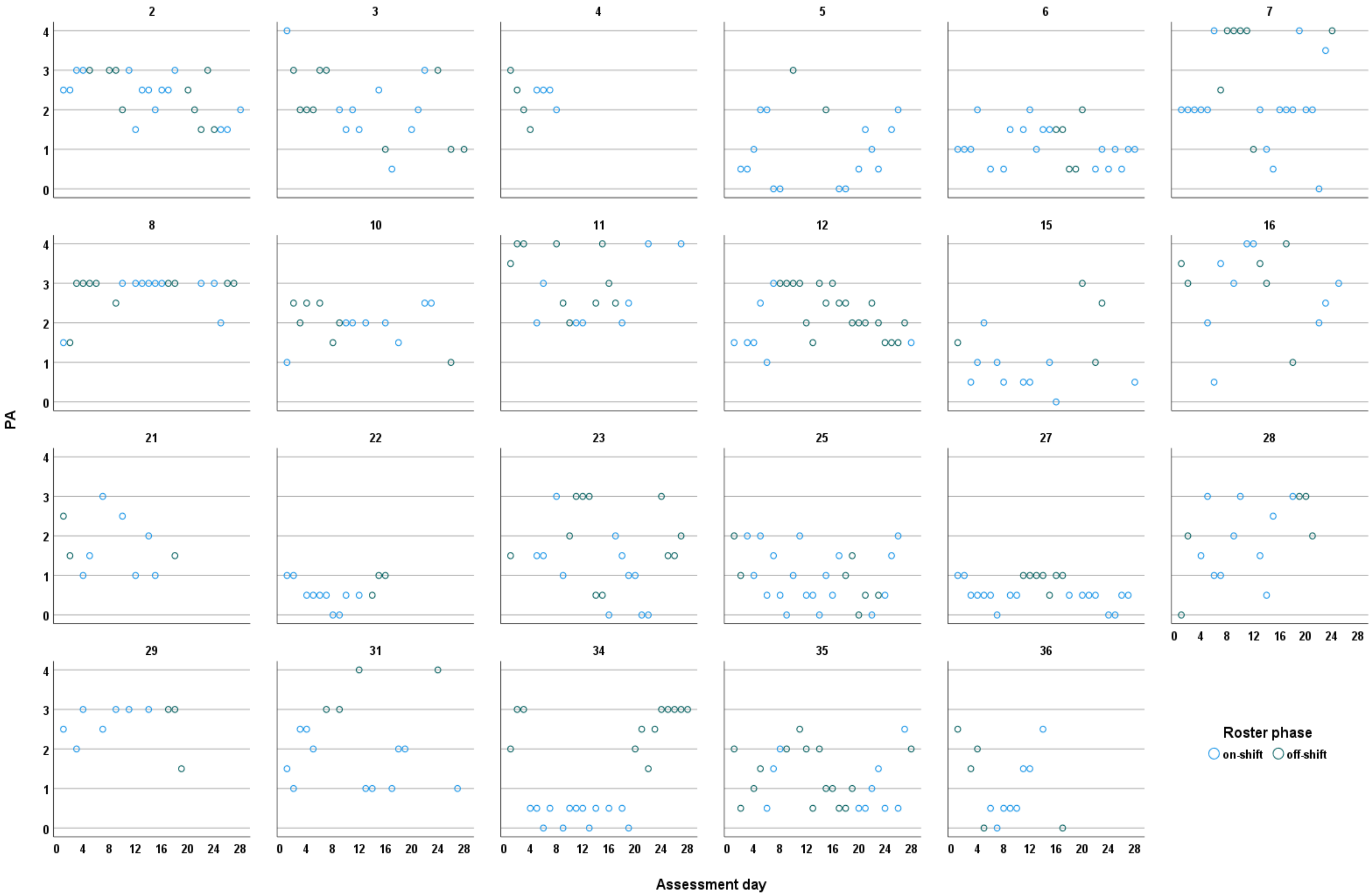


Figure S10. Daily anxious affect

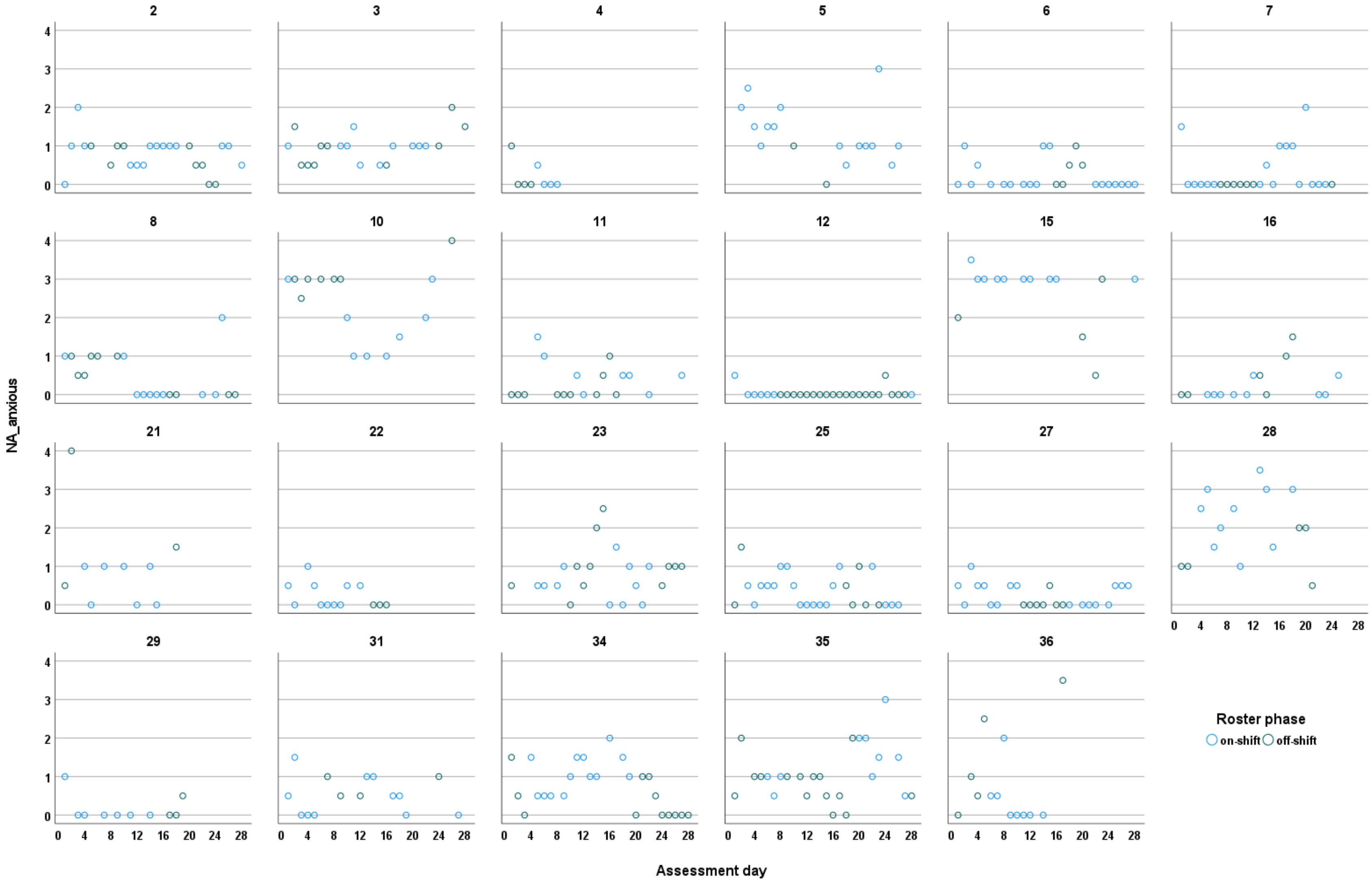


Figure S11. Daily depressed affect

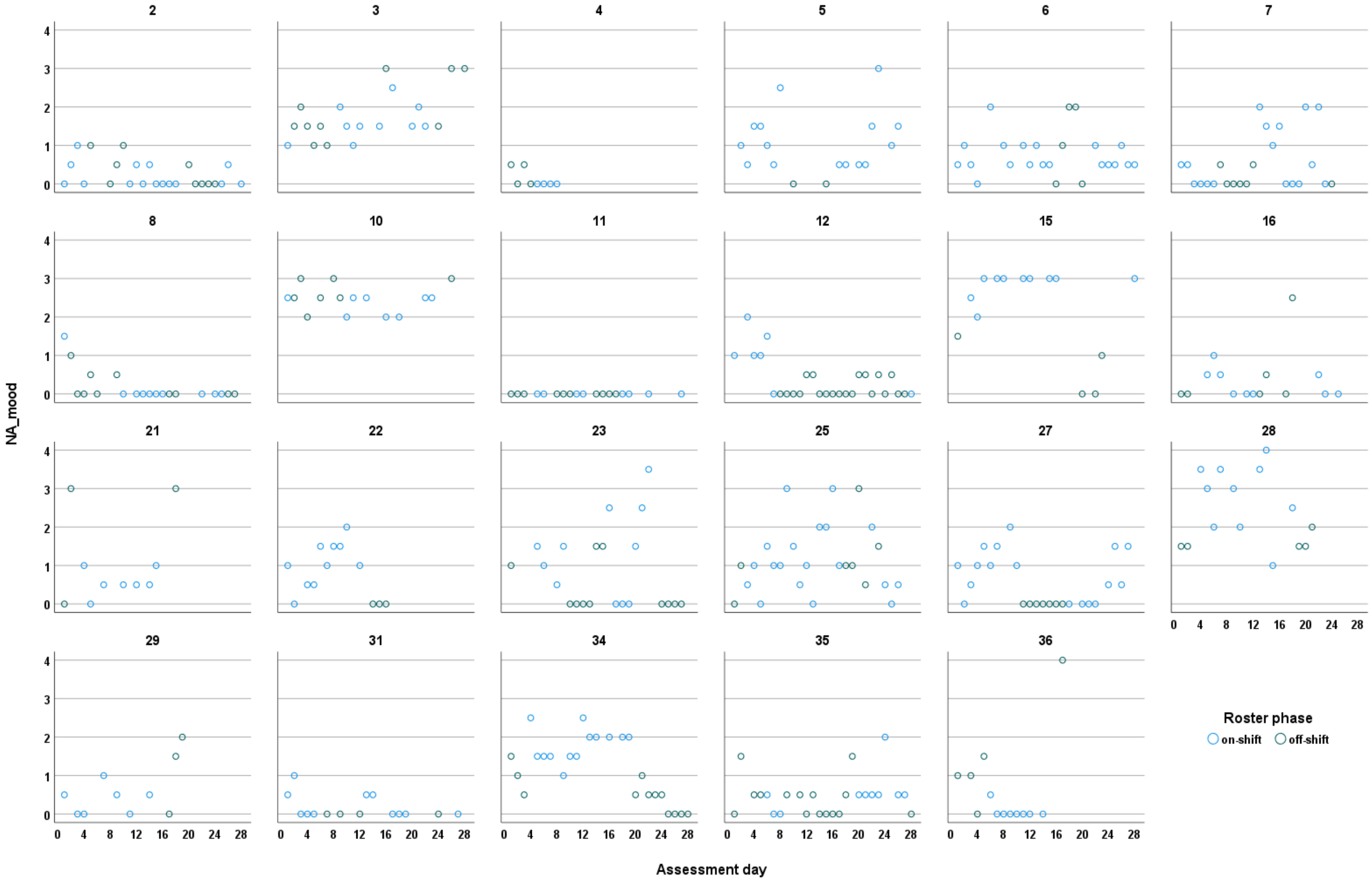


Figure S12. Daily job demand (workload)

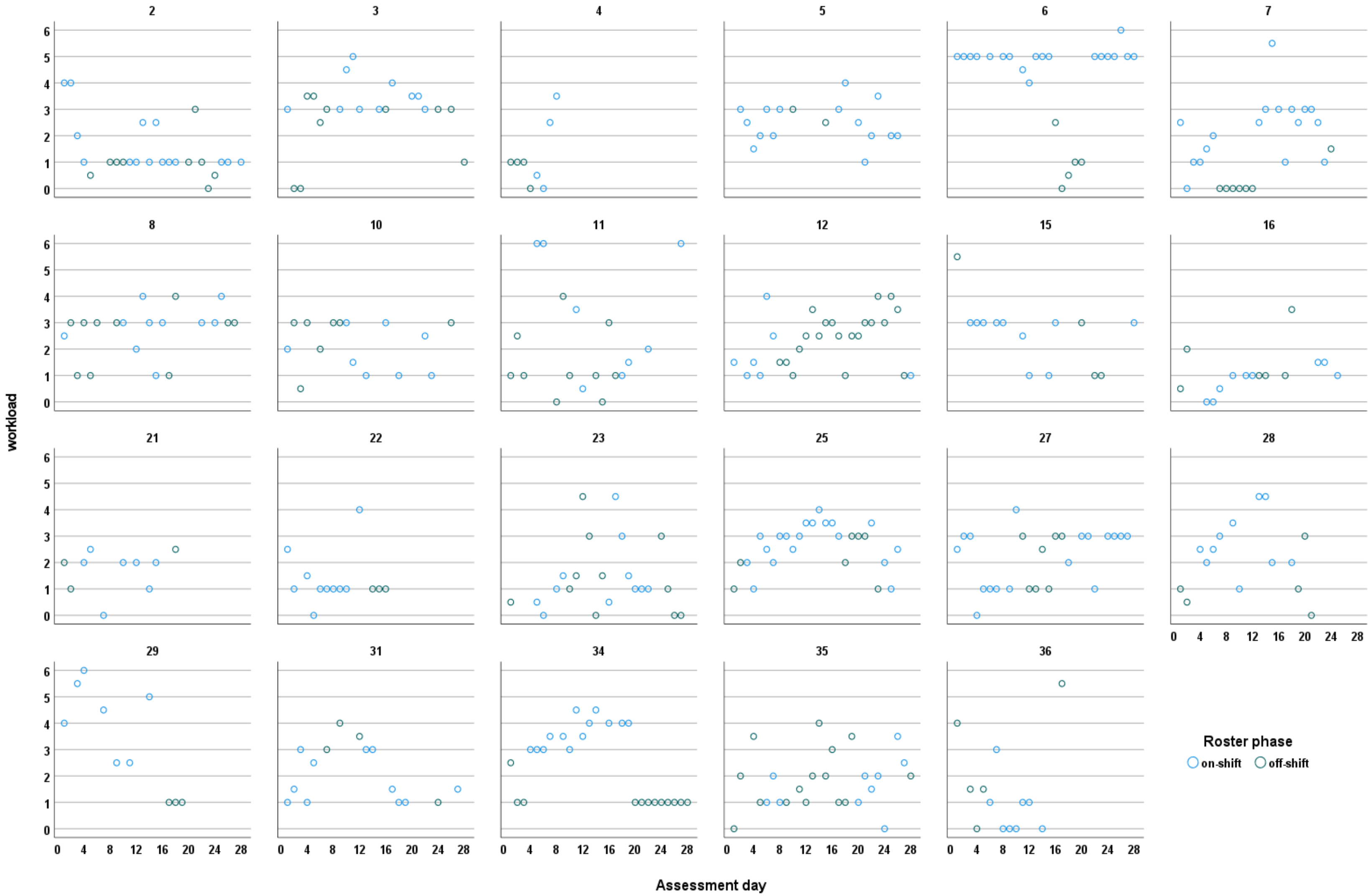
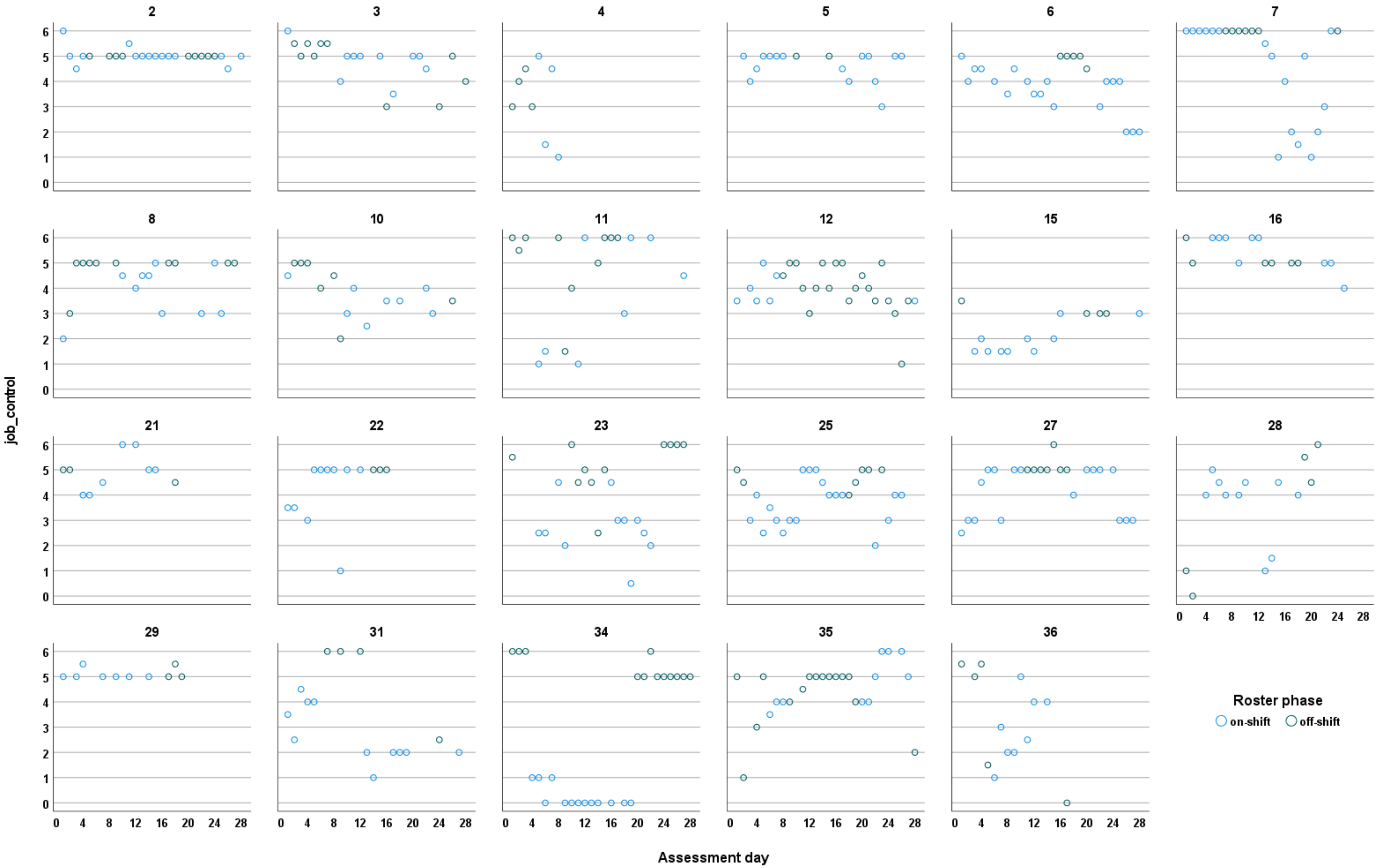


Figure S13. Daily job control



Supplementary Information S13. Spaghetti plots of the relationships between psychosocial factors and health outcomes in FIFO workers

