***"A hard day's night?"* The effects of Compressed Working Week interventions on the health and work-life balance of shift workers: a systematic review**

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Abstract

Objective To systematically review studies of the effects of the Compressed Working Week on the health and work-life balance of shift workers, and to identify any differential impacts by socio-economic group.

Design Systematic review. Following QUORUM guidelines, we searched for published or unpublished experimental and quasi-experimental studies.

Data sources: 27 electronic databases, websites, bibliographies, and expert contacts.

Results 40 observational studies were found. The majority of studies only measured self-reported outcomes and the methodological quality of the included studies was not very high. Interventions did not always improve the health of shift workers, but in the five prospective studies with a control group, there were no detrimental effects on self-reported health. However, work-life balance was generally improved. No studies reported differential impacts by socio-economic group, however most of the studies were conducted on homogeneous populations.

Conclusion This review suggests that the Compressed Working Week can improve work-life balance, and that it may do so with a low risk of adverse health or organisational effects. However, better designed studies which measure objective health outcomes are needed..

Abstract: 175 words

INTRODUCTION

Work has long been acknowledged as an important social determinant of health and health inequalities.[1-4] Employment, or lack of it, and the quality and type of employment are vital in terms of income and social status in all advanced industrialised societies. However, the nature of work has altered considerably over the past two decades, not least in terms of the cultivation of labour market practices in which skills, working hours, contracts, conditions, pay and location are more flexible.[5,6] Similarly, a 24 hour society has started to emerge with associated concerns about abnormal working hours and work-life balance (WLB).[7]

In this context, recent reports from the UK Department of Health and Department of Work and Pensions, the US Department of Health and Human Services, and the World Health Organization show that the workplace is increasingly being considered by policymakers as an important intervention point at which health can be improved and health inequalities reduced.[4,8-11] Attention to date though has focused on the psychosocial work environment, in particular psychological demands and job control (individual decision authority), as explored in depth in the Whitehall studies.[12-16] However there is a largely-untapped literature on the effects of particular types of work patterning on health and health inequalities, and in particular there is a large body of evidence spanning several decades, which describes the negative effects of shift work on health and wellbeing.[17-18]

Reported health problems associated with shift work include sleep disturbances, fatigue, digestive problems, and stress-related illnesses, as well as increases in general morbidity, and in sickness absence.[9] These health problems may derive from disruption to physiological, psychological and social circadian rhythms[17-18] as shift work, particularly that involving night work, disrupts the natural circadian rhythm, leading to disruption of sleep (as natural alerting mechanisms such as the cortisol surge and temperature rise will interrupt sleep) and daytime functioning (wakefulness at night will be reduced by temperature drops and melatonin surges). Sudden changes in schedule can therefore have an effect akin to ‘jet lag’. Disruption to the circadian rhythm can also lead to disharmony within the body as some

functions (e.g., heart rate) adapt more quickly than others (typically endogenous functions such as body temperature, melatonin).[18] This leads to desynchronisation which itself can result in psychological malaise, fatigue and gastro-intestinal problems. Realignment can take several weeks.[18] Most existing research emphasises these physiological changes, but shift work also involves significant *social* desynchronisation, involving working at times and on days that may make it difficult to maintain a balanced domestic and social life (WLB).[20] Literature also suggests that cardiovascular problems such as hypertension and heart disease may be related to shift work. [21] It has also been suggested that shift work is associated with breast cancer, (possibly due to circadian disruption) and the birth of pre-term (premature) babies, but the current evidence base is inconclusive.[22-24] Shift work may also involve increased risk of injuries and accidents as performance fluctuates.[26]

Shift work may therefore be an important, but largely overlooked determinant of health and wellbeing for many workers. The practice is common with one in five European workers involved in shift work,[25] though the definition of the term can be complex (the Labour Force Survey for example identifies ten different categories).[27] Shift work is also socially patterned, being less common in graduates, and more common amongst manual workers and those working in the manufacturing or health care sectors.[27]

Changes to the organisation of shift work have the potential to reduce these negative health effects and perhaps also have an impact on social inequalities in health and wellbeing. A popular organisational level intervention is changing the hours of shift work by introducing a Compressed Working Week (CWW). The CWW is an alternative work schedule in which the hours worked per day are increased whilst the days worked are decreased in order to work the standard number of weekly hours in less than five days. [28] The CWW therefore represents a radical break with the 8 hour working day length favoured by workers and trade unions.[27] However, a cap still remains on the number of hours worked per week (a maximum of 48 hours under the European Union Working Time Directive).[27] The most popular forms of CWW are the *12 hour CWW*, *10 hour CWW* and the *Ottawa* system.[18] The

12 hour CWW involves four 12 hour shifts (day, night) over four days with three or four days off. Under a *10 hour CWW*, four 10 hour shifts are worked followed by three days off. The *Ottawa* system consists of three or four 10 hour morning or afternoon shifts spread over four days then two days off. This is followed by a block of seven 8 hour nights then six days off.

In this paper, we present the results of the first systematic review of primary empirical studies on the health and WLB effects of changes to the organisation and experience of shift work brought about by CWW interventions, and any differential impacts by social group. Although previous literature reviews of CWW exist, these concentrate on observational epidemiological (descriptive or comparative) studies rather than evaluative intervention studies and have not been conducted using full systematic review methodology.[7,19,29]

METHODS

Inclusion and Exclusion

We sought to identify all empirical studies (both prospective and retrospective, with or without control groups) that examined the effects of CWW interventions on the health and WLB of shift workers and their families. For the purposes of the review, shift work was defined as "any regularly taken employment outside the hours of 0700 and 1800".[18] Interventions had to be implemented in actual workplaces and so non-workplace laboratory-based studies were excluded. Health related outcomes included specific diseases as well as more general measures of physical or psychological health and wellbeing. Sickness absence, health behaviours and injuries resulting from workplace accidents were included, as were physiological measures, and measures of physical and mental wellbeing such as tiredness, fatigue and sleep.[22] The social impacts of the interventions, specifically on WLB were also examined. Organisational effects (e.g. job satisfaction, individual or organisational performance), when reported alongside the primary outcomes (health and WLB), were also recorded to help in understanding the motivations behind the CWW interventions and also their viability. Impacts on inequalities in health were considered as outcomes.