Figure S14. Relationship between job demand, affect, and sleep quality

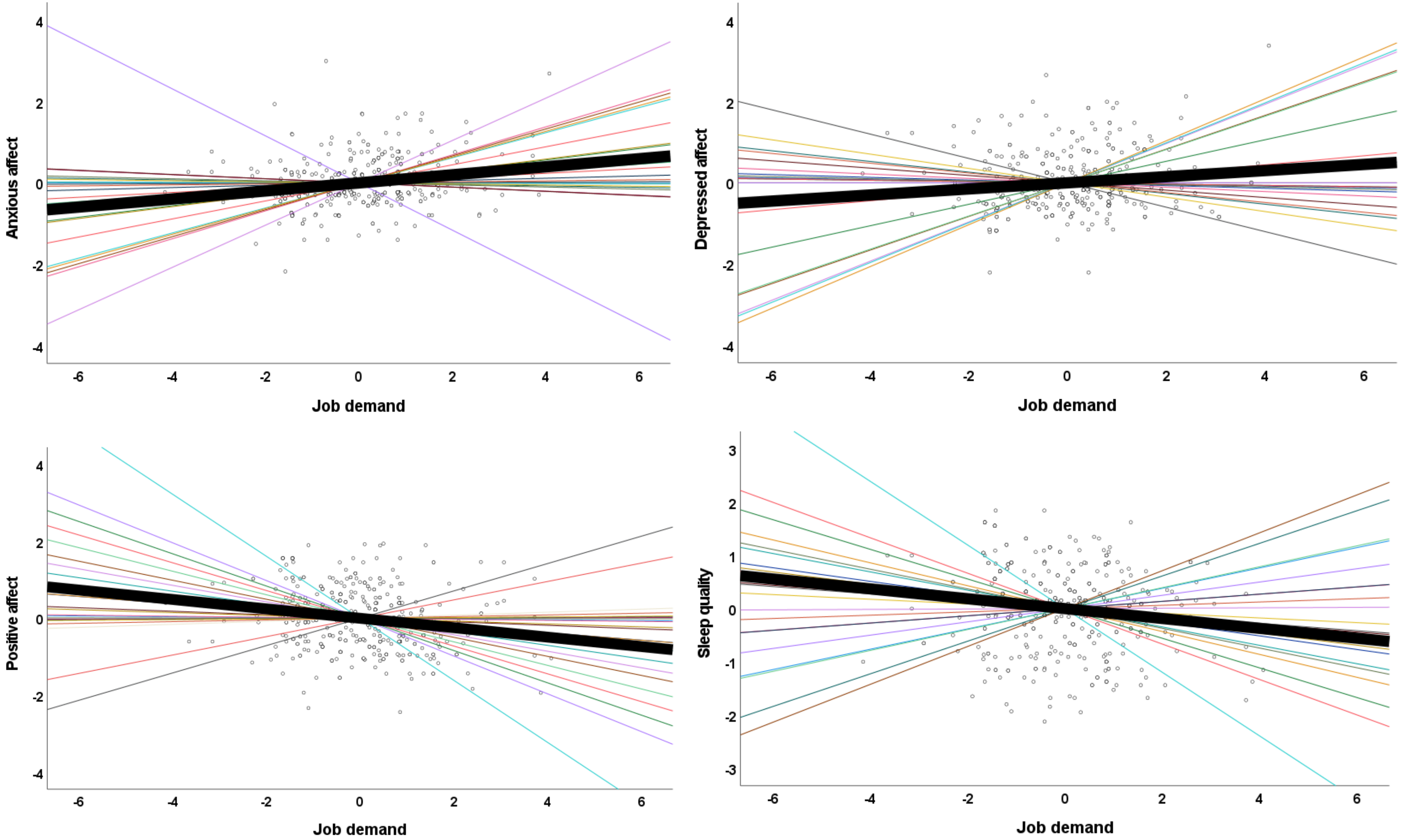
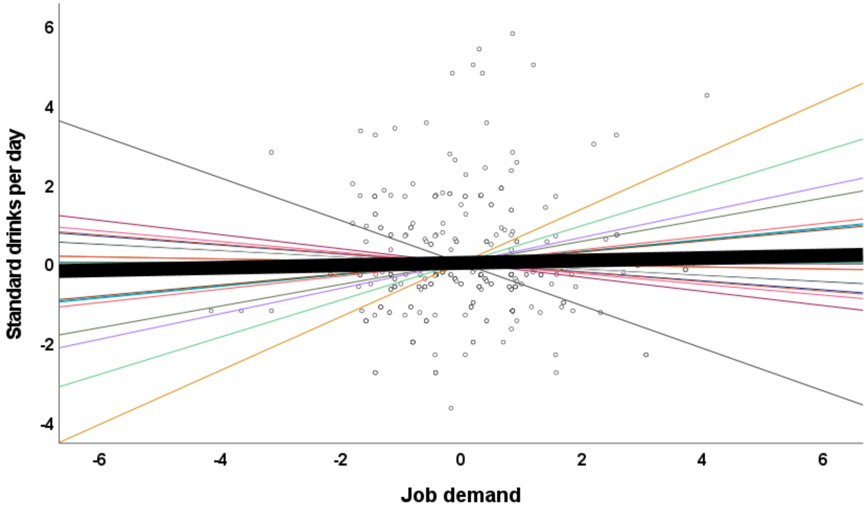
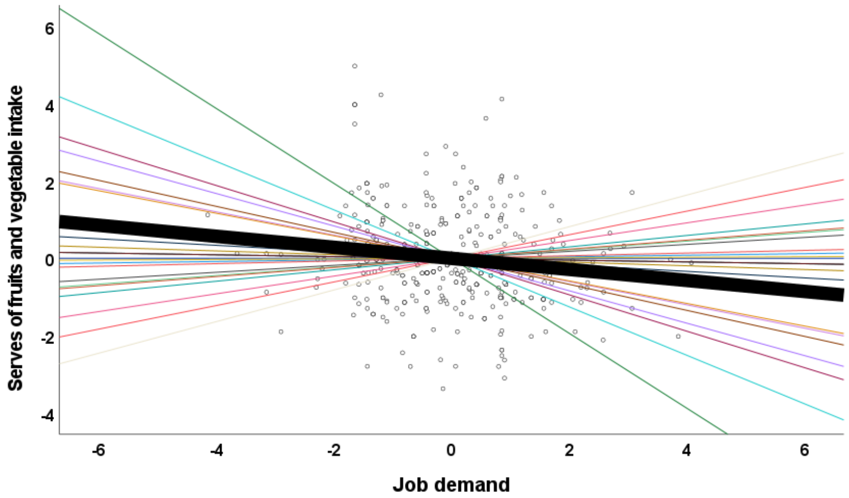


Figure S15. Relationship between job demand and behaviours





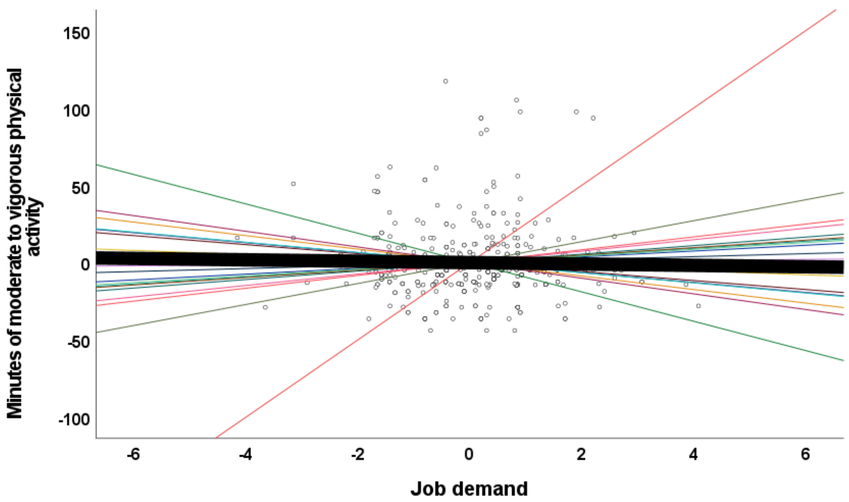


Figure S16. Relationship between job control, affect, and sleep quality

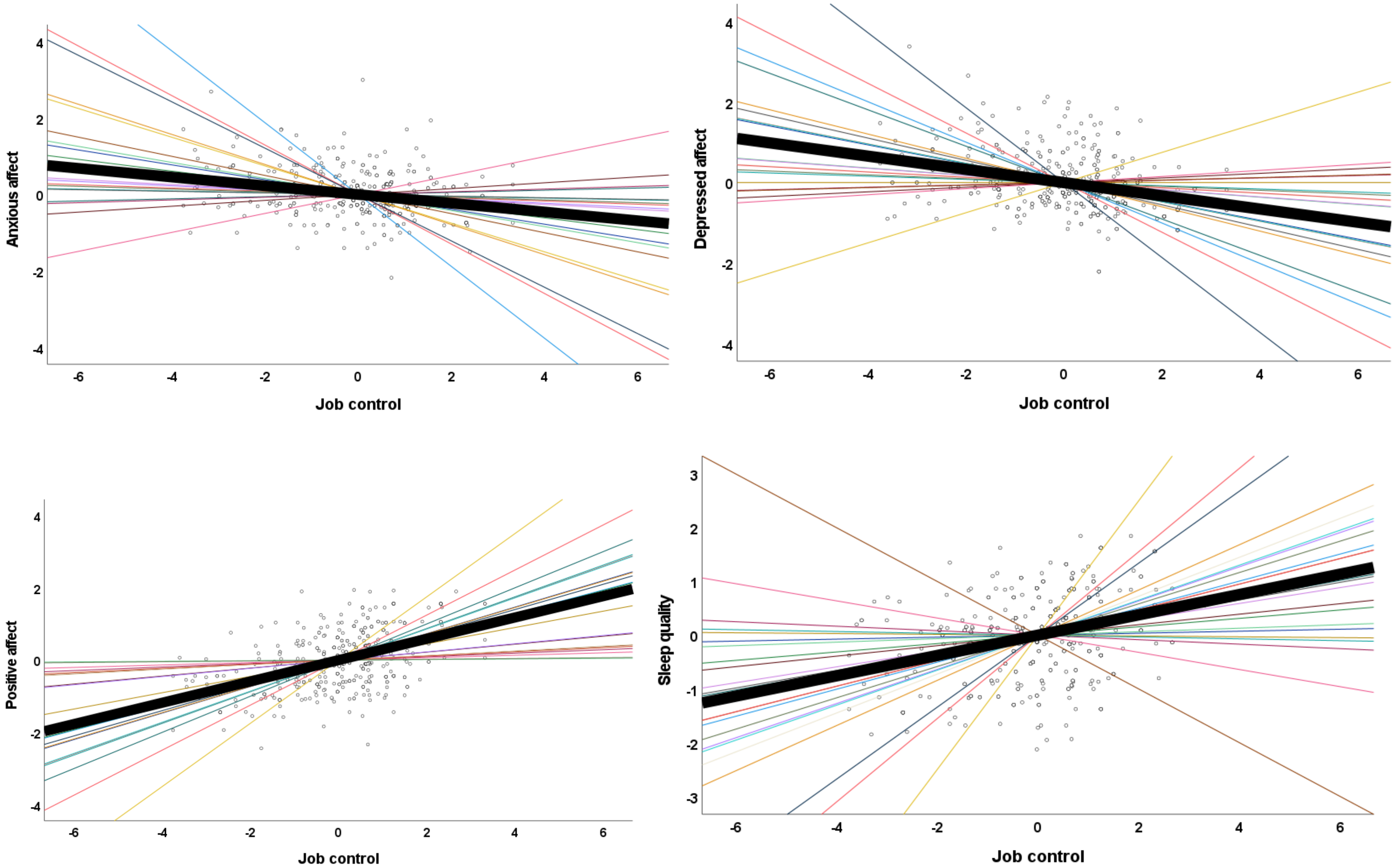
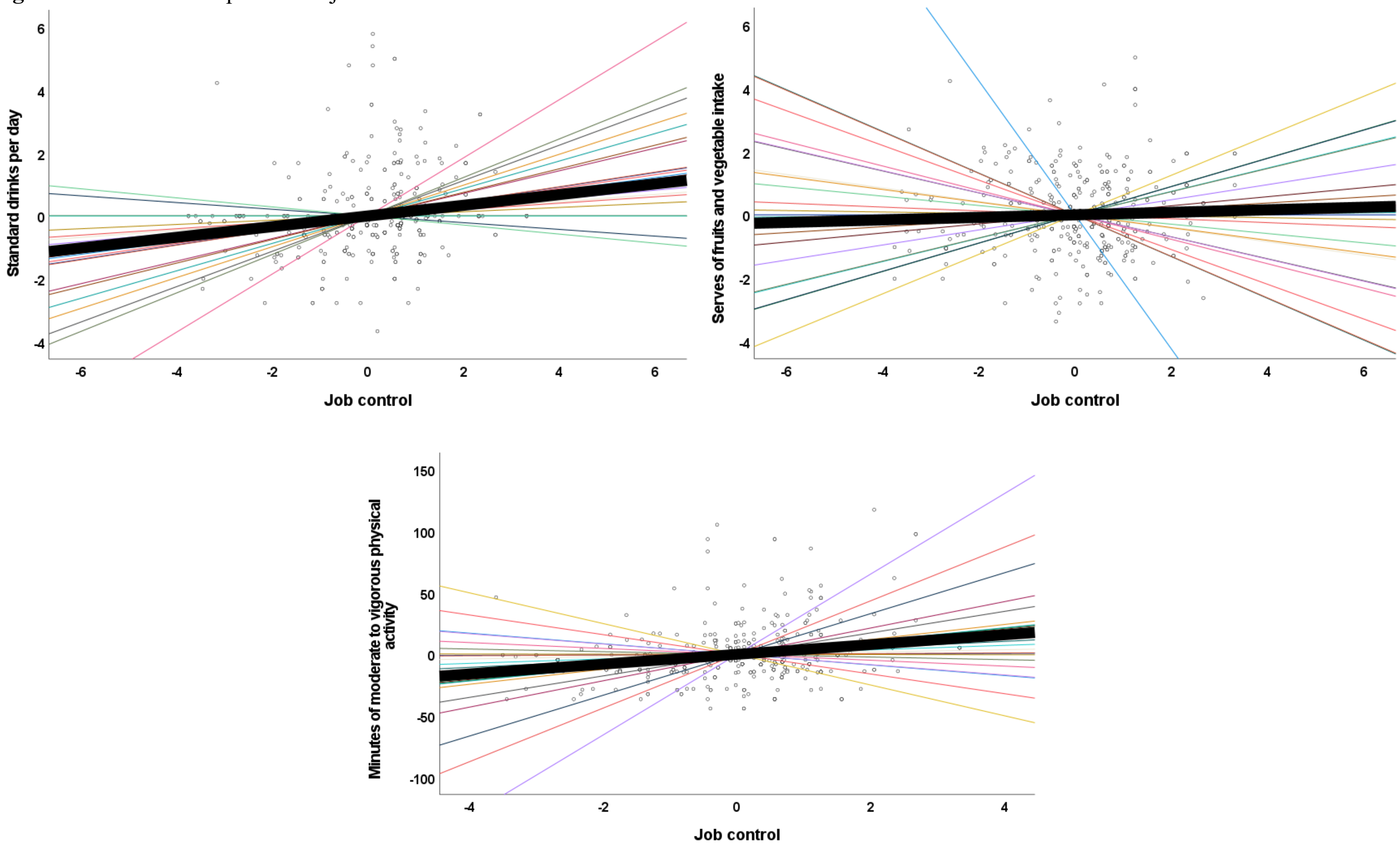


Figure S17. Relationship between job control and behaviours



Supplementary Information S14. Full model of multilevel models predicting daily health outcomes in FIFO workers

Table S13. Multilevel linear model of the effect of shift period on anxious affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.502357	0.433993	26.144	3.462	0.002	0.610510	2.394204
Day	-0.003908	0.004105	99.528	-0.952	0.343	-0.012054	0.004238
Age	-0.025075	0.013081	24.255	-1.917	0.067	-0.052058	0.001908
Shift hours	0.148994	0.384108	23.067	0.388	0.702	-0.645464	0.943453
Shift pattern	0.057768	0.283849	22.944	0.204	0.841	-0.529498	0.645033
Gender	-0.533370	0.274397	22.355	-1.944	0.065	-1.101911	0.035172
FIFO role	-0.501379	0.330349	22.981	-1.518	0.143	-1.184788	0.182030
Have children	-0.560886	0.386712	26.831	-1.450	0.159	-1.354589	0.232816
Marital status	-0.495540	0.423552	26.399	-1.170	0.252	-1.365524	0.374444
Shift period	0.041872	0.129844	22.114	0.322	0.750	-0.227327	0.311072
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.247388	0.087994	2.811		0.005	0.123201	0.496757
Shift period	0.292683	0.116358	2.515		0.012	0.134276	0.637965
*Residuals***							
AR1 diagonal	0.304247	0.024135	12.606		<0.001	0.260437	0.355427
AR1 rho	0.161067	0.075848	2.124		0.034	0.009864	0.305069

Anxious affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1)
Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S14. Multilevel linear model of the effect of shift period on depressed affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.560440	0.499928	27.987	3.121	0.004	0.536363	2.584518
Day	0.000624	0.005130	95.689	0.122	0.904	-0.009560	0.010807
Age	-0.017171	0.015044	25.795	-1.141	0.264	-0.048106	0.013763
Shift hours	0.246116	0.440512	24.230	0.559	0.581	-0.662598	1.154831
Shift pattern	0.127575	0.325270	24.071	0.392	0.698	-0.543644	0.798795
Gender	-0.367880	0.314489	23.473	-1.170	0.254	-1.017726	0.281966
FIFO role	-0.280371	0.379041	24.190	-0.740	0.467	-1.062348	0.501606
Have children	-0.470841	0.447246	29.091	-1.053	0.301	-1.385436	0.443755
Marital status	-0.794895	0.488111	28.287	-1.629	0.115	-1.794288	0.204498
Shift period	0.218984	0.167379	22.112	1.308	0.204	-0.128038	0.566006
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.313802	0.112555	2.788		0.005	0.155362	0.633819
Shift period	0.507615	0.193588	2.622		0.009	0.240388	1.071903
*Residuals***							
AR1 diagonal	0.402822	0.034291	11.747		<0.001	0.340921	0.475962
AR1 rho	0.291309	0.065505	4.447		<0.001	0.158359	0.413884

Depressed affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S15. Multilevel linear model of the effect of shift period on positive effect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.687060	0.249881	33.063	6.751	<0.001	1.178711	2.195409
Day	0.007188	0.005285	113.629	1.360	0.177	-0.003282	0.017659
Age	0.005232	0.007028	23.301	0.744	0.464	-0.009296	0.019761
Shift hours	0.102999	0.200507	21.382	0.514	0.613	-0.313526	0.519523
Shift pattern	0.225234	0.147067	20.530	1.532	0.141	-0.081036	0.531504
Gender	0.038599	0.139735	19.398	0.276	0.785	-0.253464	0.330662
FIFO role	0.085120	0.169429	19.215	0.502	0.621	-0.269231	0.439471
Have children	0.244787	0.222508	30.738	1.100	0.280	-0.209177	0.698752
Marital status	0.153123	0.240954	29.427	0.635	0.530	-0.339373	0.645619
Shift period	-0.358757	0.105302	28.182	-3.407	0.002	-0.574396	-0.143118
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects***							
Intercept	0.018006	0.022621	0.796		0.426	0.001535	0.211236
Shift period	0.104634	0.071031	1.473		0.141	0.027659	0.395831
*Residuals***							
AR1 diagonal	0.514259	0.042463	12.111		<0.001	0.437418	0.604598
AR1 rho	0.192941	0.065971	2.925		0.003	0.061014	0.318242

Positive affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S16. Multilevel linear model of the effect of shift period on sleep quality

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.333436	0.434584	29.154	5.369	<0.001	1.444817	3.222055
Day	-0.008035	0.005905	103.709	-1.361	0.177	-0.019745	0.003676
Age	-0.026737	0.012922	25.617	-2.069	0.049	-0.053319	-0.000155
Shift hours	0.140260	0.377007	23.675	0.372	0.713	-0.638410	0.918929
Shift pattern	-0.448447	0.277798	23.419	-1.614	0.120	-1.022548	0.125654
Gender	0.371564	0.267855	22.640	1.387	0.179	-0.183023	0.926152
FIFO role	0.058509	0.323610	23.347	0.181	0.858	-0.610379	0.727397
Have children	-0.481942	0.388528	30.012	-1.240	0.224	-1.275407	0.311523
Marital status	-0.113230	0.423073	28.987	-0.268	0.791	-0.978529	0.752068
Shift period	-0.497905	0.138932	25.869	-3.584	0.001	-0.783554	-0.212256
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	0.195998	0.083035	2.360		0.018	0.085436	0.449639
Shift period	0.264614	0.121848	2.172		0.030	0.107315	0.652481
*Residual***							
AR1 diagonal	0.548932	0.045679	12.017		<0.001	0.466323	0.646175
AR1 rho	0.284822	0.063252	4.503		<0.001	0.156703	0.403513

Sleep quality (0=very poor to 3=very good); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S17. Generalised linear mixed model of the effect of shift period on fruit and vegetable intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	0.797	0.2133	3.738	<0.001	0.378	1.217	2.219	1.459	3.377
Day	0.003	0.0029	0.883	0.378	-0.003	0.008	1.003	0.997	1.008
Age	0.005	0.0080	0.629	0.530	-0.011	0.021	1.005	0.989	1.021
Shift hours	-0.046	0.2299	-0.200	0.841	-0.498	0.406	0.955	0.608	1.501
Shift pattern	0.028	0.1671	0.170	0.865	-0.300	0.357	1.029	0.741	1.429
Gender	0.022	0.2060	0.106	0.916	-0.383	0.427	1.022	0.682	1.533
FIFO role	0.108	0.3000	0.359	0.720	-0.483	0.698	1.114	0.617	2.009
Have children	0.636	0.1676	3.797	<0.001	0.307	0.966	1.890	1.359	2.628
Marital status	0.314	0.2114	1.486	0.138	-0.102	0.730	1.369	0.903	2.075
Shift period	-0.090	0.0838	-1.073	0.284	-0.255	0.075	0.914	0.775	1.078
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	0.195	0.082	2.377	0.017	0.086	0.446			
Shift period	0.115	0.051	2.245	0.025	0.048	0.275			
*Residual***									
AR1 diagonal	0.340	0.035	9.744	<0.001	0.278	0.416			
AR1 rho	0.312	0.086	3.641	<0.001	0.136	0.469			

Note: Probability distribution: Negative binomial, Link function: Log; Fruits and vegetable intake: Number serves intake; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle; Day of assessment (centred at day 14); age (mean centred at 0); gender (male=0, female=1); marital status (married=0, single=1); have children (yes=0, no=1), FIFO role (manual=0, office=1); Shift pattern (rotation shift=0, regular fixed shift=1); shift hours (≤12=0, >12=1)

Table S18. Generalised linear mixed model of the effect of shift period on alcohol intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-3.457	1.1970	-2.888	0.004	-5.810	-1.104	0.032	0.003	0.332
Day	-0.017	0.0108	-1.610	0.108	-0.039	0.004	0.983	0.962	1.004
Age	0.022	0.0440	0.492	0.623	-0.065	0.108	1.022	0.937	1.114
Shift hours	0.050	1.3847	0.036	0.971	-2.672	2.772	1.051	0.069	15.990
Shift pattern	0.985	1.1906	0.828	0.408	-1.355	3.326	2.678	0.258	27.816
Gender	-1.008	0.9857	-1.023	0.307	-2.946	0.929	0.365	0.053	2.533
FIFO role	0.479	0.8788	0.545	0.586	-1.248	2.207	1.615	0.287	9.086
Have children	0.554	0.9304	0.595	0.552	-1.275	2.382	1.739	0.279	10.831
Marital status	2.856	0.8292	3.444	<0.001	1.226	4.486	17.393	3.408	88.769
Shift period	-1.353	0.4821	-2.806	0.005	-2.300	-0.405	0.259	0.100	0.667
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	4.496	2.242	2.005	0.045	1.692	11.949			
Shift period	2.989	1.549	1.929	0.054	1.082	8.254			
*Residual***									
AR1 diagonal	0.667	0.052	12.896	<0.001	0.573	0.776			
AR1 rho	0.166	0.064	2.610	0.009	0.039	0.287			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S19. Generalised linear mixed model of the effect of shift period on physical activity

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-0.534	1.0308	-0.518	0.605	-2.560	1.493	0.586	0.077	4.449
Day	-0.013	0.0267	-0.485	0.628	-0.066	1.247	0.987	0.937	1.040
Age	-0.072	0.0474	-1.516	0.130	-0.165	1.637	0.931	0.848	1.022
Shift hours	1.198	1.1586	1.034	0.302	-1.079	3.476	3.315	0.340	32.329
Shift pattern	0.011	0.8269	0.014	0.989	-1.614	0.021	1.011	0.199	5.139
Gender	-0.291	0.7823	-0.371	0.711	-1.828	0.040	0.748	0.161	3.481
FIFO role	-0.725	1.0476	-0.692	0.489	-2.784	1.334	0.484	0.062	3.798
Have children	0.393	1.0403	0.378	0.706	-1.652	2.438	1.482	0.192	11.451
Marital status	-0.069	0.9494	-0.073	0.942	-1.936	1.797	0.933	0.144	6.031
Shift period	-0.931	0.5059	-1.841	0.066	-1.926	0.063	0.394	0.146	1.065
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	2.829	1.570	1.801	0.072	0.953	8.397			
Shift period	3.667	1.760	2.083	0.037	1.431	9.396			
*Residual***									
AR1 diagonal	0.688	0.067	10.241	<0.001	0.568	0.833			
AR1 rho	0.444	0.060	7.375	<0.001	0.319	0.554			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S20. Multilevel linear model predicting anxious affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.797886	.383806	29.091	4.684	<.001	1.013022	2.582750
Day	-.006215	.003944	102.618	-1.576	.118	-.014038	.001608
Age	-.020383	.011255	26.536	-1.811	.081	-.043495	.002729
Shift hours	.478798	.366305	25.976	1.307	.203	-.274187	1.231784
Shift pattern	.299413	.267995	25.813	1.117	.274	-.251654	.850479
Gender	-.503457	.236721	23.930	-2.127	.044	-.992101	-.014812
FIFO role	-.340487	.305124	23.856	-1.116	.276	-.970435	.289460
Have children	-.818023	.347523	30.029	-2.354	.025	-1.527731	-.108315
Marital status	-.951388	.403447	30.350	-2.358	.025	-1.774938	-.127838
Shift period	-.111763	.126258	23.878	-.885	.385	-.372417	.148891
Job demand (between-persons)	-.087525	.162008	27.683	-.540	.593	-.419555	.244505
Job demand (within-person)	.052998	.025014	390.925	2.119	.035	.003819	.102176
Job control (between-persons)	-.503832	.167079	27.971	-3.016	.005	-.846095	-.161570
Job control (within-person)	-.136775	.025197	374.057	-5.428	<.001	-.186320	-.087229
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.171348	.061996	2.764		.006	.084315	.348220
Shift period	.266241	.106086	2.510		.012	.121929	.581359
*Residual***							
AR1 diagonal	.276067	.021971	12.565		<.001	.236195	.322671
AR1 rho	.166200	.074553	2.229		.026	.017482	.307724

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S21. Multilevel linear model predicting depressed affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.644325	.472655	28.169	3.479	.002	.676396	2.612253
Day	-.001646	.005019	97.025	-.328	.744	-.011608	.008316
Age	-.013992	.013880	25.847	-1.008	.323	-.042532	.014547
Shift hours	.433841	.452132	25.381	.960	.346	-.496633	1.364316
Shift pattern	.247426	.330497	25.142	.749	.461	-.433052	.927904
Gender	-.323102	.291877	23.333	-1.107	.280	-.926420	.280216
FIFO role	-.302538	.376263	23.271	-.804	.429	-1.080396	.475320
Have children	-.553126	.429049	29.258	-1.289	.207	-1.430293	.324042
Marital status	-.915598	.496939	29.310	-1.842	.076	-1.931485	.100289
Shift period	.104773	.154218	22.685	.679	.504	-.214496	.424043
Job demand (between-persons)	.152497	.199888	26.931	.763	.452	-.257688	.562683
Job demand (within-person)	.018276	.029090	404.049	.628	.530	-.038910	.075462
Job control (between-persons)	-.276969	.206287	27.284	-1.343	.190	-.700029	.146091
Job control (within-person)	-.116921	.029468	398.001	-3.968	<.001	-.174853	-.058989
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.258179	.095399	2.706		.007	.125140	.532655
Shift period	.398284	.162552	2.450		.014	.178975	.886328
*Residuals***							
AR1 diagonal	.388008	.033085	11.727		<.001	.328291	.458587
AR1 rho	.280332	.066207	4.234		<.001	.146157	.404379

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S22. Multilevel linear model predicting positive affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.004439	.380473	29.289	5.268	<.001	1.226617	2.782261
Day	-.004037	.005577	109.75	-.724	.471	-.015088	.007015
Age	-.035244	.011026	25.477	-3.197	.004	-.057930	-.012557
Shift hours	-.005461	.363042	26.350	-.015	.988	-.751223	.740301
Shift pattern	-.480286	.263344	25.244	-1.824	.080	-1.022388	.061815
Gender	.334202	.232194	23.405	1.439	.163	-.145668	.814072
FIFO role	-.087176	.300293	23.744	-.290	.774	-.707304	.532951
Have children	-.232264	.340244	28.336	-.683	.500	-.928851	.464322
Marital status	-.232264	.393801	28.283	.431	.670	-.636495	.976108
Shift period	-.273922	.101975	28.147	-2.686	.012	-.482759	-.065085
Job demand (between-persons)	-.059766	.157792	25.854	-.379	.708	-.384201	.264669
Job demand (within-person)	-.011023	.031269	359.381	-.353	.725	-.072516	.050470
Job control (between-persons)	.401239	.163331	26.555	2.457	.021	.065850	.736629
Job control (within-person)	.236381	.031412	311.766	7.525	<.001	.174574	.298188
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.149866	.060305	2.485		.013	.068106	.329777
Shift period	.059419	.060653	.980		.327	.008036	.439340
*Residual***							
AR1 diagonal	.500250	.040888	12.235		<.001	.426200	.587165
AR1 rho	.280797	.061606	4.558		<.001	.156177	.396616

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S23. Multilevel linear model predicting sleep quality

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.635159	.316920	105.56	8.315	<.001	2.006803	3.263515
Day	.014863	.006949	107.163	2.139	.035	.001088	.028638
Age	.006605	.008022	65.494	.823	.413	-.009415	.022625
Shift hours	.124421	.266302	118.081	.467	.641	-.402926	.651768
Shift pattern	.268595	.194052	108.814	1.384	.169	-.116017	.653207
Gender	-.095903	.146381	85.153	-.655	.514	-.386940	.195134
FIFO role	.209604	.190247	91.092	1.102	.273	-.168292	.587501
Have children	.367216	.274727	84.523	1.337	.185	-.179059	.913490
Marital status	.154247	.349587	114.391	.441	.660	-.538257	.846751
Shift period	-.200721	.136055	39.081	-1.475	.148	-.475900	.074458
Job demand (between-persons)	-.114933	.124106	117.499	-.926	.356	-.360708	.130842
Job demand (within-person)	-.012764	.040439	312.989	-.316	.752	-.092330	.066802
Job control (between-persons)	-.015708	.128453	118.115	-.122	.903	-.270078	.238662
Job control (within-person)	.008196	.039977	287.160	.205	.838	-.070488	.086881
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept[a]	-	-	-	-	-	-	-
Shift period	.139253	.091127	1.528		.126	.038617	.502144
*Residuals***							
AR1 diagonal	.537789	.049536	10.857		<.001	.448960	.644193
AR1 rho	.255179	.065578	3.891		<.001	.122838	.378602

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random intercept in the model predicting sleep quality was omitted due to non-convergence of the model; Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S24. Generalized linear mixed model predicting fruit and vegetable intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	.931	.2038	4.567	.000	.530	1.332	2.536	1.699	3.787
Day	.002	.0029	.752	.453	-.004	.008	1.002	.996	1.008
Age	.007	.0077	.858	.392	-.009	.022	1.007	.991	1.022
Shift hours	.070	.2101	.334	.739	-.343	.483	1.073	.709	1.622
Shift pattern	.117	.1611	.724	.470	-.200	.434	1.124	.818	1.543
Gender	-.013	.2050	-.065	.949	-.416	.390	.987	.659	1.477
FIFO role	.253	.3022	.837	.403	-.342	.847	1.288	.711	2.333
Have children	.507	.1367	3.708	.000	.238	.776	1.660	1.269	2.172
Marital status	.087	.1849	.470	.639	-.277	.451	1.091	.758	1.569
Shift period	-.107	.0879	-1.220	.223	-.280	.066	.898	.756	1.068
Job demand (between-persons)	-.155	.0674	-2.304	.022	-.288	-.023	.856	.750	.978
Job demand (within-person)	-.006	.0119	-.498	.619	-.029	.017	.994	.971	1.018
Job control (between-persons)	-.197	.0815	-2.412	.016	-.357	-.036	.822	.700	.964
Job control (within-person)	-.023	.0194	-1.209	.228	-.062	.015	.977	.940	1.015
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	.202	.091	2.213	.027	.083	.491			
Shift period	.123	.054	2.256	.024	.051	.292			
*Residual***									
AR1 diagonal	.337	.034	9.776	.000	.275	.411			
AR1 rho	.305	.086	3.561	.000	.129	.463			

Note: Probability distribution: Negative binomial, Link function: Log; Fruits and vegetable intake: Number serves intake; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S25. Generalised linear mixed model predicting physical activity

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-.410	1.2126	-.338	.736	-2.793	1.974	.664	.061	7.200
Day	-.004	.0294	-1.585	.886	-.062	.054	.996	.940	1.055
Age	-.080	.0502	-.143	.114	-.178	.019	.924	.837	1.019
Shift hours	2.687	1.1540	2.328	.020	.418	4.955	14.686	1.519	141.944
Shift pattern	.986	.8084	1.219	.223	-.603	2.575	2.680	.547	13.132
Gender	-.585	.8987	-.651	.515	-2.352	1.182	.557	.095	3.260
FIFO role	-.529	1.1026	-.480	.632	-2.697	1.638	.589	.067	5.147
Have children	-.140	1.1597	-.121	.904	-2.420	2.140	.869	.089	8.497
Marital status	-1.202	1.2827	-.937	.349	-3.723	1.320	.301	.024	3.743
Shift period	-.742	.4796	-1.548	.122	-1.685	.200	.476	.185	1.222
Job demand (between-persons)	-.276	.5821	-.474	.636	-1.420	.868	.759	.242	2.383
Job demand (within-person)	.113	.0925	1.216	.225	-.069	.294	1.119	.933	1.342
Job control (between-persons)	-.961	.5886	-1.632	.103	-2.118	.197	.383	.120	1.217
Job control (within-person)	.413	.1699	2.428	.016	.079	.747	1.511	1.082	2.110
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	3.446	1.751	1.751	.080	1.125	10.555			
Shift period	3.327	1.751	1.900	.057	1.186	9.334			
*Residuals***									
AR1 diagonal	.721	.069	10.450	<.001	.597	.869			
AR1 rho	.435	.061	7.187	<.001	.310	.546			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S26. Generalised linear mixed model predicting alcohol intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-3.135	1.5752	-1.990	.047	-6.231	-.039	.044	.002	.962
Day	-.008	.0143	-.546	.586	-.036	.020	.992	.965	1.020
Age	.033	.0509	.645	.519	-.067	.133	1.033	.935	1.142
Shift hours	1.466	1.9819	.740	.460	-2.430	5.362	4.330	.088	213.05
Shift pattern	2.332	1.7562	1.328	.185	-1.120	5.784	10.299	.326	325.13
Gender	-1.538	1.0681	-1.440	.151	-3.637	.562	.215	.026	1.754
FIFO role	1.981	.8200	2.416	.016	.369	3.593	7.252	1.447	36.348
Have children	-.376	1.4288	-.263	.793	-3.184	2.433	.687	.041	11.394
Marital status	.837	1.7407	.481	.631	-2.585	4.259	2.310	.075	70.747
Shift period	-1.084	.5087	-2.132	.034	-2.084	-.084	.338	.124	.919
Job demand (between-persons)	-1.817	.7430	-2.446	.015	-3.278	-.357	.162	.038	.700
Job demand (within-person)	.238	.1488	1.602	.110	-.054	.531	1.269	.947	1.700
Job control (between-persons)	-1.280	.9664	-1.325	.186	-3.180	.619	.278	.042	1.858
Job control (within-person)	.648	.1695	3.826	<.001	.315	.982	1.913	1.371	2.669
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	5.832	3.204	1.820	.069	1.987	17.119			
Shift period	3.847	2.005	1.919	.055	1.385	10.683			
*Residuals***									
AR1 diagonal	.667	.052	12.795	<.001	.572	.777			
AR1 rho	.182	.066	2.759	.006	.050	.307			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S27. Multilevel linear model predicting anxious affect with interactions between job demand and control

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.760	.379	29.055	4.641	<.001	.985	2.536
Day	-.006	.004	108.308	-1.627	.107	-.014	.001
Age	-.022	.011	26.909	-1.968	-.059	-.045	.001
Shift hours	.568	.363	26.145	1.566	.129	-.178	1.313
Shift pattern	.351	.265	25.906	1.323	.197	-.194	.896
Gender	-.548	.236	24.694	-2.321	.029	-1.034	-.061
FIFO role	-.359	.302	23.899	-1.190	.246	-.982	.264
Have children	-.827	.343	29.848	-2.412	.022	-1.528	-.127
Marital status	-.971	.399	30.344	-2.434	.021	-1.785	-.157
Shift period	-.091	.123	23.801	-.738	.468	-.344	.163
Job demand (between-persons)	-.101	.160	27.565	-.633	.532	-.429	.227
Job demand (within-person)	.052	.025	387.357	2.105	.036	.003	.101
Job control (between-persons)	-.529	.166	28.280	-3.195	.003	-.868	-.190
Job control (within-person)	-.119	.026	370.610	-4.626	<.001	-.170	-.069
Daily job demand*daily job control	-.039	.016	389.111	-2.501	.013	-.070	-.008
Daily job demand*aggregate job control	-.067	.034	348.152	-1.961	.051	-.134	.000
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.169	.061	2.789		.005	.084	.341
Shift period	.250	.101	2.489		.013	.114	.550
*Residual***							
AR1 diagonal	.268	.021	12.807		<.001	.230	.312
AR1 rho	.138	.075	1.847		.065	-.010	.280

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S28. Multilevel linear model predicting depressed affect with interactions between job demand and control

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.603	.466	28.307	3.438	.002	-.729	2.557
Day	-.001	.005	100.894	-.273	.785	-.011	.008
Age	-.015	.014	26.310	-1.087	.287	-.043	.013
Shift hours	.523	.447	25.669	1.171	.252	-.396	1.442
Shift pattern	.300	.326	25.355	.920	.366	-.371	.972
Gender	-.349	.290	24.121	-1.202	.241	-.947	.250
FIFO role	-.312	.371	23.434	-.841	.409	-1.080	.455
Have children	-.557	.423	29.249	-1.317	.198	-1.421	.307
Marital status	-.939	.490	29.415	-1.915	.065	-1.941	.063
Shift period	.125	.148	22.521	.850	.404	-.180	.431
Job demand (betweenpersons)	.141	.197	26.944	.713	.482	.648	.545
Job demand (within-person)	.019	.029	404.193	.668	.504	-.264	.076
Job control (between-persons)	-.312	.204	27.578	-1.528	.138	-.037	.106
Job control (within person)	-.105	.030	399.642	-3.465	<.001	-.164	-.045
Daily job demand*daily job control	-.033	.018	393.974	-1.833	.068	-.069	.002
Daily job demand*aggregate job control	-.092	.040	367.631	-2.276	.023	-.172	-.013
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.252	.093	2.725		.006	.123	.518
Shift period	.355	.149	2.376		.017	.155	.809
*Residual***							
AR1 diagonal	.380	.032	11.876		<.001	.322	.448
AR1 rho	.268	.066	4.071		<.001	.135	.392

*Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S29. Multilevel linear model predicting positive affect with interactions between job demand and control

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.026	.383	29.366	5.283	<.001	1.242	2.809
Day	-.004	.006	107.708	-.686	.494	-.015	.007
Age	-.034	.011	25.675	-3.089	.005	-.057	-.011
Shift hours	-.032	.366	26.481	-.087	.932	-.784	.721
Shift pattern	-.491	.265	25.303	-1.849	.076	-1.037	.055
Gender	.372	.236	24.127	1.579	.127	-.114	.859
FIFO role	-.081	.303	23.868	-.269	.791	-.707	.544
Have children	-.232	.342	28.228	-.679	.503	-.933	.468
Marital status	.166	.396	28.153	.418	.679	-.645	.977
Shift period	-.286	.101	27.207	-2.839	.008	-.493	-.079
Job demand (between-persons)	-.058	.159	25.761	-.363	.720	-.384	.269
Job demand (within-person)	-.010	.031	353.583	-.325	.745	-.071	.051
Job control (between-persons)	.405	.164	26.456	2.466	.020	.068	.743
Job control (within-person)	.225	.032	306.650	6.950	<.001	.161	.289
Daily job demand*daily job control	.028	.020	411.683	1.350	.178	-.013	.068
Daily job demand*aggregate job control	.042	.042	237.724	.992	.322	-.041	.126
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
Intercept	.154	.062	2.501		.012	.070	.337
Shift period	.052	.060	.860		.390	.005	.503
*Residual***							
AR1 diagonal	.501	.041	12.156		<.001	.426	.588
AR1 rho	.291	.062	4.706		<.001	.166	.407

Positive affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S30. Multilevel linear model predicting sleep quality with interactions between job demand and control

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.588	.309	107.070	8.364	<.001	1.975	3.202
Day	.014	.007	111.069	2.031	.045	.000	.027
Age	.004	.008	63.917	.546	.587	-.011	.020
Shift hours	.129	.260	117.038	.496	.621	-.385	.643
Shift pattern	.272	.189	108.634	1.441	.152	-.102	.646
Gender	-.144	.146	84.464	-.989	.325	-.435	.146
FIFO role	.188	.184	89.154	1.025	.308	-.177	.553
Have children	.406	.266	83.231	1.525	.131	-.124	.936
Marital status	.192	.340	115.107	.563	.574	-.482	.866
Shift period	-.187	.133	44.139	-1.410	.166	-.455	.080
Job demand (between person)	-.109	.120	115.343	-.908	.366	-.348	.129
Job demand (within person)	-.026	.040	312.049	-.633	.527	-.105	.054
Job control (between person)	.051	.128	101.122	.398	.691	-.203	.305
Job control (within person)	.016	.041	297.603	.392	.695	-.064	.097
Daily job demand*daily job control	-.021	.026	300.205	-.816	.415	-.073	.030
Daily job demand*aggregate job control	.137	.062	227.365	2.213	.028	.015	.260
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effects**							
[a]Intercept	-	-	-		-	-	-
Shift period	.124	.080	1.542		.123	.035	.441
*Residual***							
AR1 diagonal	.523	.047	11.092		<.001	.438	.624
AR1 rho	.226	.067	3.392		<.001	.092	.352

Sleep quality (0=very poor to 3=very good); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in the model and was omitted; Shift period: on-shift days (1) vs off-shift day (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S31. Generalized linear mixed model predicting fruit and vegetable intake with interactions between job demand and control