Search strategy

We searched 27 electronic databases and websites for documents of any type, from any country, at any time and in any language. Details of the databases searched and an example search for MEDLINE are detailed in Boxes 1 and 2. The full search strategy is available in Web Appendix 1. We also searched bibliographies, and reference lists.

Box 1: Databases and websites

The following 27 databases and websites were searched from start date to November 2005: ASSIA (CSA), EU Community Research & Development Information Service, Dissertation Abstracts, Eric (CSA), European Commission Libraries Catalogue, Econlit (Webspirs), Electronic Collections Online (FirstSearch), Embase (Ovid), Geobase (FirstSearch), Harvard Business Review, HMIC (OVID), Index to Theses, International Bibliography of the Social Sciences (OVID), JSTOR, Labordoc, Management Contents (Dialog), Medline (Ovid), Medline In-Process & Other Non-Indexed Citations (OVID), NTIS, PAIS (Webspirs), PapersFirst (FirstSearch), Psycinfo (Ovid), REGARD (ESRC), Research Papers in Economics, Social Science Citation Index (Web of Science), Sigle (Webspirs), Sociological Abstracts (CSA).

Data Extraction

We located 13308 titles, of which 419 were examined in more detail, and of these 88 were retrieved for full paper analysis. The lead reviewer (CB) excluded obviously irrelevant titles and abstracts from the initial literature search, and retrieved full text copies of the remainder. Studies making any reference to health or wellbeing were independently appraised by two reviewers (CB and MP), who re-examined papers jointly to resolve disagreements. We included percentages, confidence intervals (CIs), *P* values, and effect sizes when they were reported in the original study or calculated these statistics (using final sample sizes) if sufficient information was available (although lack of data was a problem in some studies).

Box 2: Example search strategy (MEDLINE)

1. shiftwork$.ti,ab.
2. nightwork$.ti,ab.
3. ((shift or shifts) adj2 (work$ or night$)).ti,ab.
4. (night$ adj2 work$).ti,ab.
5. nightshift$.ti,ab.
6. ((shift or shifts) adj2 (rota$ or system or systems or schedule$ or roster$)).ti,ab.
7. ((shift or shifts) adj2 (extend$ or pattern$ or cycle$)).ti,ab.
8. ((shift or shifts) adj2 (evening or late or early or weekend or twilight)).ti,ab.
9. (hour$ adj (shift or shifts)).ti,ab.
10. ((shift or shifts) adj2 (continental or continuous or turnaround or split)).ti,ab.
11. ((nonstandard or non-standard) adj2 (work$ or shift or shifts)).ti,ab.
12. ((unsocia$ or antisocia$ or anti-socia$) adj2 (work$ or shift or shifts)).ti,ab.
13. (irregular$ adj2 (work$ or shift or shifts)).ti,ab.
14. compressed work$.ti,ab.
15. long work$ hour$.ti,ab.
16. (extend$ adj (duty or duties or work$) adj hour$).ti,ab.
17. overtime.ti,ab.
18. (flextime or flex time or flexitime or flexi time).ti,ab.
19. (flex$ adj work$).ti,ab.
20. work schedule tolerance/
21. or/1-20
22. exp Legislation/
23. legislat$.ti,ab.
24. (law or laws).ti,ab.
25. work$ time directive.ti,ab.
26. ((eu or europe$) adj3 work$).ti,ab.
27. european union/
28. (european adj (commission or union)).ti,ab.
29. bright light$.ti,ab.
30. (nap or naps or napped or napping).ti,ab.
31. clockwise.ti,ab.
32. (reorganis$ or reorganiz$ or re-organis$ or re-organiz$).ti,ab.
33. (restructur$ or re-structur$).ti,ab.
34. (entrain$ or re-entrain$).ti,ab.
35. (countermeasure$ or surveillance).ti,ab.
36. (reschedul$ or re-schedul$ or redesign$ or re-design$).ti,ab.
37. ergonomic$.ti,ab.
38. (self help or selfhelp).ti,ab.
39. (self schedul$ or self roster$).ti,ab.
40. program development/
41. (coping or cope$).ti,ab.
42. exp counseling/
43. counsel$.ti,ab.
44. empower$.ti,ab.
45. circadian rhythm/
46. circadian.ti,ab.
47. phototherapy/
48. phototherap$.ti,ab.
49. (light treatment or light therap$).ti,ab.
50. Melatonin/
51. melatonin$.ti,ab.
52. ((structur$ or organis$ or organiz$ or management or managerial) adj3 (chang$ or modif$ or design$ or intervention$)).ti,ab.
53. ((structur$ or organis$ or organiz$ or management or managerial) adj3 (impact$ or alter$ or adapt$ or measure$ or strateg$)).ti,ab.
54. ((structur$ or organis$ or organiz$ or management or managerial) adj3 (reduc$ or increas$ or particip$ or educat$ or train$ or program$)).ti,ab.
55. ((shift$ or work$ or hour$) adj3 (chang$ or modif$ or design$ or intervention$)).ti,ab.
56. ((shift$ or work$ or hour$) adj3 (impact$ or alter$ or adapt$ or measure$ or manag$ or strateg$)).ti,ab.
57. ((shift$ or work$ or hour$) adj3 (reduc$ or increas$ or particip$ or educat$ or train$ or program$)).ti,ab.
58. or/22-57
59. 21 and 58
60. animals/
61. humans/
62. 60 not (60 and 61)
63. 59 not 62

Critical Appraisal

Critical appraisal criteria were adapted from existing systematic reviews of the health effects of employment interventions and, guidance for the evaluation of non-randomised studies (Box 3).[30-32] Two reviewers (CB and MP) independently appraised the included studies according to these criteria.[33] The critical appraisal criteria were used for descriptive purposes only and to highlight variations in the quality of studies (see tables 1-3). No quality score was calculated.

Box 3: Critical Appraisal Criteria [30-32]

1. Is the study prospective?
2. Is there a representative sample?
3. Is there an appropriate control group?
4. Is the baseline response greater than 60%?
5. Is the follow-up greater than 80% in a cohort study, or greater than 60% in a cross-sectional study?
6. Have the authors adjusted for non-response and drop-out?
7. Are the authors' conclusions substantiated by the data presented?
8. Is there adjustment for confounders?
9. Were the entire intervention group exposed to the intervention? Was there any contamination between the intervention and control groups?
10. Were appropriate statistical tests used?

These criteria were used to appraise all of the included studies. The results of this process are presented under the critical appraisal section of the results tables 1-3, with the numbers 1-10 representing satisfactory fulfilment of the corresponding criterion.

RESULTS

Forty studies examined the effects of CWW interventions on the health and WLB of shift workers.[34-83] The majority of CWW studies examined changes to four days of 12-hour shifts, although four examined changes to 10-hour shifts,[34,35,56-59,61] and a couple the introduction of the Ottawa shift system.[37,78] Twenty-three of the studies were prospective cohorts,[34-61] of which five were controlled.[34-39] In this paper, we focus our detailed comments on the results of these better designed studies (that is, the prospective cohorts with control group), although the overall synthesis reflects the results of all 40 studies.. Most of the CWW studies were based in one of four distinct occupational settings: health care organisations (9), the police force (8), manufacturing companies (11) and energy industries (9). No studies were found relating to other key shift working occupations such as retail or entertainment workers.[26] The majority of health outcomes, and all WLB ones, were self-

reported. In a sizeable number of the CWW studies, the intervention was either at the behest of the work force,[34-36,41,47,49,60,69,70,83] or from the management out of a stated desire to improve health or WLB.[37,50,62-64,66,71,74,79,80,82] However, in other studies, the motivation was more obviously efficiency or productivity.[46,48,51,53,54,59,61,67,77,78,81] Results are summarised by study design in tables 1-3 and detailed results are available in Web Appendix 2.

Health related outcomes

The effects of the CWW interventions on health outcomes were not conclusive: a number of studies reported some improvements in workforce health,[34-38,42-45,47-50,52,54,56-60,62-65,67,68,72-74,78-83] whilst others found no change,[39,40,46,53,55,66,69-71,75,76,77] and two found only negative effects.[41,51]

The five prospective cohort studies with control groups[34-39] found that there were no detrimental effects on self-reported health related outcomes after the introduction of CWW (table 1) and in four of the studies, some improvements were recorded. [34-38] In one Canadian study of 30 police officers,[34,35] self-reported health behaviour in the form of sporting activities improved in the intervention group compared to the control group (intervention mean 8.1 to 13.9, comparison mean 7.9 to 7.0, $F=8.8, p<.01$) but sickness absence rates did not change significantly. In another study of 70 UK police officers,[37] all but one (sleep quality) of the self-reported health indicators improved significantly in the intervention group (e.g. for the General Health Questionnaire scores, the intervention mean improved from 11.2 to 7.1, whereas the comparison mean worsened from 11.0 to 11.9, $F=15.56$, $p<.001$). However, our critical appraisal of this study identified notable differences in health at baseline between the control and intervention groups: the intervention group had a better baseline score than the control group, thereby possibly leading to an exaggerated intervention effect.

Table 1: Compressed Working Week - prospective cohort studies with a control group

Study	Design & Critical Appraisal (see criteria in box 3)	Setting & Participants	Summary Results≠ ↑ = improvement ↓ = worsening ↔ = little change	
Barton-Cunningham 1981, 1982[34,35]	5 month and 6 month follow-ups Final sample: n=30 (17 intervention, 13 control) Critical appraisal: 1 4 7 9	Police Force, Canada. Police Officers, majority men. Five 8hr shifts, two days off to Four 10hr shifts, three days off	Sporting activities Absenteeism Time spent on domestic chores Time spent on family matters Time spent with spouse Time spent socialising with friends Job satisfaction	↑ ↔ ↑ ↑ ↑ ↑ ↔
Barton-Cunningham 1989[36]	Unspecified follow-up Final sample: n=85 (68 intervention, 17 control) Critical appraisal: 1 7 9 10	Mine, Canada. Mine operatives and plant operators, young married males, age<39. Five 8hr shifts, two days off to Four 12hr shifts, four days off.	Absence Accidents Sleep problems Tiredness Family satisfaction Satisfaction with work	↑ ↑ ↔ ↔ ↔ ↔
Totterdell & Smith 1992[37]	6 month follow-up Final sample: n=70 (40 intervention, 30 control) Critical appraisal: 1 2 3 5 7 9 10	Police service, UK. Police Officers. Seven 8hr shifts, two days off to 'Ottawa' system (10hr days and 8hr nights).	GHQ Lack of sleep Fatigue Headaches Stomach aches Sleep duration Stress Feeling unwell Irregular meals Sleep quality Insufficient time for family Insufficient time for friends Insufficient time for social life Personal life disrupted Planning social life difficult Domestic arrangements difficult Poor relations with family Not enough free time Effective at work Fatigue affects work	↑ ↑* ↑* ↑* ↑* ↑* ↑* ↑* ↑* ↔ ↑* ↑* ↑* ↑* ↑* ↑* ↑* ↑* ↑* ↑*
Lowden et al 1998[38]	10 month follow-up Final sample: n=46 (32 intervention, 14 control) Critical appraisal: 1 2 4 5 7 9 10	Chemical plant, Sweden. Plant operators, mainly men. Five 8hr shifts, three days off to Two or three 12hr shifts, up to five days off	Easy to fall asleep Rested when wake up Sleep quality Fatigue Sufficient sleep General health Time for social/family activities Satisfaction with hours	↑ ↑ ↑ ↔ ↔ ↔ ↑ ↑
Smith et al 1998[39]	6 month follow-up Final sample: n=45 (27 intervention, 18 control) Critical appraisal: 1 2 4 7 8 9 10	Police service, UK. Police Officers, mainly men. Five or seven 8hr shifts, two or three days off to site A: Flexible starts with four 12hr shifts, then four days off or site B: Rigid starts with four 12hr shifts, then four days off.	Sleep duration (day) Standard Shiftwork Index Sleep quality (rest) Standard Shiftwork Index Chronic fatigue Standard Shiftwork Index Physical health Standard Shiftwork Index GHQ-12 Workload Social/domestic interference	↑† ↓† ↔ ↔ ↔ ↑† ↔

≠ Effect sizes have been added to the text where appropriate and the detailed results are available in web appendix table 1.