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	.939	.2087	4.498	<.001	.528	1.349	2.556	1.696	3.854
Day	.002	.0029	.721	.471	-.004	.008	1.002	.996	1.008
Age	.007	.0080	.905	.366	-.008	.023	1.007	.992	1.023
Shift hours	.037	.2137	.174	.862	-.383	.458	1.038	.682	1.580
Shift pattern	.106	.1613	.657	.512	-.211	.423	1.112	.809	1.527
Gender	.013	.2107	.060	.952	-.402	.427	1.013	.669	1.533
FIFO role	.256	.3052	.840	.402	-.344	.857	1.292	.709	2.356
Have children	.512	.1418	3.610	<.001	.233	.791	1.669	1.262	2.206
Marital status	.089	.1888	.474	.636	-.282	.461	1.094	.754	1.586
Shift period	-.108	.0892	-1.212	.226	-.284	.067	.897	.753	1.070
Job demand (between-persons)	-.146	.0682	-2.146	.033	-.281	-.012	.864	.755	.988
Job demand (within-person)	-.007	.0108	-.653	.514	-.028	.014	.993	.972	1.014
Job control (between persons)	-.179	.0827	-2.164	.031	-.342	-.016	.836	.710	.984
Job control (within person)	-.026	.0185	-1.399	.163	-.062	.011	.974	.940	1.011
Daily job demand*daily job control	.020	.0146	1.394	.164	-.008	.049	1.021	.992	1.050
Daily job demand*aggregate job control	.027	.0223	1.191	.235	-.017	.070	1.027	.983	1.073
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	.202	.091	2.213	.027	.083	.490			
Shift period	.118	.052	2.254	.024	.049	.281			
*Residual***									
AR1 diagonal	.337	.034	9.797	<.001	.276	.411			
AR1 rho	.307	.084	3.640	<.001	.134	.462			

Note: Probability distribution: Negative binomial, Link function: Log; Fruits and vegetable intake: Number serves intake; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S32. Generalised linear mixed model predicting physical activity with interactions between job demand and control

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-0.193	1.2981	-0.149	0.882	-2.745	2.359	0.824	0.064	10.576
Day	0.000	0.0283	-0.007	0.994	-0.056	0.055	1.00	0.946	1.057
Age	-0.069	0.0565	-1.225	0.221	-0.18	0.042	0.933	0.835	1.043
Shift hours	2.609	1.1626	2.244	0.025	0.323	4.894	13.583	1.382	133.522
Shift pattern	0.932	0.806	1.156	0.248	-0.653	2.516	2.539	0.521	12.380
Gender	-0.431	0.9054	-0.475	0.635	-2.21	1.349	0.650	0.110	3.855
FIFO role	-0.367	1.1565	-0.317	0.751	-2.641	1.906	0.693	0.071	6.728
Have children	-0.178	1.2024	-0.148	0.882	-2.542	2.185	0.837	0.079	8.895
Marital status	-1.400	1.3378	-1.046	0.296	-4.03	1.23	0.247	0.018	3.422
Shift period	-0.778	0.4954	-1.571	0.117	-1.752	0.195	0.459	0.173	1.216
Job demand (between-persons)	-0.343	0.6048	-0.567	0.571	-1.532	0.846	0.710	0.216	2.330
Job demand (within-person)	0.059	0.0973	0.606	0.545	-0.132	0.25	1.061	0.876	1.284
Job control (between-persons)	-1.080	0.6081	-1.775	0.077	-2.275	0.116	0.34	0.103	1.123
Job control (within-person)	0.398	0.163	2.44	0.015	0.077	0.718	1.489	1.080	2.051
Daily job demand*daily job control	0.200	0.1112	1.796	0.073	-0.019	0.418	1.221	0.981	1.520
Daily job demand*aggregate job control	-0.032	0.1047	-0.308	0.759	-0.238	0.174	0.968	0.788	1.190
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	3.602	2.059	1.750	0.080	1.175	11.041			
Shift period	3.573	1.832	1.951	0.051	1.308	9.758			
*Residuals***									
AR1 diagonal	0.708	0.069	10.333	<0.001	0.586	0.856			
AR1 rho	0.438	0.061	7.147	<0.001	0.311	0.550			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Table S33. Generalised linear mixed model predicting alcohol intake with interaction between job demand and control

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-3.769	1.7614	-2.14	0.033	-7.232	-0.306	0.023	0.001	0.736
Day	-0.012	0.0139	-0.893	0.372	-0.04	0.015	0.988	0.961	1.015
Age	0.030	0.0615	0.487	0.627	-0.091	0.151	1.030	0.913	1.163
Shift hours	1.503	2.0684	0.727	0.468	-2.563	5.569	4.496	0.077	262.267
Shift pattern	2.461	1.8416	1.336	0.182	-1.159	6.082	11.72	0.314	437.731
Gender	-2.128	1.3293	-1.601	0.110	-4.741	0.485	0.119	0.009	1.625
FIFO role	2.209	0.9130	2.419	0.016	0.414	4.003	9.103	1.513	54.782
Have children	-0.245	1.6153	-0.151	0.88	-3.420	2.931	0.783	0.033	18.744
Marital status	1.346	1.7624	0.764	0.446	-2.119	4.810	3.841	0.120	122.765
Shift period	-1.125	0.5571	-2.02	0.044	-2.220	-0.030	0.325	0.109	0.970
Job demand (between-persons)	-2.061	0.7981	-2.583	0.010	-3.630	-0.492	0.127	0.027	0.611
Job demand (within-person)	0.232	0.1325	1.753	0.080	-0.028	0.493	1.261	0.972	1.637
Job control (between-persons)	-1.188	0.9833	-1.208	0.228	-3.121	0.745	0.305	0.044	2.106
Job control (within-person)	0.772	0.1818	4.247	<.001	0.415	1.129	2.164	1.514	3.094
Daily job demand*daily job control	-0.161	0.1082	-1.492	0.136	-0.374	0.051	0.851	0.688	1.053
Daily job demand*aggregate job control	0.558	0.1497	3.725	<.001	0.263	0.852	1.747	1.301	2.345
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	7.857	4.198	1.872	0.061	2.757	22.390			
Shift period	5.403	2.629	2.055	0.040	2.082	14.020			
*Residuals***									
AR1 diagonal	0.593	0.046	12.929	<0.001	0.510	0.690			
AR1 rho	0.170	0.061	2.792	0.005	0.049	0.286			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), gender (male=0, female=1), marital status (married=0, single=1), have children (yes=0, no=1), FIFO role (manual=0, office=1), Shift pattern (rotation shift=0, regular fixed shift=1), shift hours (≤12=0, >12=1)

Appendix J: Supplementary files in Chapter 9

Supplementary Information S15. Panel plots of daily data over assessment days among partners of FIFO workers.