* There were significant differences between intervention and control groups at baseline.

† Effect disappeared when shift work experience was controlled for.

In a Swedish study of 46 chemical plant workers,[38] self-reported sleep quality was generally better in the intervention group (e.g. mean scores for “feeling rested when wake up” improved in the intervention group (from 4.06 to 4.47) whilst they worsened in the comparison group (4.38 to 4.23). However, self-reported changes in fatigue, sufficient levels of sleep and general health did not differ from the control group at follow up. Our critical appraisal of this study[38] queried the suitability of the control group, and it noted a lack of adjustment for confounders or non-response (table 1). In a Canadian study of 85 young male mineworkers,[36] self-reported sleep problems and tiredness showed no difference between the intervention and control groups but levels of sickness absence decreased substantially (reduction of 73% in the intervention group compared to only 2% in the control group) as did the number of accidents (reduction of 69% in the intervention group compared to only 10% in the control group). The critical appraisal of this study,[36] though, suggests that the sample was not representative, the baseline and follow-up responses were low and there was a lack of adjustment for confounders or non-response (table 1).

In the other study,[39] of 45 UK police officers, self-reported health did not improve: chronic fatigue, physical health and GHQ-12 (a generic measure of psychological stress) scores did not differ between the intervention and the control group at follow up, and the significant improvement in sleep duration in the intervention group disappeared when shift work experience was taken into account. This study was not notably different from the others in terms of methodological quality.

Although these studies were robust in terms of study design (employing a control group) the sample sizes were small, ranging from 23 to 85, and the lengths of follow-up were relatively short. No study followed up respondents for at least a year which may be the optimum as it allows for the possibility of controlling for possible seasonal effects. It should also be noted that three of the five controlled prospective studies were conducted in the police force and so care is needed in generalizing from these results to other occupational groups involved in shift work.

The uncontrolled prospective studies (table 2) were also inconclusive, as whilst the majority identified an improvement in one or another of the various health outcomes measured, they found little effect for other health outcomes.[43-45,49,50,52,54,56-59,62-65,67,68] Amongst the five largest studies (sample sizes >100),[49][51][59][60][61] two reported mixed health effects,[49][59] two reported health improvements [60][61] and one recorded a negative health effect. [51] Williams' study of 131 male chemical plant workers[49] recorded an improvement in self-reported depression (decreased from 2.43 to 2.12, $t=2.32$, $p<.05$) but found no change in absence and injury rates.[49] Similarly, a study of Canadian mine workers [59] found that after the introduction of CWW, sleep (mean difference = -0.3, $t=2.43$, $p<0.01$) and tiredness (mean difference = 0.9; $t=4.77$, $p<0.001$) worsened on the day shift whilst gastro-intestinal problems (mean difference = -0.4, $t=2.35$, $p<0.01$) and headaches (mean difference = -0.3, $t=2.07$, $p=0.03$) improved. Two studies of American production workers [60][61] reported various improvements in self-reported health including a decrease in the prevalence of common shift related health disorders (such as heart burn, acid stomach, diarrhoea) from 43.8% to 27% ($p<.001$)[59] and a decrease in sickness absence (e.g. from 11.39 to 4.69 days).[61] However, in a study of 150 UK nurses,[51] dissatisfaction with levels of mental (0.8 [0.53:1.07]) and physical (0.7,[0.50:0.90]) fatigue increased.

A number of smaller studies of varying methodological quality and sample size reported no changes in any of the health indicators.[40,46,53,55,66] Other studies were more conclusive, finding significant improvements in sleep duration,[42] absence,[47] physiological distress, fatigue and stress,[48] sleep between shifts, sleep difficulties, and health disorders.[60] In all these studies,[42,47,48,60] employees were either involved in the design and implementation of the intervention or they were supportive of the change. Importantly, only two studies, both based in health care settings, found that all the self-reported measures of health used worsened after the introduction of the CWW.[41,51] Overall, the prospective studies were rather limited in terms of length of follow-up and sample size: only 3 studies had lengths of follow-up of 12 months or more, and the studies were small (tending to involve 15 to 50 participants).

Table 2: Compressed Working Week – other prospective studies (grouped by study design)