Figure S18. Daily standard drink intake

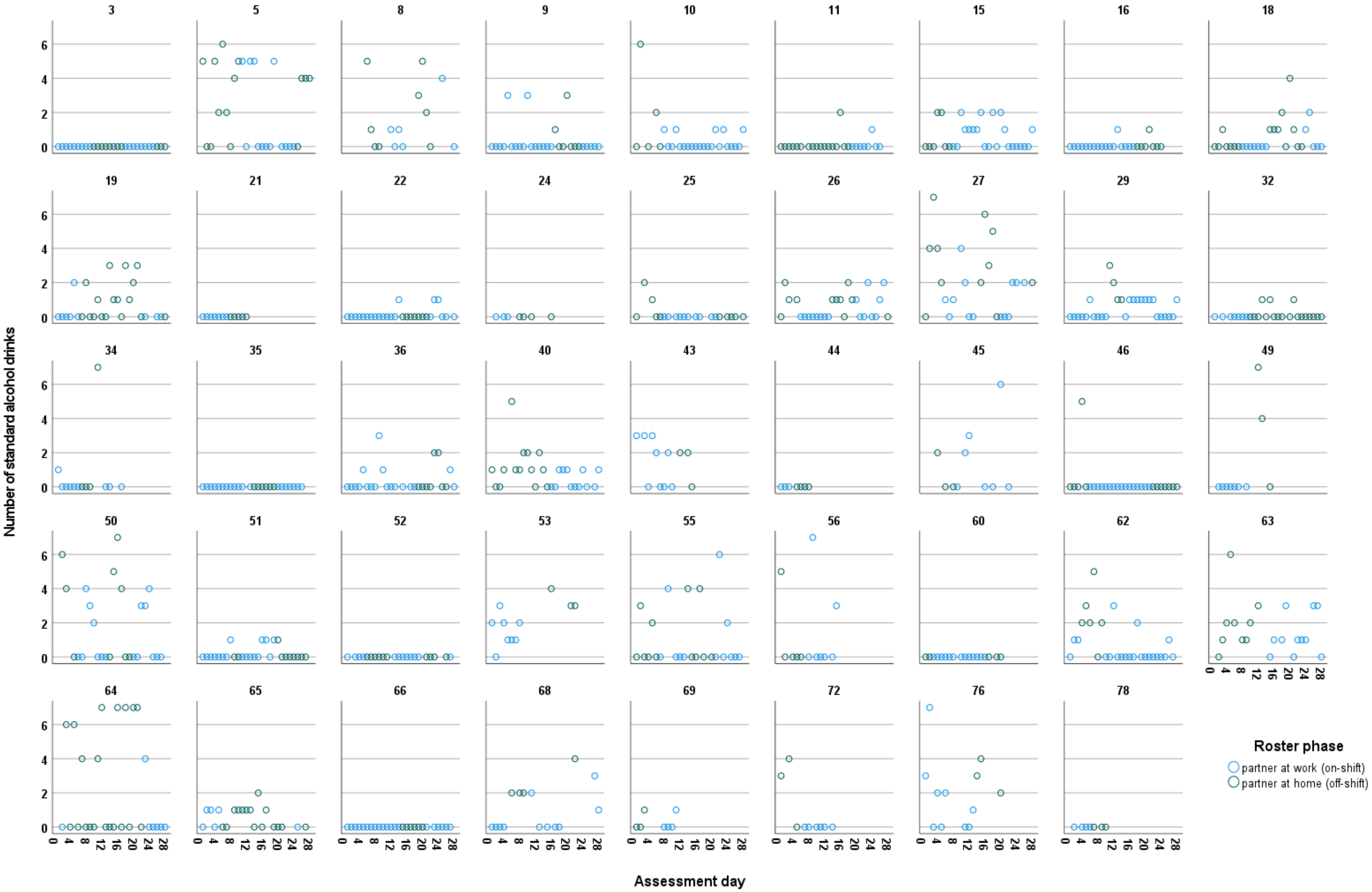


Figure S19. Daily number of cigarettes smoked

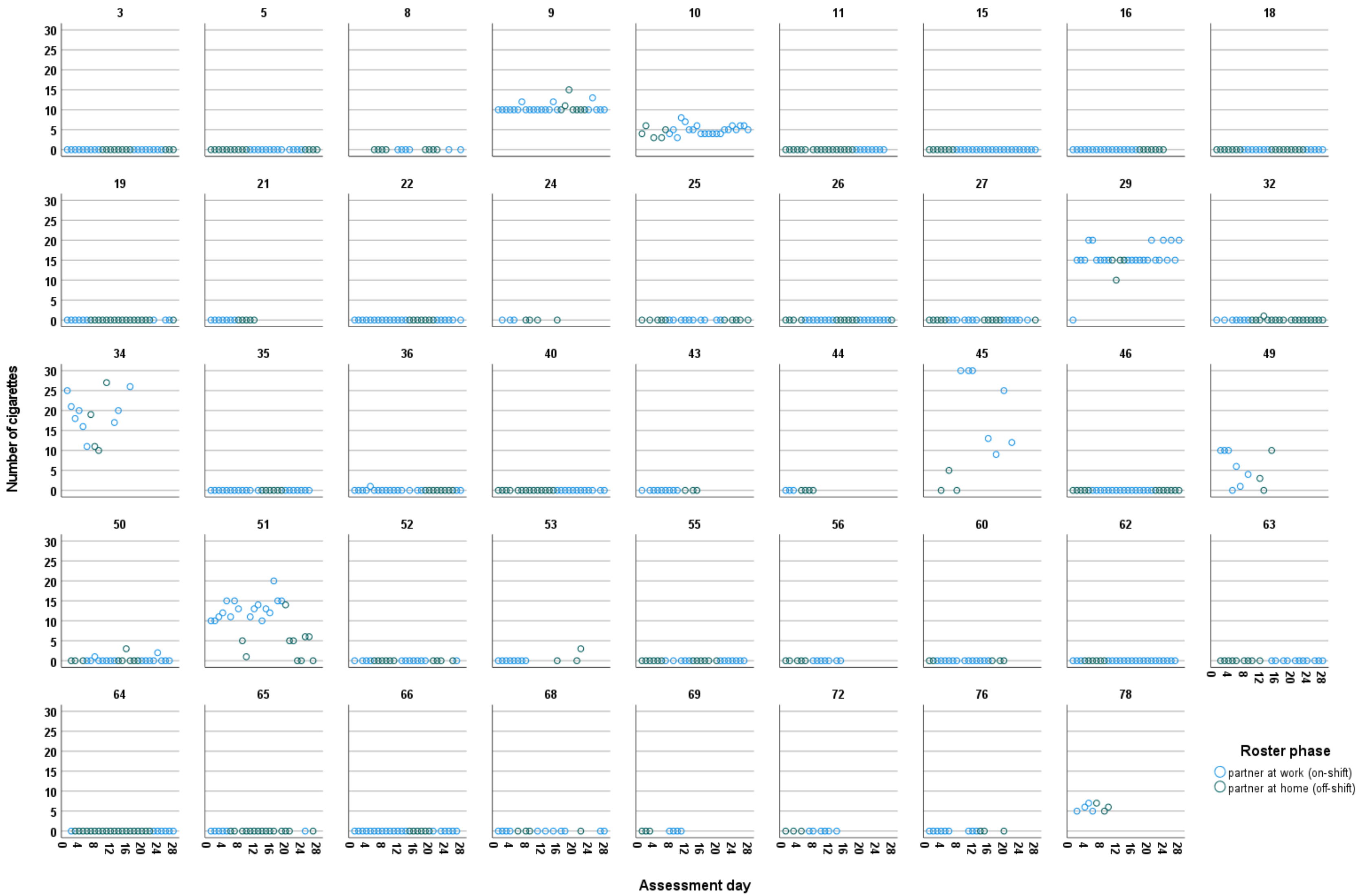


Figure S20. Daily minutes of moderate to vigorous physical activity

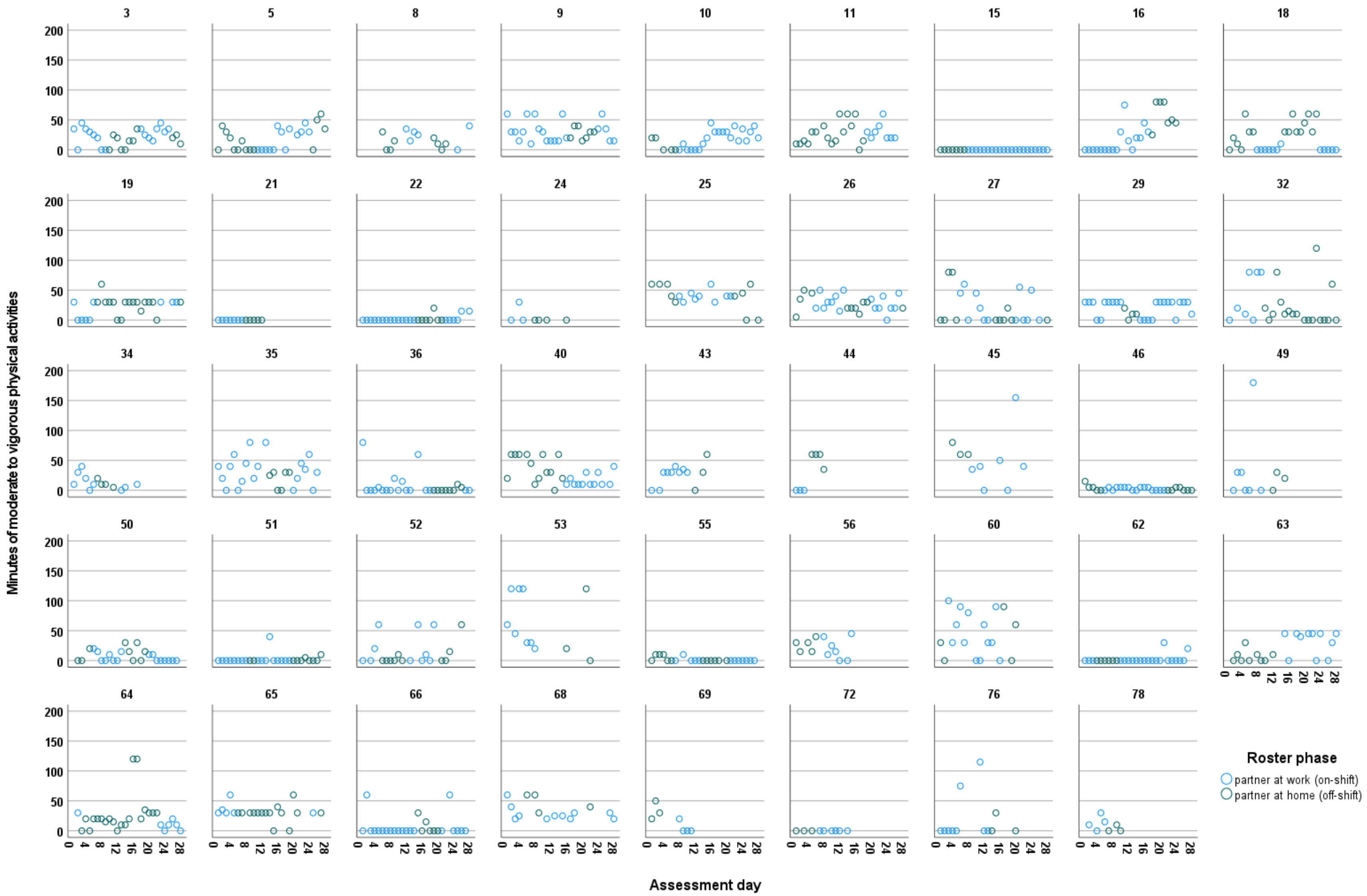


Figure S21. Daily sleep quality

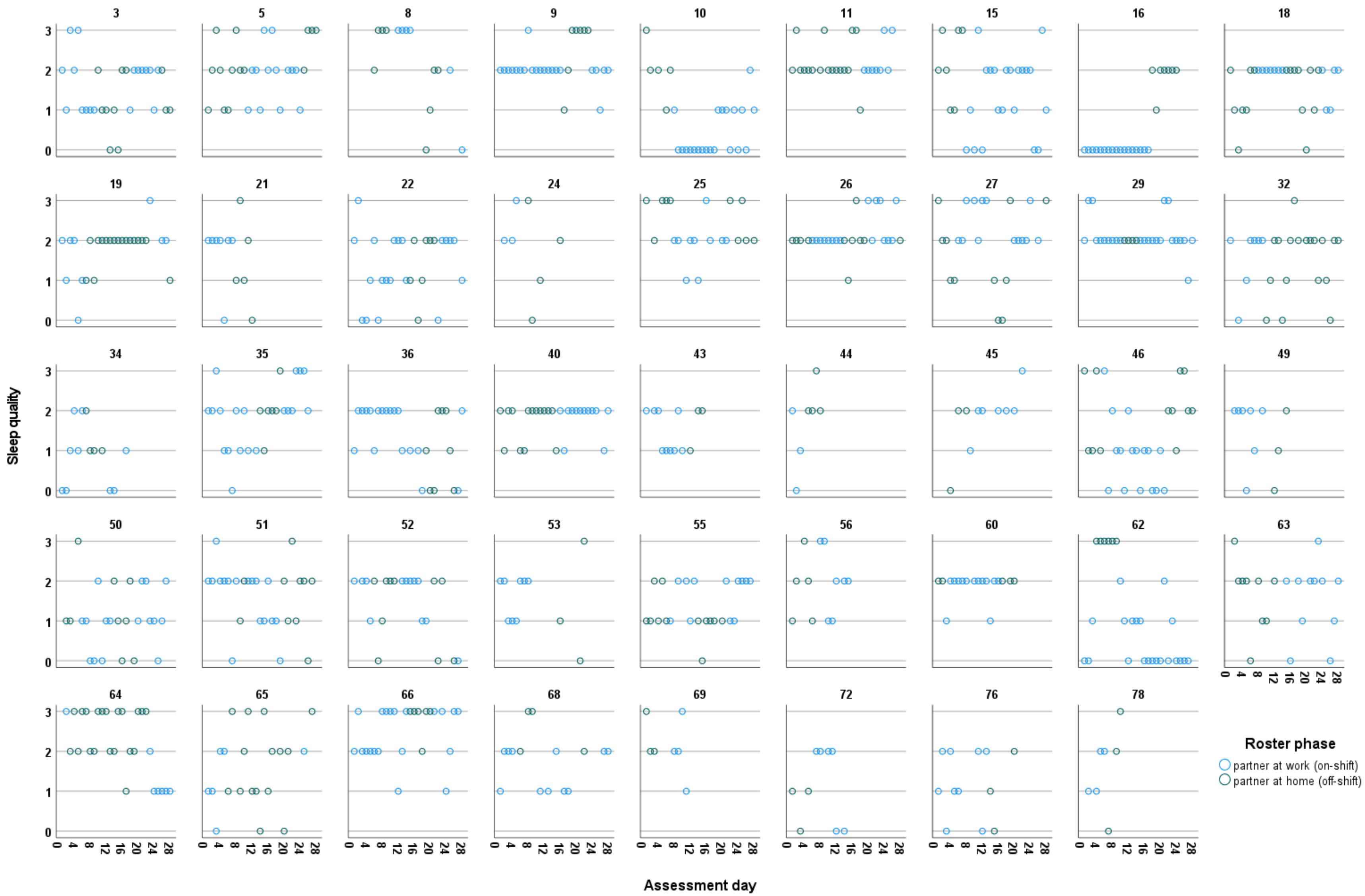


Figure S22. Daily serves of fruits and vegetable intake

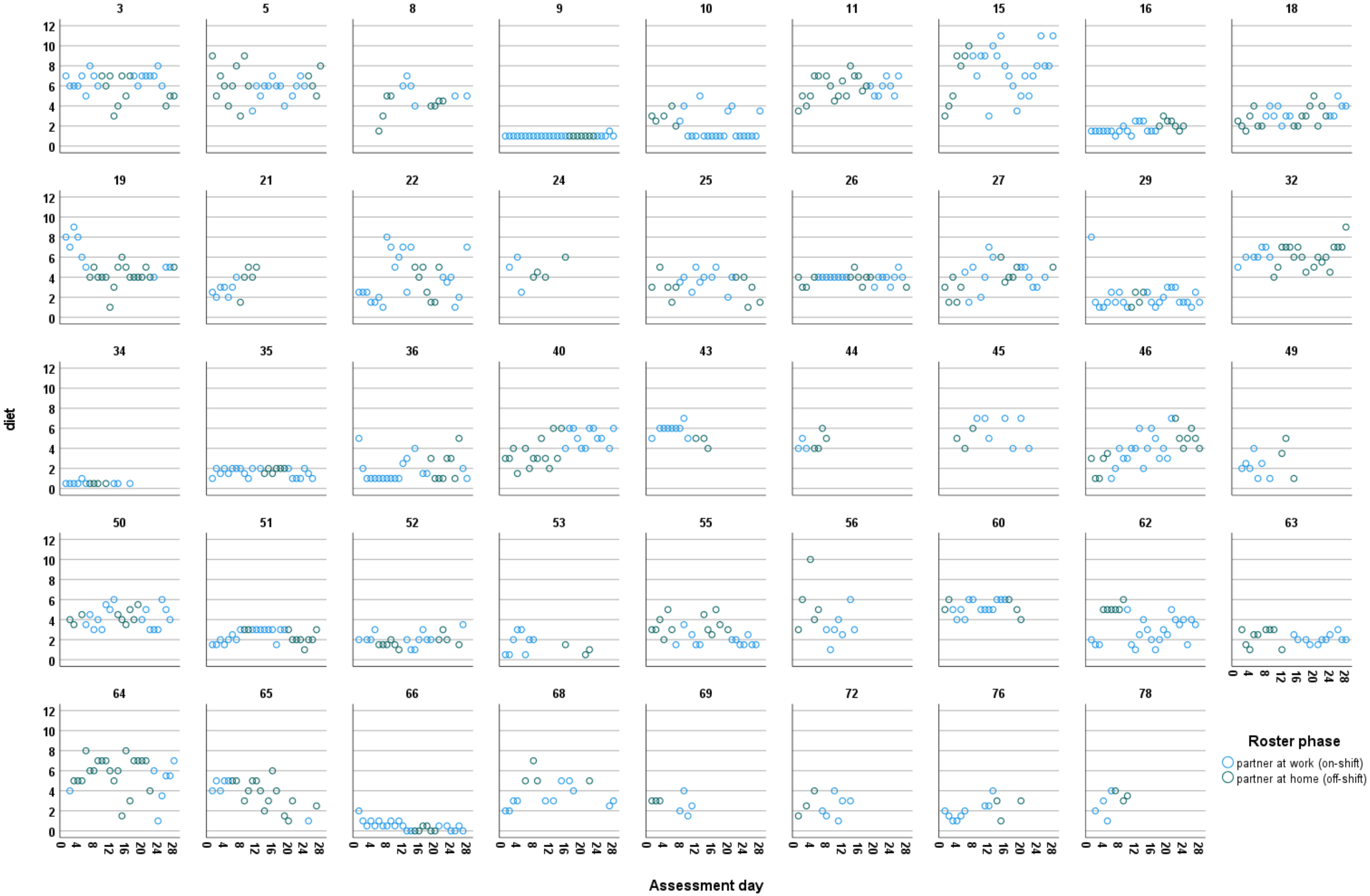


Figure S23. Daily positive affect

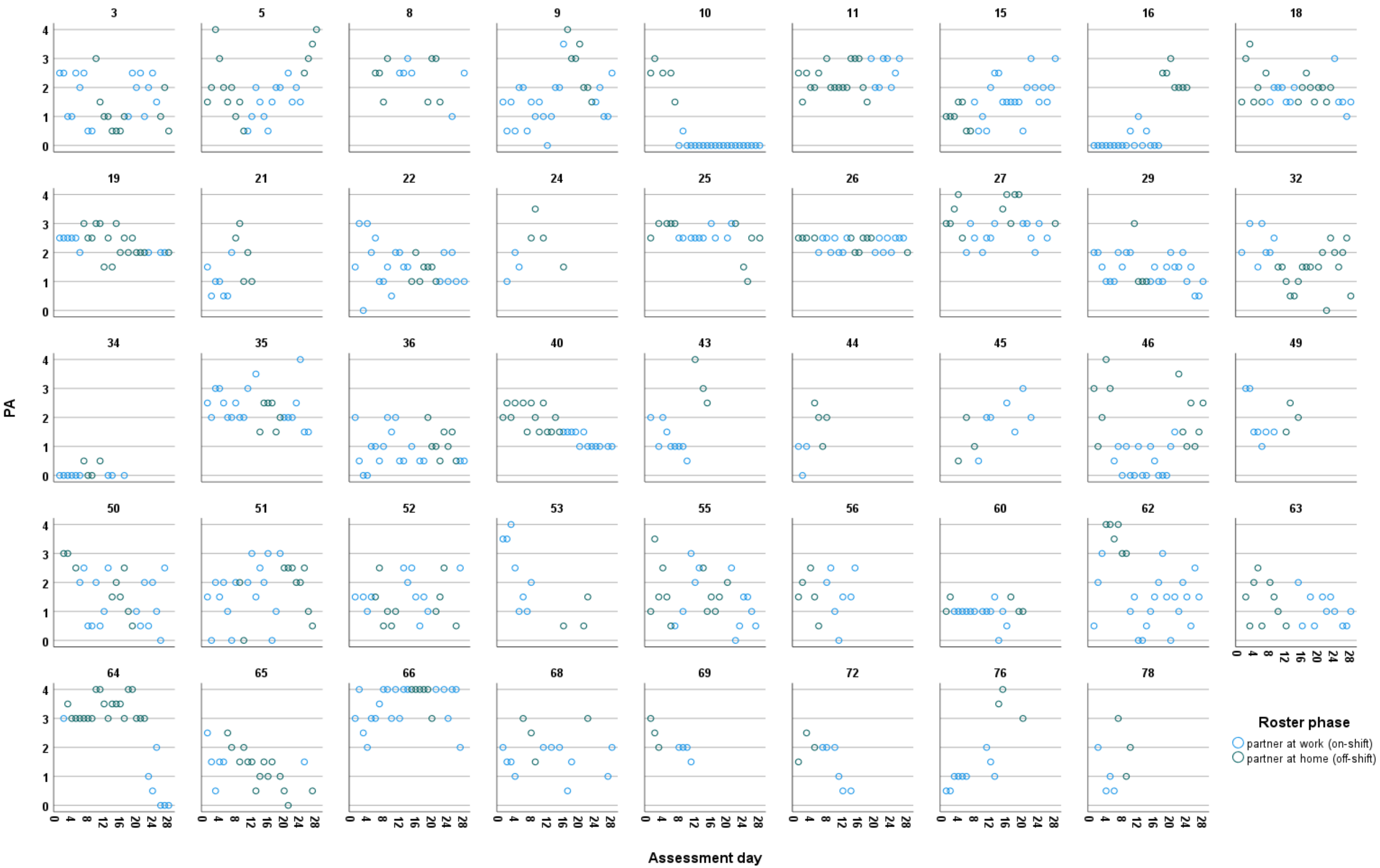


Figure S24. Daily anxious affect

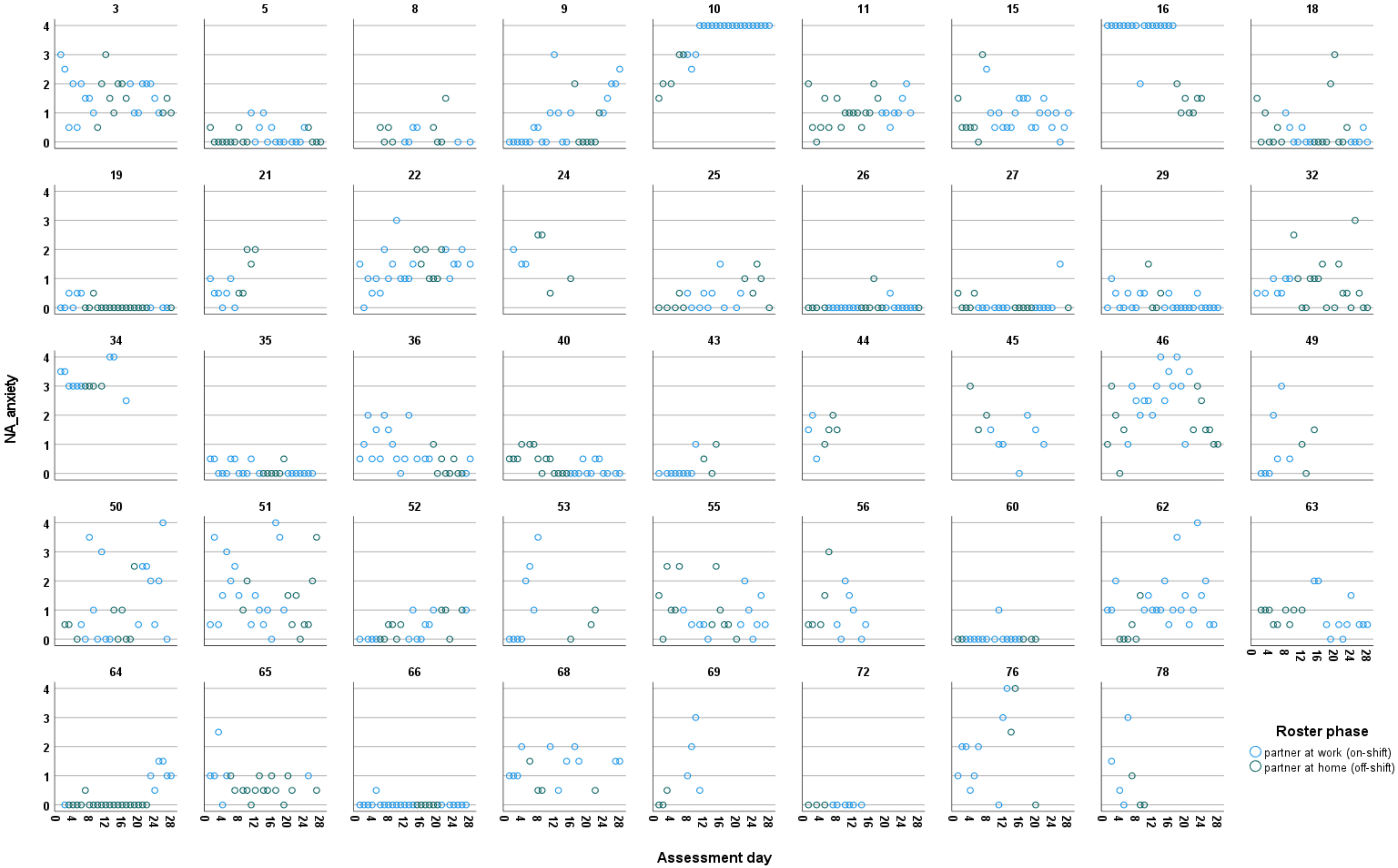
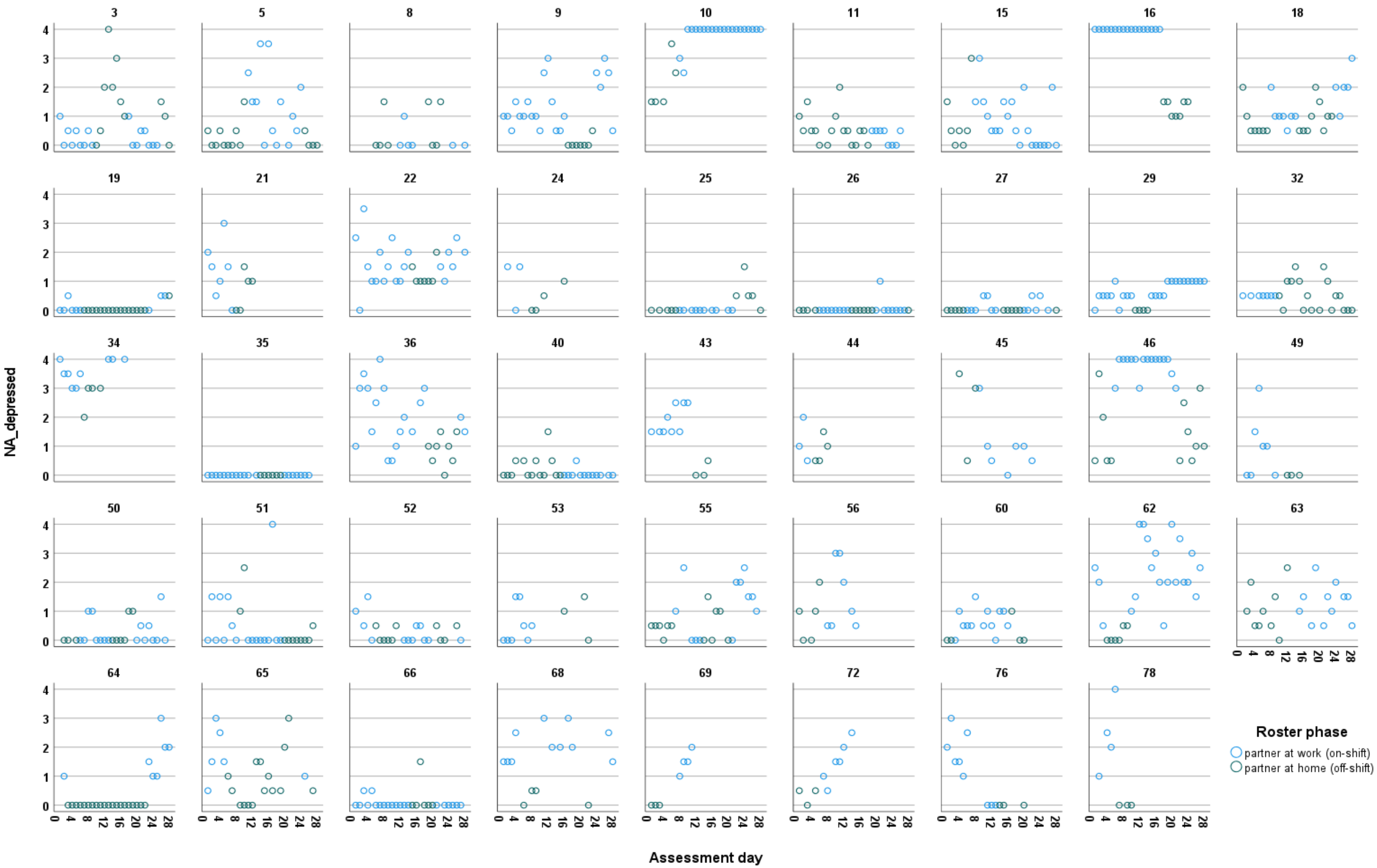


Figure S25. Daily depressed affect



Supplementary Information S16. Spaghetti plots of the within-person relationships between psychosocial factors and health outcomes in partners of FIFO workers