Study	Design & Critical Appraisal (see criteria in box 3)	Setting & Participants	Summary Results≠ ↑ = improvement ↓ = worsening ↔ = little change	
PROSPECTIVE COHORT STUDIES				
Stinson & Hazlett, 1975[40]	1 month follow-up Final sample: n=23 Critical appraisal: 1 2 4 7 9 10	Hospital, Canada. Nurses, mainly female. Five 8hr shifts, two days off to Three/four 12hr shifts, four/three days off	Tired on the job Time available for recreation Not feeling overloaded with work	↔ ↑ ↔
Eaton & Gottselig, 1980[41]	6 month follow-up Final sample: n=24 Critical appraisal: 1 2 7 9 10	Hospital, Canada. Nurses, mainly female. 8hr shifts to 12hr shifts	*Personal Health Survey:* Health complaints Cardiovascular complaints Anxiety Anger-frustration *Nurses perception questionnaire:* Fatigue Felt more rested Absence Accidents and injuries *Minnesota Satisfaction Questionnaire:* Job satisfaction Turnover Incidents and errors	 ↓ ↓ ↓ ↓ ↓ ↑ ↔ ↔ ↔ ↓ ↔
Peacock et al, 1983[42]	6 month follow-up. Final sample: n=75 Critical appraisal: 1 7 9 10	Police Force, Canada. Police Officers. Eight 8hr shifts, four days off to Five 12hr shifts, three days off	Sleep duration Alertness	↑ ↔
Rosa et al, 1989; Lewis & Swaim, 1986; Rosa, 1991[43-45]	7 month follow up Final sample: n=50 Critical appraisal: 1 5 9 10	Processing plant, USA. Control room operators, mainly male aged 25-34. Five/seven 8hr shifts, two/four days off to Three/four 12hr shifts, three/six days off	Gastro-intestinal state (night) Gastro-intestinal state (day) Exercise Napping after shift (night) Napping after shift (day) Stress Total sleep time Number of awakenings Sleep depth Sleep quality Sleep latency Adjust personal routine for work Missed social events	↑ ↔ ↓ ↑ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↓ ↔
Jansen & Mull, 1990[46]	6 month follow up Final sample: n=87 Critical appraisal: 1 2 7 9 10	Confectionary Factory, Netherlands. Packaging Department workers, all female, 46 full-time, 41 part-time. Five 8hr shifts, two days off to Three 12hr shifts, four days off	Fatigue Gastro-intestinal complaints Time spent with family Satisfaction with leisure time	↔ ↔ ↑ ↔
Slota & Balas-Stevens, 1990[47]	3 month follow up Final sample: n=36 Critical appraisal: 1 2 9 10	Hospital, USA. Nurses, all female. Five 8hr shifts, two days off to Three 12.5hr shifts, four days off	Absence Concern about scheduling of vacation time Ability to request time off Incidents and errors Personal productivity	↑ ↔ ↔ ↔
Pierce & Dunham, 1992[48]	12 month follow up Final sample: n=50	Police Force, USA. Police officers, mainly male.	Physiological distress Fatigue Stress	↑ ↑ ↑

	Critical appraisal: 1 2 4 7 9 10	Seven/ten 8hr shifts, two/three days off to Four 12hr shifts, four days off	Schedule interference with personal activities Satisfaction with leisure time Life satisfaction Satisfaction with organisational association Satisfaction with workload Job satisfaction Organisational effectiveness Performance	↑ ↑ ↑ ↔ ↔ ↑ ↑ ↔
Williams, 1992[49]	6 month follow up Final sample: n=131 Critical appraisal: 1 2 4 5 6 7 9 10	Chemical Plant, USA. Operators, mainly white males. Six/seven 8hr shifts, two/four days off to Three/four 12hr shifts, two to seven days off	Depression Absence Accidents General life satisfaction Conflict between work and non-work time Social/community involvement Planning activities with family Job satisfaction	↑ ↔ ↔ ↑ ↑ ↔ ↑ ↔
Rosa & Bonnet, 1993[50]	8 month follow up Final sample: n=10 Critical appraisal: 1 7 9 10	Gas Processing Plant, USA. Computer operators, all male. Four/seven 8hr shifts, two/three days off to Two/three 12hr shifts, two/three days off	Sleepiness (day) Sleepiness (night) Total sleep time (night) Total sleep time (day) Sleep depth Sleep latency Number of awakenings Exercise Work related adjustment of meal times Work related adjustment of personal schedules	↑ ↔ ↑ ↔ ↓ ↔ ↔ ↔ ↔ ↔
Todd et al, 1993[51]	6 month follow up Final sample: n=150 Critical appraisal: 1 2 4 7 9 10	Hospital, UK. Nurses, mainly female. Three/four 12hr shifts, three/four days off	Dissatisfaction with fatigue Dissatisfaction with ease of getting childcare Dissatisfaction with amount of time spent with family Dissatisfaction with how personal life is put second Job satisfaction	↓ ↓ ↓ ↓ ↓
Williamson et al, 1994[52]	7 month follow up Final sample: n=18 Critical appraisal: 1 2 4 7 9 10	Computer Company, Australia. Computer operators (80%) and supervisors (20%). Two-Five 8hr shifts, one/two days off to Four 12hr shifts, Four days off.	Loss of appetite Gastro-intestinal symptoms Sleep and fatigue Headaches Irritability Heart problems GHQ Visit to doctor Consumption of social drugs Job satisfaction	↑ ↑ ↑ ↑ ↑ ↑ ↑ ↔ ↔ ↔
Freer & Murphy-Black, 1995[53]	1 month follow up Final sample: n=13 Critical appraisal: 1 4 5 6 9	Hospital, UK. Nurses and midwives. 12hr flexible shifts	Stress Enjoyment at work Morale at work	↔ ↑ ↑
Campolo et al, 1998[54]	12 month follow up Final sample: n=20 Critical appraisal: 1 2 4 9	Hospital, Australia. Nurses, all female. 6hr morning shifts, 8hr afternoon shifts, 9.5hr night shifts to Four 12hr shifts, three days off	Fatigue Gastro-intestinal symptoms Absence Sleep length Sleep quality Work demands Time spent on hobbies Time with family and friends Performance	↑ ↓ ↔ ↔ ↔ ↓ ↑ ↔ ↔
Di Milia, 1998[55]	2, 3, 4 and 5 month follow ups	Coal mine, Australia. Electricians, all male.	Sleep duration	↔

	Final sample: n=3 Critical appraisal: 1 5 9 10	Seven 8hr shifts, two/four days off to Four 12hr shifts, two/eight days off.		
Paley et al, 1994a; 1994b; 1998[56-58]	16 month follow up Final sample: n=15 Critical appraisal: 1 2 4 5 9 10	Fire Department, USA. Fire fighters, all male. Five/seven 8hr shifts, two/three days off to Two 10hr day shifts, two 14hr night shifts, four days off.	Sleep length (night) Sleep length (day) Sleepiness	↑ ↔ ↔
Heslegrave et al, 2000[59]	1 month follow up Final sample: n=120 Critical appraisal: 1 2 7 9 10	Metal Mine, Canada. Mining operatives, mostly male. Five 8hr shifts, two days off (weekends) to Two/three/four 10hr shifts, two/three days off.	Sleep duration (day) Sleep duration (night) Sleep duration (rest) Tiredness (day) Tiredness (rest) Tiredness (night) Gastro-intestinal problems Headaches Performance (day) Performance (night)	↓ ↔ ↔ ↓ ↓ ↔ ↑ ↑ ↓ ↑
Johnson & Sharit, 2001[60]	11 month and 8 year follow ups Final sample: n=104 Critical appraisal: 1 4 7 8 9 10	Manufacturing Company, USA. Production workers. 8hr rotating shifts to 12hr rotating shifts.	Sleep between shifts Sleep difficulties Health disorders Satisfaction with system Productivity Production quality	↑ ↑ ↑ ↑ ↑ ↑
Von Borkenhagen-Chandler, 2004[61]	1 month follow up Final sample: n=121 Critical appraisal: 1 7 9	Aerospace Manufacturing Company, USA. Final assembly and Flight test workers. Five 8hr shifts, two days off to Four 10hr shifts (Mon – Thurs) with three days off or three 12hr shifts (Fri-Sun) with four days off.	Absence Job satisfaction	↑ ↑*
PROSPECTIVE REPEAT CROSS SECTION STUDIES WITH CONTROL GROUP				
Duchon et al 1994, 1997; Keran et al, 1994† [62-64]	10 month follow-up Final sample: n=22 (17 intervention, 5 control) Critical appraisal: 1 4 5 7 9	Metal mine, Canada. Miners. Seven 8hr shifts, two/three days off to Four 12hr shifts, Four days off.	Health problems Eating habits Sleep difficulties after night shift Minor aches and pains Stress *Stanford Sleepiness Scale:* Sleepiness Sleep length Family life Morale	↔ ↑ ↓ ↓ ↔ ↔ ↔ ↑ ↑
Smith et al, 1998[65]	6 month follow-up Final sample: n=62 (47 intervention, 15 control) Critical appraisal: 1 2 4 5 7 8 9 10	Sewage treatment plant, Australia. Sewage workers. Seven 8hr shifts, two/ days off to Two/three 12hr shifts, two/four days off	*GHQ-12:* Psychological complaints Minor health complaints Circadian malaise Muscular complaints Minor infections Day sleep quality Night sleep quality Tiredness Fatigue Physical health Mental health Interference of work with home life Interference of work with social life Work-life satisfaction Work performance	 ↑ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↑ ↑ ↔ ↔
Cydulka et al, 1994[66]	1 and 6 month follow-ups	Hospital, USA. Ambulance workers and	Somatic distress Organisational stress	↔ ↔

	Final sample: n=140 (27 intervention, 113 control) Critical appraisal: 1 2 4 5 7 8 9 10	Paramedics. Six 8hr shifts, two days off to Three 12hr shifts, two days off	Job dissatisfaction	↔
PROSPECTIVE REPEAT CROSS SECTION STUDIES				
Heslegrave et al, 2000[67]	12 month follow-up Final sample: n=66 Critical appraisal: 1 2 4 5 7 9 10	Nuclear Power Plant, Canada. Power plant operators, mainly male. Three/four/seven 9hr shifts, two/six days off to Four 12.5hr shifts, Four days off.	Fatigue Sleep Performance	↓ ↔ ↓
Mitchell and Williamson, 2000[68]	6 month follow-up Final sample: n=12 Critical appraisal: 1 2 4 5 7 9 10	Electrical Power Station, Australia. Power station workers (supervisors, fire fighters, turbine operators), all male. Seven 8hr shifts, one/two/four days off to Five/six 12hr shifts, two/three/seven days off	Health complaints Alcohol consumption Sleep quality Absence Sleep disturbance Sleep length Chronic fatigue Physical health GHQ Somatic Anxiety Feeling stressed Social life Domestic life Coping with social life Coping with home life Work performance	↑ ↑ ↑ ↓ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↑ ↑ ↑ ↑ ↔

≠ Effect sizes have been added to the text where appropriate and the detailed results are available in web appendix table 2.
† Results only presented for the intervention group
* Amongst some workers only

The pattern was similar for the retrospective studies (table 3) with only a minority reporting any significant intervention effect (table 3).[72-74,78-83] The majority of the significant effects, though, were positive, particularly in terms of self-reported general health and morbidity;[72,73,78] headaches, gastric upset, diarrhoea, and alcohol problems;[72,73] sleep;[74] and injuries.[79-81,83] These retrospective studies were generally of low quality e.g. all had sample sizes <100; and low response rates. However, one of the larger and better quality retrospective studies,[72,73] e.g it had a sample of 247, a response rate >60% and adjusted for demographic confounders, reported a significant decrease in age standardised morbidity ratio amongst men from 1.02 (95% CI 1.00:1.05) to 0.47 (95% CI 0.46:0.48) but a non-significant decrease in women from 0.76 (95% CI 0.71:0.82) to 0.67 (95% CI 0.63:0.71).

Table 3: Compressed Working Week – retrospective studies (grouped by study design)