Figure S26. Relationship between job demand, affect, and sleep quality

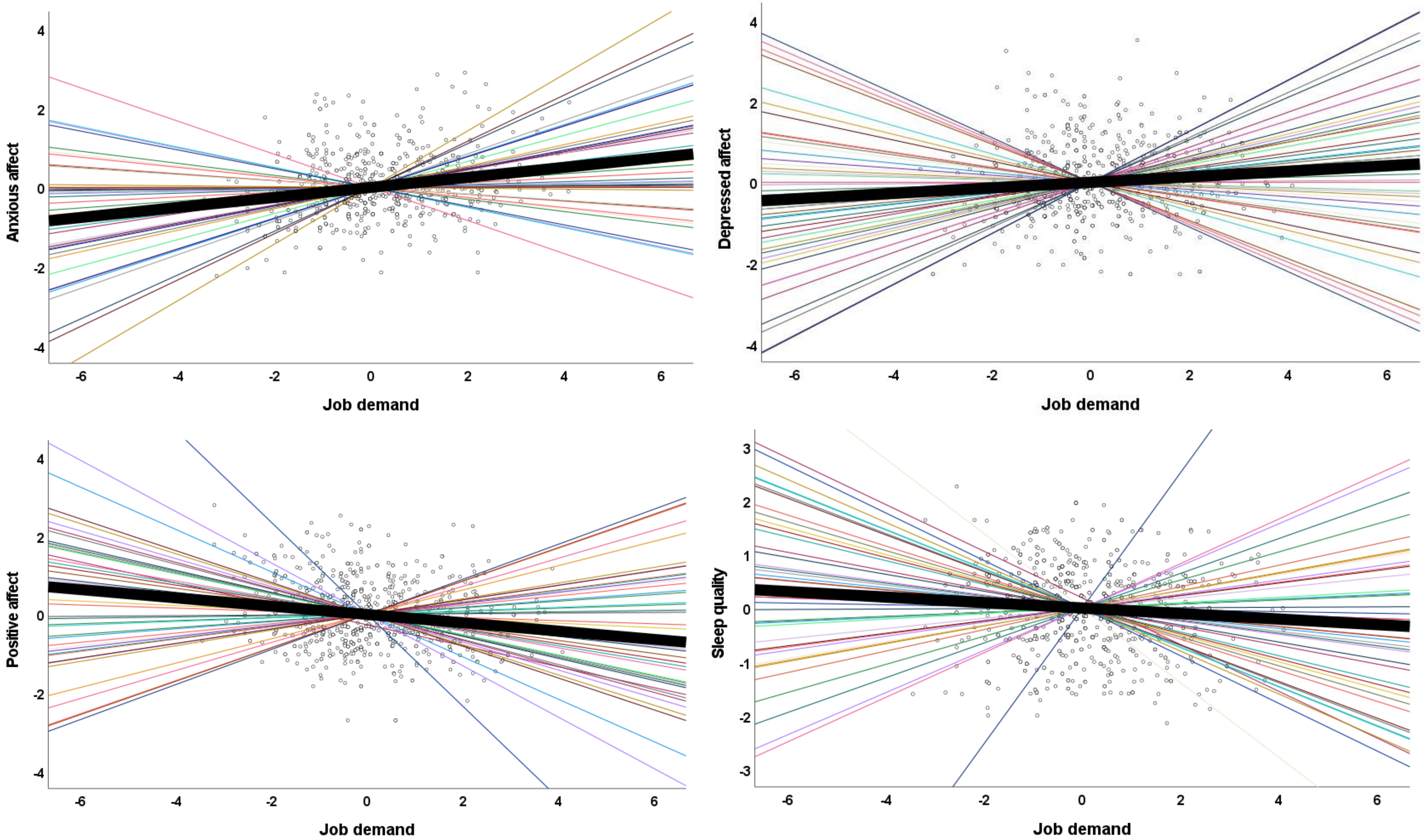


Figure S27. Relationship between job demand and behaviours

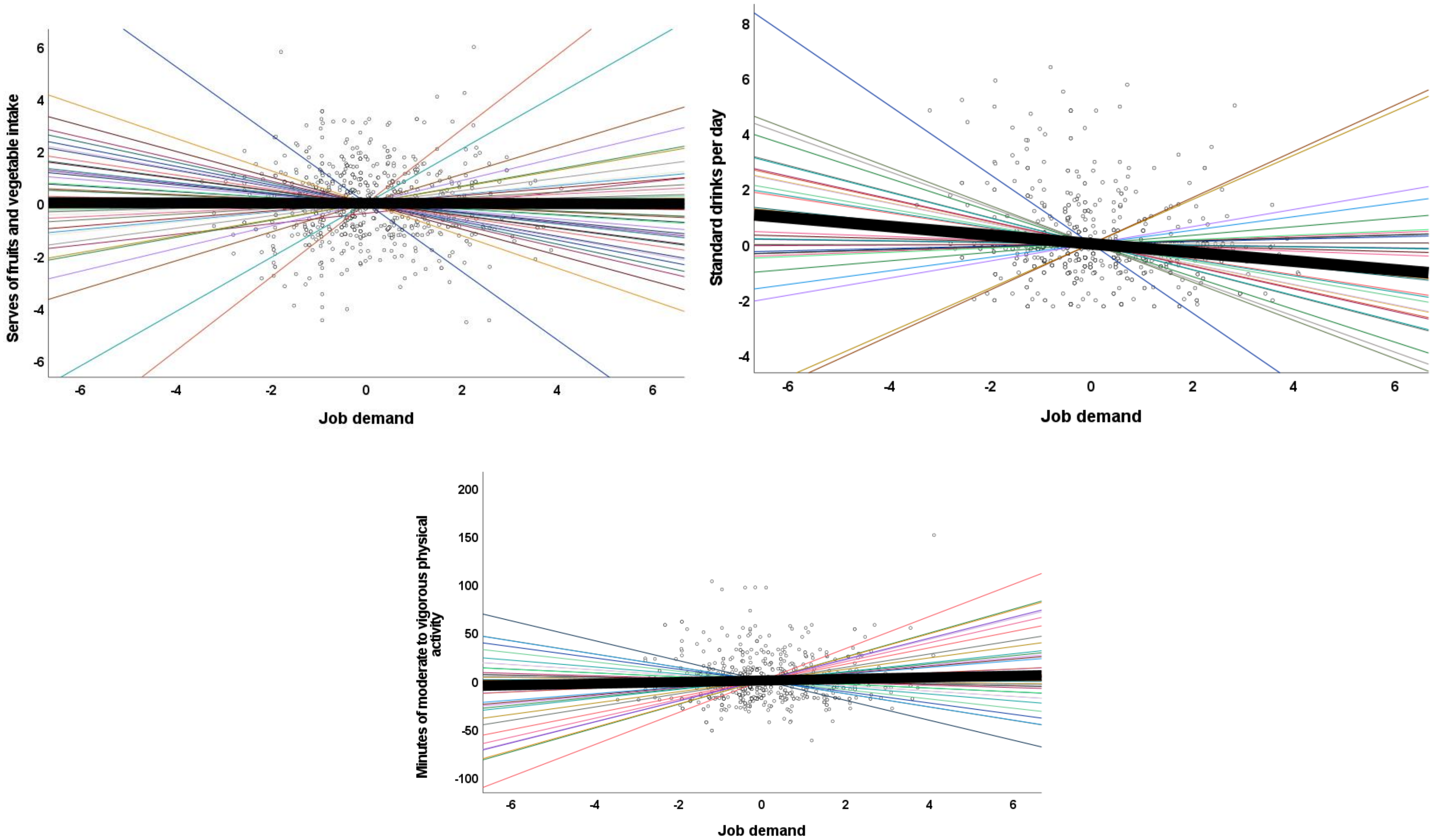


Figure S28. Relationship between job control, affect, and sleep quality

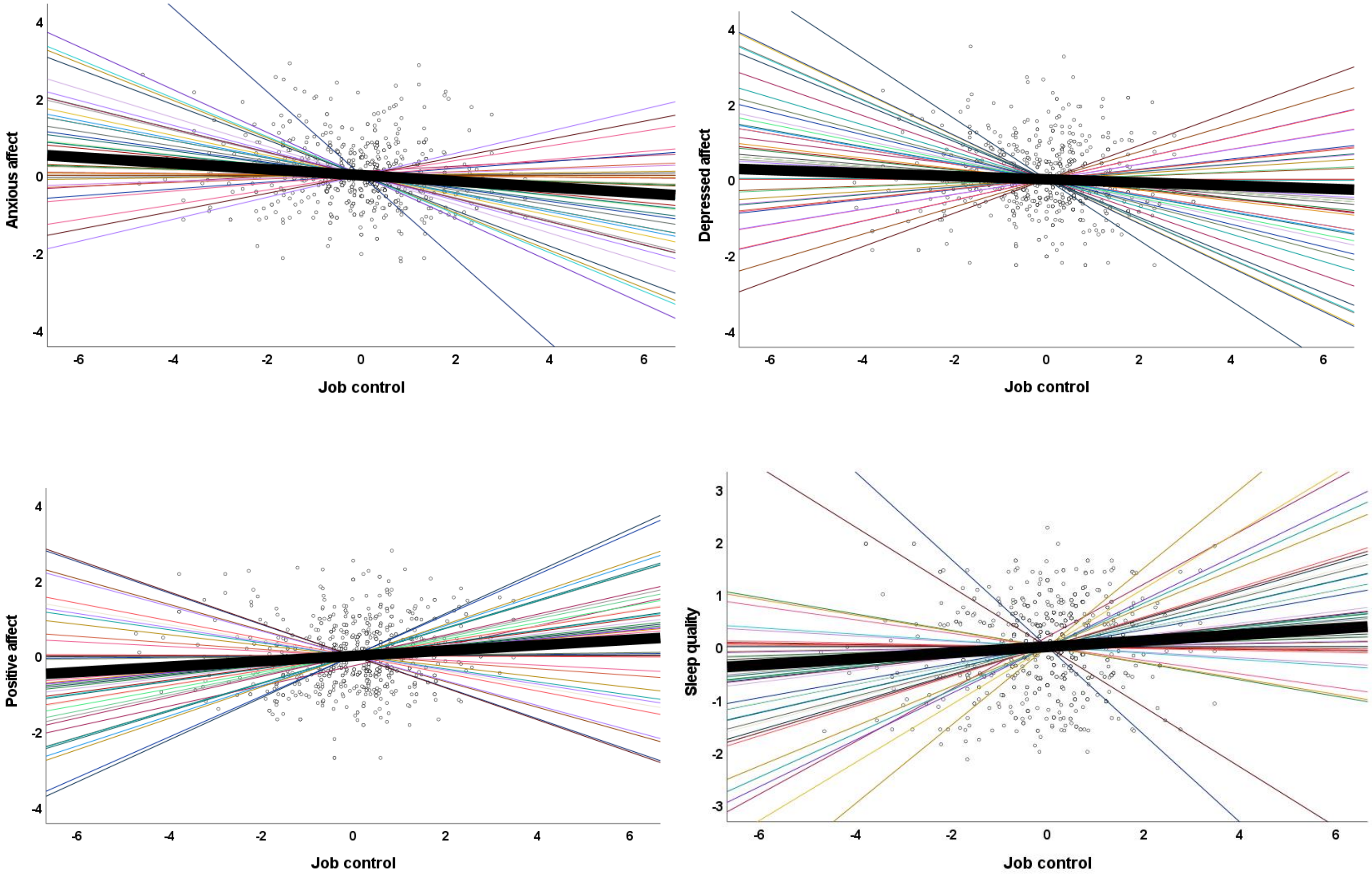


Figure S29. Relationship between job demand and behaviours

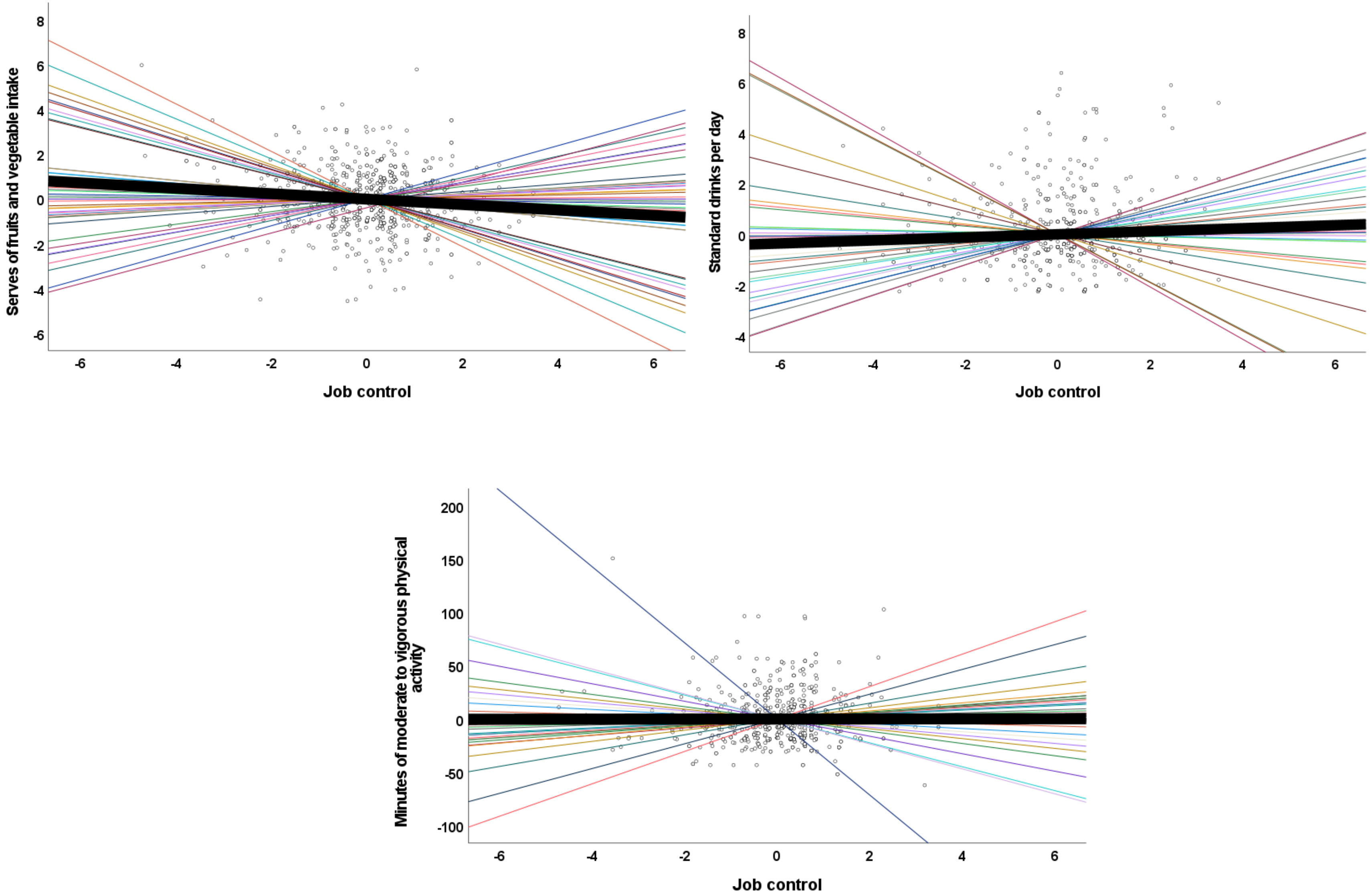


Figure S30. Relationship between social support, affect, and sleep quality

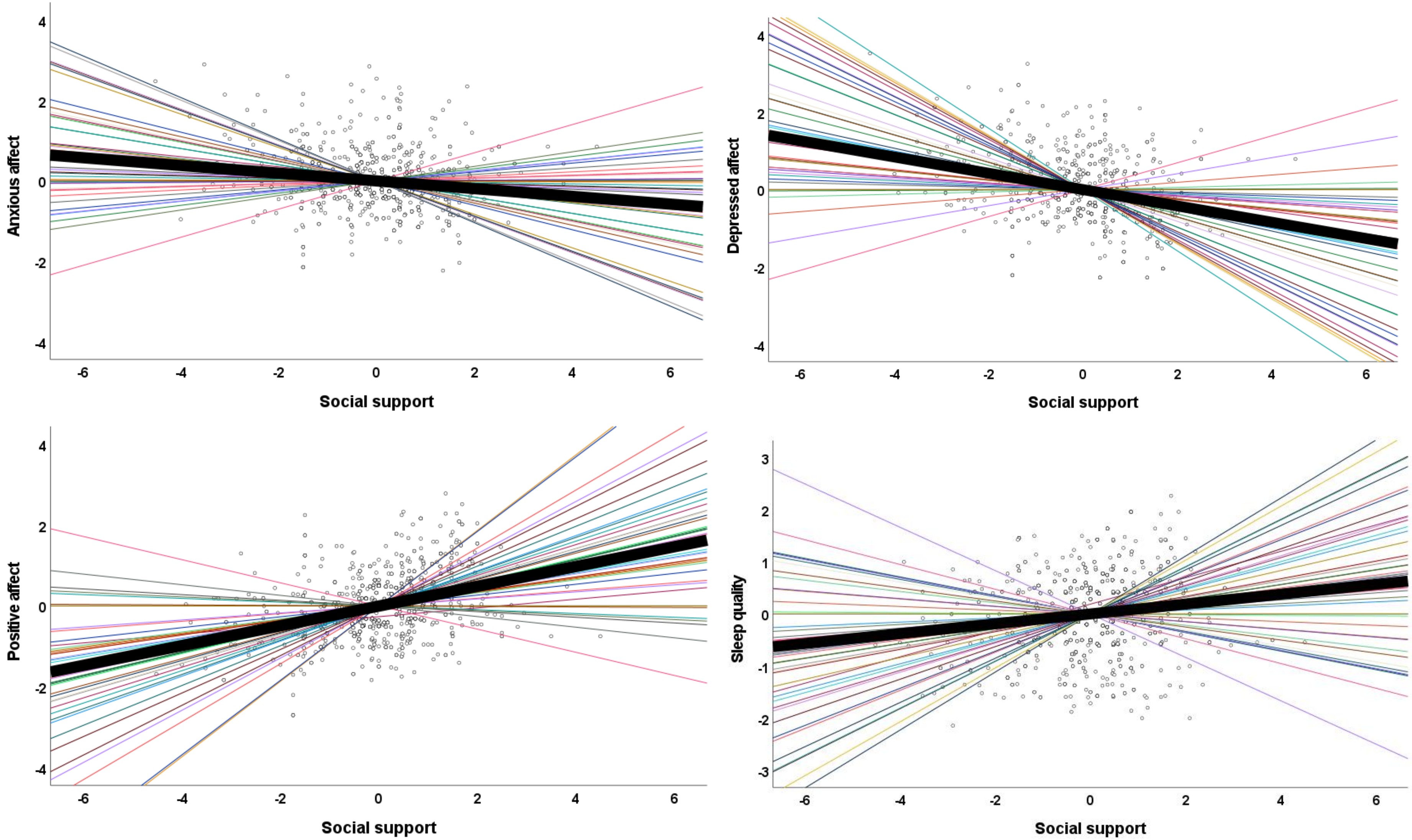
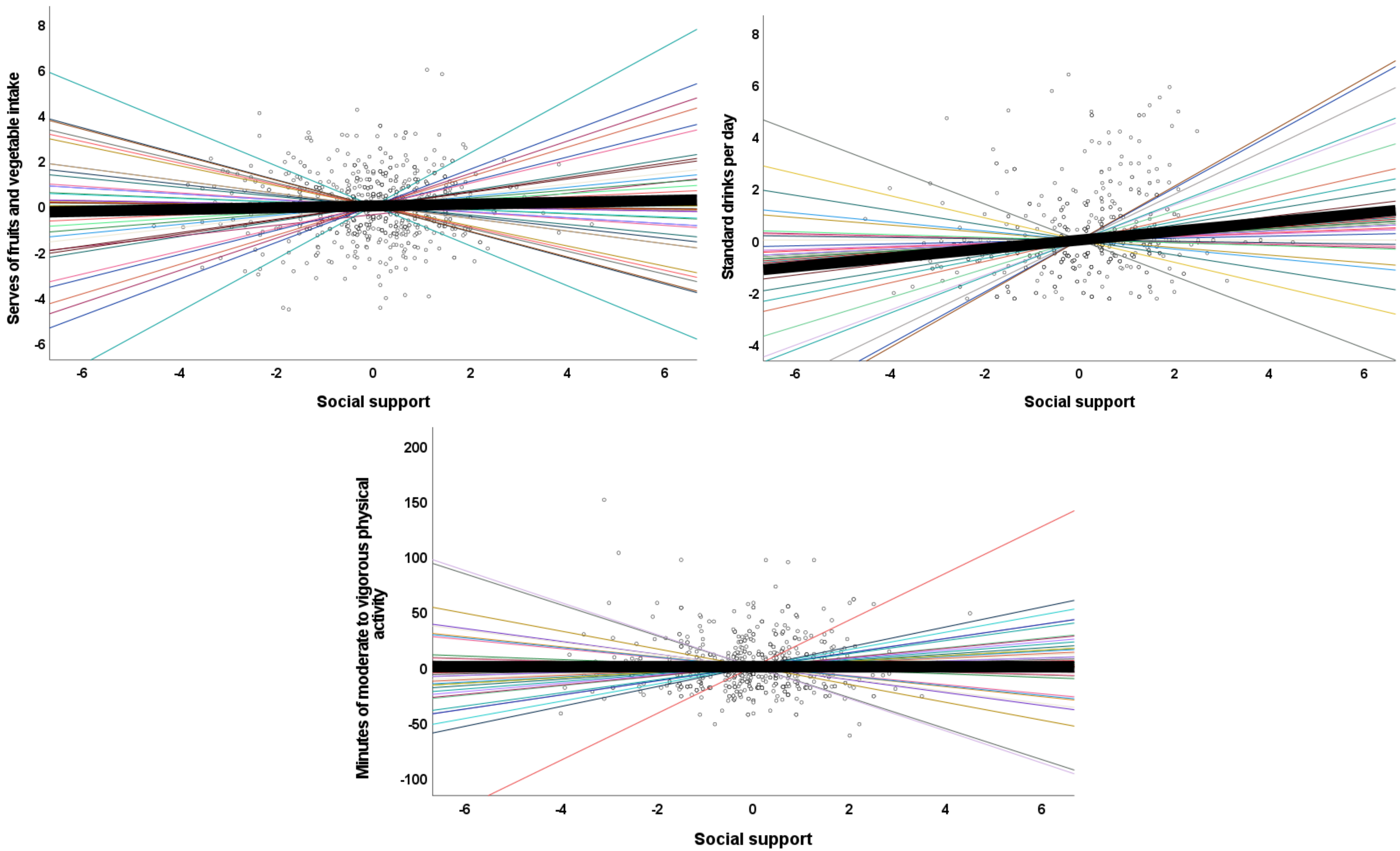


Figure S31. Relationship between social support and behaviours



Supplementary Information S17. Full model of multilevel models predicting daily health outcomes in partners of FIFO workers

Table S34. Multilevel linear models on the effect of shift period on affects and anxious affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	0.446	0.255	31.530	1.750	0.090	-0.073	0.965
Day	0.005	0.004	224.139	1.334	0.184	-0.003	0.013
Age	-0.014	0.013	28.342	-1.071	0.293	-0.042	0.013
Shift hours	-0.199	0.193	31.663	-1.026	0.313	-0.593	0.196
Shift pattern	0.159	0.176	29.226	0.904	0.373	-0.201	0.519
Employment	-0.097	0.206	34.711	-0.470	0.641	-0.516	0.322
FIFO duration	-0.009	0.017	31.949	-0.514	0.611	-0.044	0.026
Consecutive days at work	0.035	0.014	34.794	2.448	0.020	0.006	0.064
Consecutive days at home	-0.033	0.015	37.854	-2.172	0.036	-0.063	-0.002
Have children	0.488	0.246	33.438	1.985	0.055	-0.012	0.989
Shift period	0.174	0.117	33.485	1.496	0.144	-0.063	0.411
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.130	0.048	2.719		0.007	0.063	0.267
Shift period	0.304	0.102	2.983		0.003	0.158	0.587
*Residuals***							
AR1 diagonal	0.444	0.026	16.979		<0.001	0.396	0.498
AR1 rho	0.114	0.045	2.519		0.012	0.025	0.201

Anxious affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S35. Multilevel linear models of the effect of shift period on depressed affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	0.454	0.237	30.217	1.920	0.064	-0.029	0.937
Day	0.003	0.004	205.085	0.850	0.396	-0.004	0.011
Age	-0.017	0.012	26.271	-1.390	0.176	-0.043	0.008
Shift hours	-0.120	0.180	30.243	-0.666	0.510	-0.488	0.248
Shift pattern	0.099	0.163	27.632	0.606	0.549	-0.235	0.433
Employment	-0.136	0.193	33.892	-0.705	0.486	-0.529	0.256
FIFO duration	-0.009	0.016	30.608	-0.546	0.589	-0.042	0.024
Consecutive days at work	0.006	0.013	34.310	0.475	0.638	-0.021	0.033
Consecutive days at home	0.001	0.014	37.323	0.043	0.966	-0.028	0.029
Have children	0.241	0.230	32.788	1.049	0.302	-0.227	0.710
Shift period	0.497	0.162	32.534	3.062	0.004	0.167	0.828
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.101	0.042	2.415		0.016	0.045	0.228
Shift period	0.704	0.202	3.486		<0.001	0.401	1.236
*Residuals***							
AR1 diagonal	0.402	0.024	16.511		<0.001	0.357	0.452
AR1 rho	0.162	0.045	3.578		<0.001	0.072	0.250