Study	Design & Critical Appraisal (see criteria in box 3)	Setting & Participants	Summary Results≠ ↑ = improvement ↓ = worsening ↔ = little change	
RETROSPECTIVE COHORT STUDIES WITH CONTROL GROUP				
Venne, 1993; 1997[69,70]	Historical data: 12 month pre average, 24 month post average. Final sample: n=102 (70 intervention, 32 control) Critical appraisal: 4 5 7 9 10	Prison, Canada. Prison Guards. Five 8hr shifts, two days off to Two/three 12hr shifts, two/three days off	Absence	↔
Yamada et al, 2001[71]	Historical data: 2, 8, 14 and 24 month follow-ups Final sample: n=205 (189 intervention, 16 control) Critical appraisal: 2 4 5 6 9	Electronic parts manufacturer, Japan. Processing machine operators. Five 8hr shifts, two days off to Two/three 12hr shifts, two/three days off.	Lower back pain Stiff shoulder Joint pain Limb pain Dimmed sight Sore throat Poor sleep Diminished alertness Tiredness Irritation Head heaviness BMI Weight Blood pressure	↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔ ↔
RETROSPECTIVE COHORT STUDIES				
Laundry & Lees, 1989; 1991[72,73]	Historical data: 120 month pre average, 120 month post average. Final sample: n=247 Critical appraisal: 2 4 5 7 8 9 10	Synthetic yarn factory, Canada. Factory workers, 85% male. Five 8hr shifts, two days off to 12hr shifts.	Morbidity (male) Morbidity (Female) Headaches Gastric upset Diarrhoea Alcohol problems General malaise Nervous conditions Minor injury rate Severe injury rate Injury rate (male) Injury rate (female)	↑ ↔ ↑ ↑ ↑ ↑ ↔ ↔ ↑ ↔ ↑ ↔
Conrad-Beetschart, 1990[74]	After only recall data: 1 month post. Final sample: n=78 Critical appraisal: 2 4 7 9	Oil refinery, Switzerland. Operators, mainly male. Five 8hr shifts, two days off to Two/three 12hr shifts, two/three days off.	Sleep Health Leisure time Time with partner	↑ ↔ ↑ ↑
Pollock et al, 1994[75]	Historical data: 18 month pre average, 18 month post average. Final sample: n=300 Critical appraisal: 2 4 5 9	Petrochemical manufacturer and fertiliser manufacturer, Australia. Manufacturing workers. Five 8hr shifts, two days off to Four 12hr shifts, four/six days off.	Injury rates	↔
Barter-Trenholm, 1997[76]	After only recall data. Final sample: n=218 Critical appraisal: 2 4 7 9 10	Police Force, Canada. Police Officers. Five 8hr shifts, one in three weekends off to 12hr shifts, one in two weekends off.	Sleep patterns Tiredness Effectiveness	↔ ↔ ↔
Vega & Gilbert, 1997[77]	After only recall data: 8 month post. Historical data: 12 month pre average, 12 month post average.	County Sheriff's Department, USA. Patrol Officers, majority male and white.	Fatigue Quality of professional lives Quality of personal lives Family and personal	↔ ↑ ↑ ↑

	Final sample: 34 Critical appraisal: 2 7 9 10	Five 8hr shifts, two days off to Three 13.3hr shifts, Four days off.	activities Productivity	↑
Richbell et al, 1998*[78]	After only recall data. Historical data: 12 month pre average, 12 month post average. Final sample: n=90 Critical appraisal: 2 9	Police Force, UK. Police Officers. Five 8hr shifts to Ottawa system (9/10hr days 10hr nights).	Health Absence Quality of life Morale Service	↑ ↑ ↑ ↑ ↑
Wootten, 2000a, 2000b[79,80]	Historical data: 3 month pre average, 3 month post average. Final sample: n=20 Critical appraisal: 2 4 5 9	Hospital, UK. Nurses. 7.5hr to 12hr shifts.	Absence Accidents Staffing costs Errors	↓ ↑ ↑ ↑
Baker et al, 2000[81]	Historical data: 9 month pre average, 12 and 24 month post averages. Final sample: not stated Critical appraisal: 2 4 5 7 10	Coal Mine, Australia. Miners, maintenance workers, preparation plant workers. 8hr shifts to A: Four 12hr shifts, two/six days off; then from A to B: as system A with addition of three consecutive night shifts and no cap on overtime.	Absence Injury incident rate	↓ ↑
Bloodworth et al, 2001[82]	After only recall data. Historical data: 2 month pre average, 2 month post average. Final sample: 16 Critical appraisal: 2 4	Hospital, UK Nurses, all female. Five 7.5hr shifts, two days off to Two 6.25hr shifts, two 12hr shifts, Three days off.	Tiredness Absence Child care Performance Staff costs Errors and incidents	↔ ↑ ↑ ↔ ↑ ↔
RETROSPECTIVE REPEAT CROSS SECTION STUDIES				
Brinton, 1983[83]	Historical data: 5 month pre average, 5 month post average. Final sample: 76 Critical appraisal: 2 4 5 9	Paper Mill, USA. Wood yard workers, all male. Five 8hr shifts, two days off to Four 12hr shifts, Three/Four days off.	Injury frequency rate Absence	↑ ↑

≠ Effect sizes have been added to the text where appropriate and the detailed results are available in web appendix table 3.
* This study also used qualitative focus groups.

Fatigue

Shift work is often associated with fatigue[18,20,26] and it might be expected that CWW, due to the longer working day, the potential for moonlighting, or excessive overtime, might further increase problems of fatigue amongst shift workers. However, of the eighteen intervention studies synthesized in this review which measured fatigue or tiredness, in only four was there an adverse change in fatigue levels after the introduction of CWW.[41,51,59,67] Three studies

recorded improvements,[42,53,59] and in the other eleven there was no intervention effect.[41, 43-45, 51, 69, 72, 75, 80,81, 86] The introduction of longer working days under CWW therefore does not appear to adversely affect fatigue, however, this may well be because of the extended rest period which means that the normal weekly working hours are not exceeded in a seven day period.[28] However, it may also be due to the popularity of CWW interventions amongst workers (as they increase leisure time and/or enable moonlighting)[39] and this may bias the findings of evaluations in a positive direction, especially in studies with a short follow-up period. Subsequently, it is important that employee safeguards such as the EU working time directive or other measures which limit overtime and moonlighting are incorporated into CWW schedules.

Work-life balance

The majority of studies which examined WLB outcomes noted improvements after the introduction of CWW,[34,35,37,38,40,46,48,49,53,54,62-65,68,74,77,78,82] with only a few reporting no intervention effect[36,39,47,50] or a worsening in WLB.[43-45,51,54] However, CWW are often popular amongst shift workers largely because they value the additional days off that are afforded by the CWW model.[84] Indeed, in 22 of the CWW studies, the intervention was either specifically requested by the employees,[38,39,40,45,51,53,64,73-74,87] or implemented with their support.[48,54-59,61,65,67,71,74,78-81] Similarly, the ability of an individual worker to adapt the new schedule to his/her needs may have influenced findings.