Depressed affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S36. Multilevel linear models of the effect of shift period on positive affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.194	0.312	30.969	7.032	<0.001	1.558	2.831
Day	-0.006	0.005	180.601	-1.313	0.191	-0.015	0.003
Age	0.024	0.016	28.292	1.443	0.160	-0.010	0.057
Shift hours	-0.082	0.237	30.775	-0.348	0.730	-0.565	0.400
Shift pattern	-0.073	0.217	29.029	-0.337	0.739	-0.516	0.370
Employment	-0.054	0.251	33.020	-0.215	0.831	-0.565	0.457
FIFO duration	-0.027	0.021	30.898	-1.258	0.218	-0.070	0.017
Consecutive days at work	-0.014	0.017	32.875	-0.829	0.413	-0.050	0.021
Consecutive days at home	-0.006	0.018	34.841	-0.305	0.762	-0.042	0.031
Have children	-0.139	0.300	31.911	-0.463	0.647	-0.751	0.473
Shift period	-0.244	0.124	32.305	-1.964	0.058	-0.496	0.009
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.210	0.072	2.904		0.004	0.107	0.411
Shift period	0.332	0.119	2.799		0.005	0.165	0.669
*Residuals***							
AR1 diagonal	0.495	0.032	15.576		<0.001	0.437	0.562
AR1 rho	0.213	0.047	4.513		<0.001	0.119	0.303

Positive affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S37. Multilevel linear models of the effect of shift period on sleep quality

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.191	0.199	35.254	10.989	<0.001	1.787	2.596
Day	0.003	0.004	204.103	0.739	0.461	-0.005	0.012
Age	0.022	0.010	28.862	2.168	0.039	0.001	0.043
Shift hours	-0.187	0.150	32.977	-1.246	0.221	-0.492	0.118
Shift pattern	-0.173	0.135	30.217	-1.281	0.210	-0.449	0.103
Employment	-0.119	0.163	38.174	-0.731	0.469	-0.448	0.210
FIFO duration	-0.013	0.013	33.421	-0.960	0.344	-0.040	0.014
Consecutive days at work	0.017	0.011	38.705	1.526	0.135	-0.006	0.040
Consecutive days at home	-0.021	0.012	40.908	-1.770	0.084	-0.045	0.003
Have children	-0.234	0.193	36.797	-1.212	0.233	-0.624	0.157
Shift period	-0.095	0.100	42.818	-0.956	0.344	-0.297	0.106
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.050	0.028	1.820		0.069	0.017	0.148
Shift period	0.167	0.066	2.542		0.011	0.077	0.360
*Residuals***							
AR1 diagonal	0.561	0.034	16.715		<0.001	0.499	0.631
AR1 rho	0.118	0.049	2.431		0.015	0.022	0.213

Sleep quality (0=very bad to 3=very good); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S38. Generalised linear mixed model of the effect of shift period on alcohol intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-2.121	1.1393	-1.861	0.063	-4.358	0.116	0.120	0.013	1.123
Day	0.013	0.0138	0.925	0.355	-0.014	0.040	1.013	0.986	1.041
Age	-0.069	0.0493	-1.395	0.163	-0.166	0.028	0.933	0.847	1.028
Shift hours	1.228	0.6527	1.881	0.060	-0.054	2.509	3.414	0.948	12.298
Shift pattern	0.848	0.6950	1.220	0.223	-0.517	2.212	2.334	0.596	9.136
Employment	1.188	0.7790	1.525	0.128	-0.341	2.718	3.281	0.711	15.145
FIFO duration	0.081	0.0768	1.057	0.291	-0.070	0.232	1.085	0.933	1.261
Consecutive days at work	-0.067	0.0433	-1.549	0.122	-0.152	0.018	0.935	0.859	1.018
Consecutive days at home	0.048	0.0400	1.200	0.231	-0.031	0.126	1.049	0.970	1.135
Have children	-0.516	0.9908	-0.521	0.602	-2.462	1.429	0.597	0.085	4.175
Shift period	-1.023	0.2446	-4.182	<0.001	-1.503	-0.543	0.36	0.222	0.581
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	2.911	1.166	2.496	0.013	1.328	6.382			
Shift period									
*Residual***									
AR1 diagonal	0.832	0.049	16.953	<0.001	0.741	0.934			
AR1 rho	0.167	0.044	3.82	<0.001	0.080	0.251			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S39. Generalised linear mixed model of the effect of shift period on physical activity

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-1.476	0.6845	-2.156	0.031	-2.820	-0.132	0.229	0.060	0.877
Day	0.014	0.0171	0.813	0.417	-0.020	0.048	1.014	0.981	1.049
Age	0.011	0.0528	0.209	0.835	-0.093	0.115	1.011	0.912	1.121
Shift hours	0.678	0.6999	0.969	0.333	-0.696	2.052	1.970	0.498	7.785
Shift pattern	-1.104	0.5059	-2.182	0.029	-2.097	-0.111	0.332	0.123	0.895
Employment	1.198	0.6647	1.802	0.072	-0.108	2.503	3.312	0.898	12.217
FIFO duration	-0.076	0.0619	-1.224	0.221	-0.197	0.046	0.927	0.821	1.047
Consecutive days at work	-0.029	0.0489	-0.595	0.552	-0.125	0.067	0.971	0.882	1.069
Consecutive days at home	0.023	0.0675	0.337	0.736	-0.110	0.155	1.023	0.896	1.168
Have children	-0.484	0.9905	-0.488	0.626	-2.429	1.461	0.617	0.088	4.312
Shift period	0.228	0.3476	0.655	0.513	-0.455	0.910	1.256	0.634	2.485
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	2.639	1.161	2.273	0.023	1.114	6.253			
Shift period	2.150	0.962	2.235	0.025	0.895	5.169			
*Residual***									
AR1 diagonal	0.765	0.047	16.262	<0.001	0.678	0.863			
AR1 rho	0.151	0.047	3.191	0.001	0.057	0.242			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity: less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S40. Generalised linear mixed model of the effect of shift period on fruit and vegetable intake in partners

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	0.903	0.4191	2.156	0.032	0.080	1.727	2.468	1.083	5.622
Day	0.001	0.0031	0.297	0.766	-0.005	0.007	1.001	0.995	1.007
Age	-0.015	0.0132	-1.125	0.261	-0.041	0.011	0.985	0.960	1.011
Shift hours	-0.067	0.2007	-0.334	0.739	-0.461	0.327	0.935	0.630	1.387
Shift pattern	0.204	0.1639	1.245	0.214	-0.118	0.526	1.226	0.889	1.692
Employment	0.099	0.2483	0.399	0.690	-0.389	0.587	1.104	0.678	1.798
FIFO duration	0.020	0.0188	1.047	0.296	-0.017	0.057	1.020	0.983	1.058
Consecutive days at work	-0.009	0.0176	-0.530	0.597	-0.044	0.025	0.991	0.957	1.026
Consecutive days at home	0.012	0.0141	0.864	0.388	-0.016	0.040	1.012	0.985	1.041
Have children	0.146	0.3397	0.430	0.667	-0.521	0.814	1.157	0.594	2.256
Shift period	0.021	0.0360	0.585	0.559	-0.050	0.092	1.021	0.952	1.096
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	0.349	0.115	3.033	0.002	0.183	0.665			
[a]Shift period	-	-	-	-	-	-			
*Residual***									
AR1 diagonal	0.427	0.034	12.553	<0.001	0.365	0.499			
AR1 rho	0.411	0.051	7.990	<0.001	0.305	0.507			

Note: Probability distribution: Binomial, Link function: Logit; Fruits and vegetable intake: serves taken; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1);); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in the model and was omitted; Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S41. Multilevel linear model predicting anxious affect in partners

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	0.738	0.203	32.183	3.641	<0.001	0.325	1.151
Day	0.006	0.004	217.318	1.476	0.141	-0.002	0.013
Age	-0.002	0.012	25.225	-0.151	0.881	-0.026	0.023
Shift hours	-0.236	0.149	28.029	-1.590	0.123	-0.541	0.068
Shift pattern	0.106	0.135	27.828	0.782	0.441	-0.171	0.383
Employment	-0.102	0.158	35.090	-0.649	0.521	-0.423	0.218
FIFO duration	-0.006	0.013	30.176	-0.467	0.644	-0.033	0.021
Consecutive days at work	0.040	0.011	33.933	3.657	<0.001	0.018	0.063
Consecutive days at home	-0.039	0.012	35.912	-3.304	0.002	-0.063	-0.015
Have children	0.277	0.195	33.293	1.418	0.166	-0.120	0.674
Shift period	0.127	0.116	35.159	1.092	0.282	-0.109	0.363
Aggregate workload (between-persons)	-0.022	0.087	25.486	-0.255	0.800	-0.202	0.158
Daily workload (within-person)	0.085	0.022	623.136	3.958	<0.001	0.043	0.128
Aggregate Job control (between-persons)	-0.150	0.070	24.717	-2.136	0.043	-0.295	-0.005
Daily Job control (within-person)	-0.050	0.023	621.85	-2.167	0.031	-0.096	-0.005
Aggregate social support (between-persons)	-0.193	0.065	29.771	-2.968	0.006	-0.325	-0.06
Daily social support (within-person)	-0.086	0.023	629.061	-3.728	<0.001	-0.132	-0.041
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.069	0.030	2.253		0.024	0.029	0.164
Shift period	0.298	0.098	3.053		0.002	0.157	0.566
*Residuals***							
AR1 diagonal	0.411	0.025	16.698		<0.001	0.366	0.462
AR1 rho	0.118	0.046	2.564		0.001	0.027	0.208

Anxious affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S42. Multilevel linear model predicting depressed affect in partners

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	0.783	0.168	33.848	4.654	<0.001	0.441	1.126
Day	0.003	0.004	197.398	0.708	0.480	-0.005	0.010
Age	-0.008	0.010	22.201	-0.817	0.423	-0.028	0.012
Shift hours	-0.163	0.122	27.245	-1.339	0.192	-0.413	0.087
Shift pattern	-0.009	0.111	27.850	-0.084	0.934	-0.237	0.218
Employment	-0.199	0.134	38.185	-1.491	0.144	-0.470	0.071
FIFO duration	-0.011	0.011	29.933	-0.977	0.337	-0.033	0.012
Consecutive days at work	0.012	0.009	38.520	1.236	0.224	-0.007	0.031
Consecutive days at home	-0.003	0.010	36.867	-0.324	0.748	-0.023	0.017
Have children	0.063	0.164	36.836	0.384	0.703	-0.270	0.396
Shift period	0.453	0.166	32.887	2.735	0.010	0.116	0.790
Aggregate workload (between-persons)	-0.019	0.071	22.625	-0.265	0.793	-0.165	0.128
Daily workload (within-person)	0.004	0.020	621.065	0.220	0.826	-0.035	0.043
Aggregate Job control (between-persons)	-0.079	0.056	22.029	-1.397	0.176	-0.196	0.038
Daily Job control (within-person)	-0.013	0.021	614.566	-0.608	0.543	-0.055	0.029
Aggregate social support (between-persons)	-0.202	0.054	31.264	-3.745	<0.001	-0.312	-0.092
Daily social support (within-person)	-0.189	0.021	632.985	-8.791	<0.001	-0.231	-0.147
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.015	0.018	0.830		0.407	0.001	0.159
Shift period	0.744	0.209	3.556		<0.001	0.429	1.292
*Residuals***							
AR1 diagonal	0.363	0.022	16.278		<0.001	0.322	0.409
AR1 rho	0.199	0.045	4.429		<0.001	0.110	0.285

Depressed affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S43. Multilevel linear model predicting positive affect in partners

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	1.898	0.278	31.024	6.820	<0.001	1.331	2.466
Day	-0.005	0.004	171.501	-1.144	0.254	-0.013	0.004
Age	0.011	0.017	27.327	0.672	0.507	-0.023	0.046
Shift hours	-0.098	0.207	28.660	-0.473	0.640	-0.521	0.325
Shift pattern	-0.019	0.189	28.349	-0.102	0.919	-0.406	0.367
Employment	-0.041	0.215	32.456	-0.190	0.851	-0.478	0.396
FIFO duration	-0.026	0.018	29.866	-1.410	0.169	-0.063	0.012
Consecutive days at work	-0.018	0.015	31.319	-1.218	0.232	-0.049	0.012
Consecutive days at home	-0.002	0.016	33.039	-0.138	0.891	-0.034	0.030
Have children	0.107	0.267	30.968	0.402	0.690	-0.438	0.652
Shift period	-0.214	0.115	31.695	-1.859	0.072	-0.448	0.021
Aggregate workload (between-persons)	-0.027	0.123	27.689	-0.215	0.831	-0.279	0.226
Daily workload (within-person)	-0.030	0.022	604.727	-1.367	0.172	-0.072	0.013
Aggregate Job control (between-persons)	0.104	0.099	27.103	1.043	0.306	-0.100	0.307
Daily Job control (within-person)	0.046	0.023	599.316	1.987	0.047	0.001	0.092
Aggregate social support (between-person)	0.182	0.090	29.649	2.018	0.053	-0.002	0.365
Daily social support (within-person)	0.189	0.023	622.849	8.119	<0.001	0.144	0.235
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.137	0.052	2.627		0.009	0.065	0.290
Shift period	0.279	0.104	2.693		0.007	0.135	0.578
*Residuals***							
AR1 diagonal	0.435	0.029	15.133		<0.001	0.382	0.495
AR1 rho	0.221	0.048	4.575		<0.001	0.125	0.314

Positive affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S44. Multilevel linear model predicting sleep quality in partners

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	2.106	0.217	35.695	9.724	<0.001	1.666	2.545
Day	0.008	0.005	166.927	1.633	0.104	-0.002	0.017
Age	0.014	0.013	26.395	1.105	0.279	-0.012	0.040
Shift hours	-0.132	0.156	27.194	-0.846	0.405	-0.452	0.188
Shift pattern	-0.244	0.138	26.56	-1.769	0.088	-0.528	0.039
Employment	-0.136	0.173	35.555	-0.787	0.437	-0.487	0.215
FIFO duration	-0.003	0.014	30.253	-0.208	0.837	-0.031	0.025
Consecutive days at work	0.009	0.012	32.103	0.792	0.434	-0.014	0.033
Consecutive days at home	-0.005	0.013	34.287	-0.405	0.688	-0.032	0.022
Have children	-0.181	0.210	35.186	-0.862	0.394	-0.608	0.245
Shift period	-0.102	0.098	41.844	-1.039	0.305	-0.301	0.096
Aggregate workload (between-persons)	0.151	0.089	23.919	1.705	0.101	-0.032	0.334
Daily workload (within-person)	0.043	0.027	530.08	1.587	0.113	-0.010	0.096
Aggregate Job control (between-persons)	0.105	0.072	24.098	1.463	0.156	-0.043	0.253
Daily Job control (within-person)	-0.009	0.029	525.361	-0.317	0.752	-0.067	0.048
Aggregate social support (between-persons)	0.193	0.066	26.521	2.932	0.007	0.058	0.329
Daily social support (within-person)	-0.024	0.029	523.967	-0.815	0.415	-0.080	0.033
Covariance parameters	σ^2	Std. Error	Wald Z				
*Random effect**							
Intercept	0.039	0.027	1.451		0.147	0.010	0.152
Shift period	0.128	0.062	2.048		0.041	0.049	0.333
*Residuals***							
AR1 diagonal	0.544	0.036	15.083		<0.001	0.478	0.620
AR1 rho	0.098	0.054	1.803		0.071	-0.009	0.203

Sleep quality (0=very bad to 4=very good); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S45. Generalized linear mixed model predicting physical activity in partners

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-1.654	0.7887	-2.097	0.036	-3.203	-0.105	0.191	0.041	0.900
Day	0.012	0.0177	0.683	0.495	-0.023	0.047	1.012	0.978	1.048
Age	0.043	0.0666	0.643	0.521	-0.088	0.174	1.044	0.916	1.19
Shift hours	0.591	0.7616	0.776	0.438	-0.904	2.087	1.806	0.405	8.059
Shift pattern	-1.114	0.5256	-2.119	0.034	-2.146	-0.082	0.328	0.117	0.921
Employment	1.237	0.6703	1.845	0.066	-0.080	2.553	3.444	0.923	12.845
FIFO duration	-0.093	0.0693	-1.337	0.182	-0.229	0.043	0.912	0.796	1.044
Consecutive days at work	-0.025	0.0521	-0.478	0.633	-0.127	0.077	0.975	0.881	1.081
Consecutive days at home	0.035	0.071	0.486	0.627	-0.105	0.174	1.035	0.900	1.190
Have children	-0.424	1.0048	-0.422	0.673	-2.397	1.549	0.655	0.091	4.708
Shift period	0.252	0.3592	0.702	0.483	-0.453	0.957	1.287	0.636	2.605
Aggregate workload (between-persons)	0.538	0.3151	1.706	0.088	-0.081	1.156	1.712	0.922	3.178
Daily workload (within-person)	-0.048	0.0846	-0.572	0.567	-0.215	0.118	0.953	0.807	1.125
Aggregate Job control (between-persons)	0.562	0.3994	1.407	0.160	-0.222	1.346	1.754	0.801	3.843
Daily Job control (within-person)	-0.005	0.0872	-0.057	0.954	-0.176	0.166	0.995	0.838	1.181
Aggregate social support (between-persons)	0.039	0.2277	0.170	0.865	-0.408	0.486	1.039	0.665	1.625
Daily social support (within-person)	0.098	0.0672	1.457	0.145	-0.034	0.230	1.103	0.967	1.258
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	3.132	1.450	2.159	0.031	1.264	7.762			
Shift period	2.155	0.980	2.199	0.028	0.884	5.253			
*Residual***									
AR1 diagonal	0.763	0.047	16.155	<0.001	0.676	0.861			
AR1 rho	0.158	0.047	3.331	<0.001	0.064	0.249			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity: less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S46. Generalized linear mixed model predicting alcohol intake in partners

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-2.359	0.9707	-2.430	0.015	-4.265	-0.453	0.095	0.014	0.636
Day	0.016	0.0142	1.111	0.267	-0.012	0.044	1.016	0.988	1.045
Age	-0.021	0.0623	-0.342	0.732	-0.144	0.101	0.979	0.866	1.106
Shift hours	1.472	0.6427	2.290	0.022	0.210	2.734	4.358	1.233	15.395
Shift pattern	1.046	0.6566	1.593	0.112	-0.243	2.335	2.846	0.784	10.333
Employment	1.349	0.7422	1.818	0.070	-0.108	2.807	3.855	0.898	16.558
FIFO duration	0.085	0.0797	1.065	0.287	-0.072	0.241	1.089	0.931	1.273
Consecutive days at work	-0.060	0.0482	-1.249	0.212	-0.155	0.034	0.942	0.856	1.035
Consecutive days at home	0.074	0.0523	1.413	0.158	-0.029	0.177	1.077	0.972	1.193
Have children	-0.796	0.8844	-0.900	0.369	-2.532	0.941	0.451	0.079	2.562
Shift period	-0.974	0.2329	-4.180	<.001	-1.431	-0.516	0.378	0.239	0.597
Aggregate workload (between-persons)	0.726	0.4632	1.568	0.117	-0.183	1.636	2.067	0.833	5.133
Daily workload (within-person)	-0.010	0.0911	-0.110	0.913	-0.189	0.169	0.990	0.828	1.184
Aggregate Job control (between-persons)	0.061	0.2922	0.207	0.836	-0.513	0.634	1.062	0.599	1.886
Daily Job control (within-person)	-0.028	0.0980	-0.282	0.778	-0.220	0.165	0.973	0.803	1.179
Aggregate social support (between-persons)	0.246	0.3756	0.656	0.512	-0.491	0.984	1.279	0.612	2.675
Daily social support (within-person)	0.293	0.0989	2.960	0.003	0.099	0.487	1.340	1.104	1.627
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	3.397	1.424	2.386	0.017	1.494	7.724			
[a]Shift period	-	-	-	-	-	-			
*Residual***									
AR1 diagonal	0.867	0.051	16.874	<0.001	0.772	0.974			
AR1 rho	0.172	0.044	3.929	<0.001	0.085	0.256			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in the model and was omitted; Shift period: on-shift days (1) vs off-shift day (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S47. Generalized linear mixed model predicting fruit and vegetable intake in partners

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	0.927	0.3209	2.890	0.004	0.297	1.558	2.528	1.346	4.749
Day	0.001	0.0029	0.279	0.781	-0.005	0.007	1.001	0.995	1.007
Age	-0.013	0.0164	-0.767	0.443	-0.045	0.020	0.987	0.956	1.020
Shift hours	-0.016	0.1960	-0.080	0.936	-0.401	0.369	0.984	0.670	1.447
Shift pattern	0.223	0.1690	1.318	0.188	-0.109	0.555	1.249	0.897	1.741
Employment	0.108	0.2699	0.399	0.690	-0.423	0.638	1.114	0.655	1.893
FIFO duration	0.023	0.0201	1.120	0.263	-0.017	0.062	1.023	0.983	1.064
Consecutive days at work	-0.008	0.0168	-0.470	0.639	-0.041	0.025	0.992	0.960	1.025
Consecutive days at home	0.012	0.0124	0.988	0.324	-0.012	0.037	1.012	0.988	1.037
Have children	0.086	0.2926	0.293	0.770	-0.489	0.661	1.090	0.613	1.936
Shift period	0.017	0.0344	0.499	0.618	-0.050	0.085	1.017	0.951	1.089
Aggregate workload (between-persons)	0.005	0.1556	0.031	0.975	-0.301	0.310	1.005	0.740	1.364
Daily workload (within-person)	0.006	0.0129	0.450	0.653	-0.020	0.031	1.006	0.981	1.032
Aggregate Job control (between-persons)	-0.104	0.0987	-1.052	0.293	-0.298	0.090	0.901	0.742	1.094
Daily Job control (within-person)	-0.021	0.0180	-1.188	0.235	-0.057	0.014	0.979	0.945	1.014
Aggregate social support (between-persons)	0.001	0.1104	0.005	0.996	-0.216	0.217	1.001	0.805	1.243
Daily social support (within-person)	0.016	0.0142	1.134	0.257	-0.012	0.044	1.016	0.988	1.045
Covariance parameters	σ^2	Std. Error	Z						
*Random effects**									
Intercept	0.391	0.137	2.854	0.004	0.197	0.777			
[a]Shift period	-	-	-	-	-	-			
*Residual***									
AR1 diagonal	0.417	0.033	12.69	<0.001	0.357	0.486			
AR1 rho	0.396	0.052	7.577	<.001	0.289	0.493			

Note: Probability distribution: Negative binomial, Link function: Log; Fruits and vegetable intake: serves taken; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in the model and was omitted; Shift period: on-shift days (1) vs off-shift days (0) of a FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S48. Multilevel linear model predicting anxious affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept	0.744	0.2	32.078	3.713	<.001	0.336	1.152
Day	0.006	0.004	218.653	1.53	0.128	-0.002	0.013
Age	-0.002	0.012	24.973	-0.148	0.883	-0.026	0.023
Shift hours	-0.24	0.147	28.166	-1.632	0.114	-0.542	0.061
Shift pattern	0.098	0.134	27.897	0.731	0.471	-0.176	0.372
Employment	-0.099	0.156	35.12	-0.632	0.532	-0.416	0.219
FIFO duration	-0.005	0.013	29.881	-0.413	0.683	-0.032	0.021
Consecutive days at work	0.041	0.011	33.978	3.712	<.001	0.018	0.063
Consecutive days at home	-0.039	0.012	35.697	-3.354	0.002	-0.063	-0.015
Have children	0.264	0.193	33.251	1.363	0.182	-0.130	0.657
Shift period	0.128	0.117	35.1	1.094	0.281	-0.109	0.365
Aggregate workload (between person)	-0.022	0.086	25.125	-0.257	0.799	-0.200	0.156
Daily workload (within person)	0.042	0.035	632.064	1.210	0.227	-0.026	0.11
Aggregate Job control (between person)	-0.15	0.069	24.587	-2.164	0.04	-0.294	-0.007
Daily Job control (within person)	-0.075	0.036	622.514	-2.065	0.039	-0.146	-0.004
Aggregate social support (between person)	-0.191	0.064	30.037	-2.971	0.006	-0.322	-0.06
Daily social support (within-person)	-0.092	0.036	641.888	-2.534	0.012	-0.163	-0.021
Shift period*daily social support	0.004	0.048	628.344	0.086	0.931	-0.089	0.097
Shift period*daily workload	0.073	0.044	626.998	1.655	0.098	-0.014	0.161
Shift period*daily job control	0.045	0.047	618.92	0.965	0.335	-0.047	0.138
Covariance parameters	**σ^2**	**Std. Error**	**Wald Z**				
*Random effect**							
Intercept	0.048	0.027	1.817		0.069	0.016	0.142
Shift period	0.313	0.100	3.123		0.002	0.167	0.587
*Residuals***							
AR1 diagonal	0.409	0.024	16.767		<.001	0.364	0.460
AR1 rho	0.112	0.046	2.428		0.015	0.021	0.202

Anxious affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S49. Multilevel linear model predicting depressed affect

Parameters	γ	Std. Error	df	t	p-value	95%CI	
						Lower	Upper
Fixed effects							
Intercept							
	0.787	0.165	34.804	4.777	<.001	0.452	1.121
Day	0.003	0.004	195.899	0.723	0.47	-0.005	0.01
Age	-0.009	0.009	22.288	-0.957	0.349	-0.028	0.01
Shift hours	-0.149	0.119	28.016	-1.251	0.221	-0.394	0.095
Shift pattern	-0.009	0.109	28.774	-0.079	0.938	-0.231	0.214
Employment	-0.217	0.131	39.273	-1.652	0.107	-0.482	0.049
FIFO duration	-0.011	0.011	30.203	-0.99	0.33	-0.033	0.011
Consecutive days at work	0.011	0.009	39.831	1.169	0.25	-0.008	0.029
Consecutive days at home	-0.003	0.01	37.206	-0.279	0.782	-0.022	0.017
Have children	0.063	0.161	37.909	0.392	0.697	-0.263	0.389
Shift period	0.454	0.167	32.836	2.729	0.010	0.116	0.793
Aggregate workload (between person)	-0.025	0.069	22.522	-0.361	0.721	-0.167	0.118
Daily workload (within person)	-0.031	0.032	631.119	-0.984	0.325	-0.094	0.031
Aggregate Job control (between person)	-0.083	0.055	22.277	-1.514	0.144	-0.198	0.031
Daily Job control (within person)	-0.013	0.033	632.848	-0.379	0.705	-0.078	0.053
Aggregate social support (between person)	-0.194	0.053	32.705	-3.664	<.001	-0.302	-0.086
Daily social support (within-person)	-0.237	0.033	631.902	-7.14	<.001	-0.302	-0.172
Shift period*daily social support	0.08	0.044	631.561	1.831	0.068	-0.006	0.166
Shift period*daily workload	0.055	0.041	623.246	1.346	0.179	-0.025	0.135
Shift period*daily job control	0.003	0.043	611.867	0.068	0.946	-0.082	0.088
Covariance parameters	**σ^2**	**Std. Error**	**Wald Z**				
*Random effect**							
Intercept	0.015	0.018	0.830		0.407	0.001	0.159
Shift period	0.744	0.209	3.556		<.001	0.429	1.292
*Residuals***							
AR1 diagonal	0.363	0.022	16.278		<.001	0.322	0.409
AR1 rho	0.199	0.045	4.429		<.001	0.110	0.285

Anxious affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S50. Multilevel linear model predicting positive affect

Parameters	**γ**	**Std. Error**	**df**	**t**	**p-value**	**95%CI**	
						Lower	**Upper**
Fixed effects							
Intercept	1.888	0.278	30.965	6.782	<.001	1.32	2.456
Day	-0.005	0.004	168.713	-1.202	0.231	-0.014	0.003
Age	0.013	0.017	27.306	0.753	0.458	-0.022	0.047
Shift hours	-0.109	0.207	28.816	-0.525	0.603	-0.533	0.315
Shift pattern	-0.016	0.189	28.408	-0.086	0.932	-0.403	0.37
Employment	-0.022	0.215	32.5	-0.103	0.919	-0.459	0.415
FIFO duration	-0.026	0.018	29.807	-1.412	0.168	-0.063	0.012
Consecutive days at work	-0.017	0.015	31.344	-1.158	0.256	-0.048	0.013
Consecutive days at home	-0.003	0.016	32.996	-0.202	0.841	-0.035	0.029
Have children	0.112	0.267	30.972	0.421	0.677	-0.433	0.658
Shift period	-0.216	0.116	31.609	-1.863	0.072	-0.451	0.02
Aggregate workload (between person)	-0.02	0.123	27.648	-0.163	0.871	-0.273	0.232
Daily workload (within person)	0.01	0.035	609.539	0.286	0.775	-0.058	0.078
Aggregate Job control (between person)	0.104	0.099	27.2	1.048	0.304	-0.1	0.308
Daily Job control (within person)	0.009	0.037	608.376	0.256	0.798	-0.063	0.081
Aggregate social support (between person)	0.177	0.09	29.816	1.966	0.059	-0.007	0.361
Daily social support (within-person)	0.248	0.036	628.528	6.813	<.001	0.177	0.32
Shift period*daily social support	-0.095	0.048	609.409	-1.989	0.047	-0.189	-0.001
Shift period*daily workload	-0.058	0.044	597.996	-1.301	0.194	-0.145	0.029
Shift period*daily job control	0.056	0.047	588.572	1.199	0.231	-0.036	0.149
Covariance parameters	**σ^2**	**Std. Error**	**Wald Z**				
*Random effect**							
Intercept	0.138	0.052	2.626		0.009	0.065	0.290
Shift period	0.285	0.105	2.713		0.007	0.138	0.587
*Residuals***							
AR1 diagonal	0.431	0.029	15.087		<.001	0.378	0.491
AR1 rho	0.223	0.049	4.551		<.001	0.125	0.316

Positive affect (0=not at all to 4=extremely); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S51. Multilevel linear model predicting sleep quality

Parameters	**γ**	**Std. Error**	**df**	**t**	**p-value**	**95%CI**	
						Lower	**Upper**
Fixed effects							
Intercept	2.17	0.216	35.845	10.041	<.001	1.731	2.608
Day	0.009	0.005	164.73	1.821	0.07	-0.001	0.018
Age	0.014	0.013	25.876	1.129	0.269	-0.012	0.04
Shift hours	-0.181	0.156	27.247	-1.16	0.256	-0.501	0.139
Shift pattern	-0.286	0.138	26.493	-2.075	0.048	-0.568	-0.003
Employment	-0.133	0.172	34.867	-0.776	0.443	-0.483	0.216
FIFO duration	-0.002	0.014	29.466	-0.174	0.863	-0.03	0.026
Consecutive days at work	0.01	0.012	31.583	0.898	0.376	-0.013	0.034
Consecutive days at home	-0.006	0.013	33.407	-0.449	0.657	-0.033	0.021
Have children	-0.224	0.209	34.699	-1.07	0.292	-0.649	0.201
Shift period	-0.095	0.098	41.147	-0.969	0.338	-0.294	0.103
Aggregate workload (between person)	0.164	0.088	23.34	1.869	0.074	-0.017	0.346
Daily workload (within person)	0.015	0.044	533.256	0.335	0.738	-0.072	0.101
Aggregate Job control (between person)	0.125	0.071	23.771	1.749	0.093	-0.023	0.273
Daily Job control (within person)	0.085	0.048	524.288	1.759	0.079	-0.01	0.179
Aggregate social support (between person)	0.173	0.066	26.931	2.609	0.015	0.037	0.308
Daily social support (within-person)	0.003	0.047	544.275	0.061	0.951	-0.09	0.096
Shift period*daily social support	-0.058	0.061	531.067	-0.966	0.334	-0.177	0.06
Shift period*daily workload	0.048	0.056	533.59	0.869	0.385	-0.061	0.158
Shift period*daily job control	-0.148	0.06	521.582	-2.445	0.015	-0.266	-0.029
Covariance parameters	**σ^2**	**Std. Error**	**Wald Z**				
*Random effect**							
Intercept	0.038	0.027	1.414		0.157	0.010	0.152
Shift period	0.129	0.063	2.041		0.041	0.049	0.337
*Residuals***							
AR1 diagonal	0.534	0.036	14.939		<.001	0.468	0.609
AR1 rho	0.107	0.055	1.962		0.050	-0.001	0.212

Sleep quality (0=very bad to 4=very good); *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixe shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0)

Table S52. Generalized linear mixed model predicting physical activity

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-1.696	0.8085	-2.098	0.036	-3.284	-0.109	0.183	0.037	0.897
Day	0.012	0.018	0.649	0.516	-0.024	0.047	1.012	0.977	1.048
Age	0.042	0.0671	0.629	0.53	-0.09	0.174	1.043	0.914	1.19
Shift hours	0.649	0.7702	0.843	0.399	-0.863	2.162	1.914	0.422	8.685
Shift pattern	-1.115	0.5221	-2.136	0.033	-2.14	-0.09	0.328	0.118	0.914
Employment	1.284	0.6759	1.9	0.058	-0.043	2.612	3.613	0.958	13.622
FIFO duration	-0.092	0.0703	-1.305	0.192	-0.23	0.046	0.912	0.795	1.047
Consecutive days at work	-0.027	0.0524	-0.506	0.613	-0.13	0.076	0.974	0.879	1.079
Consecutive days at home	0.036	0.0712	0.511	0.609	-0.103	0.176	1.037	0.902	1.193
Have children	-0.475	1.0072	-0.472	0.637	-2.453	1.502	0.622	0.086	4.493
Shift period	0.254	0.3678	0.691	0.49	-0.468	0.976	1.29	0.626	2.655
Aggregate workload (between person)	0.543	0.3131	1.733	0.084	-0.072	1.157	1.721	0.93	3.182
Daily workload (within person)	-0.19	0.1579	-1.201	0.23	-0.5	0.12	0.827	0.607	1.128
Aggregate Job control (between person)	0.561	0.4073	1.377	0.169	-0.239	1.361	1.752	0.788	3.899
Daily Job control (within person)	-0.096	0.162	-0.591	0.555	-0.414	0.222	0.909	0.661	1.249
Aggregate social support (between person)	0.063	0.2332	0.269	0.788	-0.395	0.521	1.065	0.673	1.683
Daily social support (within-person)	0.01	0.1218	0.082	0.935	-0.229	0.249	1.01	0.795	1.283
Shift period*daily social support	0.125	0.1587	0.79	0.430	-0.186	0.437	1.134	0.83	1.548
Shift period*daily workload	0.22	0.2008	1.096	0.274	-0.174	0.614	1.246	0.84	1.848
Shift period*daily job control	0.181	0.2291	0.788	0.431	-0.269	0.631	1.198	0.764	1.879
Covariance parameters	**σ^2**	**Std. Error**	**Z**						
*Random effects**									
Intercept	3.178	1.471	2.161	0.031	1.283	7.871			
Shift period	2.176	0.989	2.201	0.028	0.893	5.301			
*Residual***									
AR1 diagonal	0.769	0.048	16.145	<.001	0.681	0.869			
AR1 rho	0.154	0.047	3.244	0.001	0.060	0.246			

Note: Probability distribution: Binomial, Link function: Logit; Physical activity (MVPA): less than 30 minutes=0, at least 30 minutes=1; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixe shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0); Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) odds in MVPA for a 1-unit increase in the predictor

Table S53. Generalized linear mixed model predicting alcohol intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	-2.403	0.9903	-2.427	0.016	-4.348	-0.459	0.09	0.013	0.632
Day	0.015	0.0154	0.988	0.323	-0.015	0.045	1.015	0.985	1.046
Age	-0.013	0.0637	-0.207	0.836	-0.138	0.112	0.987	0.871	1.118
Shift hours	1.373	0.6551	2.097	0.036	0.087	2.66	3.949	1.091	14.292
Shift pattern	1.028	0.6573	1.563	0.118	-0.263	2.318	2.794	0.769	10.16
Employment	1.467	0.7385	1.986	0.047	0.016	2.917	4.335	1.017	18.481
FIFO duration	0.087	0.0819	1.065	0.287	-0.074	0.248	1.091	0.929	1.282
Consecutive days at work	-0.055	0.0478	-1.15	0.251	-0.149	0.039	0.946	0.862	1.04
Consecutive days at home	0.07	0.0527	1.319	0.188	-0.034	0.173	1.072	0.967	1.189
Have children	-0.844	0.9004	-0.938	0.349	-2.613	0.924	0.43	0.073	2.519
Shift period	-0.939	0.2371	-3.959	<.001	-1.404	-0.473	0.391	0.246	0.623
Aggregate workload (between person)	0.799	0.4717	1.695	0.091	-0.127	1.726	2.224	0.881	5.616
Daily workload (within person)	0.035	0.1706	0.203	0.84	-0.301	0.37	1.035	0.74	1.447
Aggregate Job control (between person)	0.106	0.2929	0.361	0.718	-0.469	0.681	1.112	0.625	1.976
Daily Job control (within person)	-0.135	0.1589	-0.847	0.397	-0.447	0.177	0.874	0.64	1.194
Aggregate social support (between person)	0.205	0.3663	0.56	0.575	-0.514	0.925	1.228	0.598	2.521
Daily social support (within-person)	0.59	0.1655	3.566	<.001	0.265	0.915	1.804	1.304	2.497
Shift period*daily social support	-0.556	0.2783	-1.998	0.046	-1.102	-0.01	0.573	0.332	0.99
Shift period*daily workload	-0.045	0.2311	-0.194	0.846	-0.499	0.409	0.956	0.607	1.505
Shift period*daily job control	0.185	0.1664	1.111	0.267	-0.142	0.512	1.203	0.868	1.668
Covariance parameters	**σ^2**	**Std. Error**	**Z**						
*Random effects**									
Intercept	3.504	1.461	2.398	0.016	1.547	7.933			
Shift period	-	-	-	-	-	-			
*Residual***									
AR1 diagonal	0.825	0.049	16.790	<.001	0.734	0.927			
AR1 rho	0.178	0.044	4.047	<.001	0.091	0.262			

Note: Probability distribution: Binomial, Link function: Logit; Alcohol intake: yes=1, no=0; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in model and was omitted; Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0); Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) odds in alcohol intake for a 1-unit increase in the predictor

Table S54. Generalized linear mixed model predicting fruits and vegetable intake

Parameters	γ	Std. Error	t	p-value	95%CI		Exp (γ)	95%CI	
					Lower	Upper		Lower	Upper
Fixed effects									
Intercept	0.925	0.3197	2.894	0.004	0.297	1.553	2.522	1.346	4.727
Day	0.001	0.0028	0.189	0.85	-0.005	0.006	1.001	0.995	1.006
Age	-0.012	0.0164	-0.754	0.451	-0.045	0.02	0.988	0.956	1.02
Shift hours	-0.027	0.1956	-0.136	0.892	-0.411	0.358	0.974	0.663	1.43
Shift pattern	0.217	0.1698	1.276	0.202	-0.117	0.55	1.242	0.89	1.734
Employment	0.113	0.2714	0.417	0.677	-0.42	0.646	1.12	0.657	1.909
FIFO duration	0.023	0.02	1.13	0.259	-0.017	0.062	1.023	0.983	1.064
Consecutive days at work	-0.008	0.0168	-0.448	0.654	-0.041	0.026	0.992	0.96	1.026
Consecutive days at home	0.012	0.0124	0.965	0.335	-0.012	0.036	1.012	0.988	1.037
Have children	0.082	0.2933	0.279	0.78	-0.494	0.658	1.085	0.61	1.931
Shift period	0.02	0.0335	0.605	0.545	-0.046	0.086	1.02	0.955	1.09
Aggregate workload (between person)	0.007	0.1553	0.048	0.962	-0.298	0.313	1.007	0.742	1.367
Daily workload (within person)	-0.031	0.0121	-2.562	0.011	-0.055	-0.007	0.97	0.947	0.993
Aggregate Job control (between person)	-0.098	0.1005	-0.975	0.33	-0.295	0.1	0.907	0.744	1.105
Daily Job control (within person)	-0.028	0.0173	-1.615	0.107	-0.062	0.006	0.972	0.94	1.006
Aggregate social support (between person)	-0.002	0.1095	-0.018	0.986	-0.217	0.213	0.998	0.805	1.238
Daily social support (within-person)	0.028	0.023	1.232	0.219	-0.017	0.074	1.029	0.983	1.076
Shift period*daily social support	-0.027	0.0325	-0.838	0.403	-0.091	0.037	0.973	0.913	1.037
Shift period*daily workload	0.061	0.0203	2.998	0.003	0.021	0.101	1.063	1.021	1.106
Shift period*daily job control	0.008	0.0337	0.247	0.805	-0.058	0.074	1.008	0.944	1.077
Covariance parameters	**σ^2**	**Std. Error**	**Z**						
*Random effects**									
Intercept	0.392	0.137	2.857	0.004	0.197	0.778			
[a]Shift period	-	-	-	-	-	-			
*Residual***									
AR1 diagonal	0.412	0.033	12.656	<0.001	0.353	0.481			
AR1 rho	0.397	0.052	7.619	<0.001	0.481	0.495			

Note: Probability distribution: Negative binomial, Link function: Log; Fruits and vegetable intake: serves taken; *Random effect covariance structure: unstructured; **Residual covariance structure: first-order autoregressive (AR1); [a]Random effects of shift period did not fit with covariance and when estimating variances only (diagonal) in model and was omitted; Shift period: on-shift days (1) vs off shift day (0) of FIFO roster cycle, Day of assessment (centred at day 14), age (mean centred at 0), have children (yes=0, no=1), partner's shift pattern (rotation shift=0, regular fixed shift=1), partner's shift hours (≤12=0, >12=1), employment status (solely home chores=0, employ outside home=1), duration spent in FIFO (mean centred at 0), partner's days spent at home (mean centred at 0), partner's days spent at work (mean centred at 0); Exp(γ) is interpreted as an increase (values > 1) or decrease (values < 1) in serves of fruits and vegetable intake for a 1-unit increase in the predictor