Three of the five prospective cohort studies with control groups (table 1) recorded significant improvements in self-reported WLB amongst the intervention group compared to the control group.[34,35,37,38] In the Barton-Cunningham study of 30 Canadian police officers,[34,35] all four of the indicators of wellbeing used in the study were significantly improved in the intervention group (e.g. Time spent on domestic chores improved in the intervention group from a mean of 7.8 to 16.0, whereas the comparison mean worsened from 8.6 to 6.5, $F=14.7$, $p<.01$). These improvements all disappeared when the old 8 hour schedule was restored.[34,35] Similarly, in the Totterdell and Smith study of 70 UK police officers[37] all

WLB indicators were improved in the intervention group (for example, a reduction was recorded in the intervention group for “insufficient time for family”, intervention mean 56.4 to 15.5, comparison mean 63.8 to 62.6, $F=41.61$, $p<.001$)). However, there were significant differences between the intervention and control groups at baseline which suggests that the findings need to be replicated in larger studies with well-matched control groups.

The Swedish study of 46 chemical plant workers[38] also saw significant improvements in WLB with both time for social/family activities (intervention mean 2.65 to 3.02, comparison mean 3.25 to 3.02, $p<.05$), and satisfaction with hours (intervention mean 3.53 to 4.62, comparison mean 4.29 to 4.5, $p<.05$) increasing amongst the intervention group. There are some issues (as above) about the suitability of the non-randomised, non-matched control group (see Table 1).

The other prospective study with a control group of 45 UK police officers[39] found no changes in WLB (workload, social domestic interference) once shift work experience had been taken into consideration. Similarly, the study of 85 mineworkers[36] found no differences between the intervention and control groups for family satisfaction. Importantly though, none of the prospective cohort studies with control groups identified a decrease in WLB after the implementation of the CWW interventions. As noted above, these studies tended to employ relatively short periods of follow-up and small samples, and so despite the controlled design, the evidence they present is suggestive rather than convincing.

Consistently, the prospective uncontrolled studies (table 2), including two of the studies with at least 12 months follow-up, found that aspects of WLB improved after the introduction of CWW interventions.[40,46,48,49,54,62-65,68] WLB indicators (such as time available for recreation, time spent with family, or conflict between work and non-work time) improved in eight studies.[40,46,48,49,54,62-65,68] Some smaller and less methodologically robust studies (e.g. low response and follow-up rates) did not identify any changes in WLB as a result of the intervention.[47,50] Only three studies,[43-45,51,54] of which all but one[51] were revealed by our critical appraisal process to be of questionable methodological quality (e.g.

small sample size, low response and follow-up rates etc), reported any decreases in WLB and in two of these less robust studies only one or two aspects of WLB declined whilst others improved[54] or were unaffected.[43-45]

In all of the retrospective studies that measured the effects of CWW interventions on WLB, it was found to improve.[74,77,78,82] For example, improvements were reported in leisure time and time spent with partner,[74] quality of life[77] and family life,[78] and child care.[82] However, the critical appraisal process suggested that these studies had some methodological problems particularly in terms of low baseline response rates,[77,78] low or no follow up response rates,[74,77,78,82] and little adjustment for non-response or confounders.[74,77,78,82]

Health and work-life balance

The results of the CWW studies suggest a link between improved WLB and improved health. Three of the prospective studies with control groups,[34,35,37,38] six of the prospective studies without a control group[48,49,54,62-65,68] and three of the retrospective studies reporting increases in WLB,[74,78,82] also reported improvements in health, particularly mental health. Changes in WLB were less likely to be accompanied by changes in measures of physical health. For example, in five studies,[36,43-45,47,50] health improvements occurred despite no accompanying changes in WLB. This tentatively suggests that whilst changes in mental or physical health and WLB can clearly occur separately, positive changes in WLB, can translate into positive mental health effects. The relationship between WLB and physical health however is less clear. Of course, this finding may reflect the self-reported nature of the health and WLB outcomes. However, this link and possible causal pathway should be examined further in future prospective studies.

Organisational outcomes

Generally the studies suggested that the organisational effects of the CWW were small or absent with most studies finding no evidence of either benefit or detriment.[34-37,42,47,49,52,54,65,66,68,78]

Three of the prospective cohort studies with control groups (table 1) measured effects on performance (job satisfaction or effectiveness at work).[34-37] None found any significant differences between the intervention and control groups. Similarly, in the other prospective cohort studies (table 2) the majority of the sixteen that measured organisational outcomes found no effect[42,47,49,52,54,65,66,68] whilst several reported improvements; in morale,[53,62-64] job satisfaction,[61,48,60] productivity and quality[60] or organisational effectiveness.[48] However, four studies reported adverse organisational effects such as an increase in turnover,[41] decreased job satisfaction[51] or decreased performance.[59,67] Amongst the five retrospective studies which had organisational outcomes,[76-80,82] four identified benefits in terms of reduced staff costs and errors,[79,80,82] productivity,[77] or morale.[78] Overall, the balance of best evidence suggests that there were few positive or negative organisational effects, though it is possible that negative findings in this area may not have been published or may otherwise be unavailable (for example, for reasons of commercial confidentiality).

DISCUSSION

Overall, the evidence base on the health effects of CWW interventions is perhaps best described as cautiously positive: positive because whilst the CWW interventions might not always improve the self-reported health of shift workers, they are seldom detrimental (indeed, the five prospective cohorts with control groups found no detrimental effects on health); and cautious because of the methodological quality of the current evidence base (see below). .In contrast, the evidence about the effects of CWW interventions on the WLB of shift workers seems more conclusive (although the comments about methodological quality still apply): CWW improves WLB.

Research implications

The evidence base on changing the organisation of shift work by introducing CWW is relatively large by systematic review standards, both in terms of the intervention studies synthesised in this research report (40 in total), and the wider descriptive epidemiological

literature.[29] However, there are still some large evidence gaps, most notably in terms of any effects of shift work interventions on inequalities in health amongst working age populations. The majority of studies were conducted in fairly homogeneous populations (e.g. police officers, male production workers, or female nurses) and, perhaps in part due to this, only one study differentiated outcomes by gender,[72,73] and none of the studies differentiated by occupational grade or socio-economic group.

A key question remains of whether changing the organisation of shift work by introducing CWW has the potential to decrease health inequalities amongst the working age population. An important consideration in this respect is the social patterning of shift work in the UK, which tends to be concentrated amongst workers from lower socio-economic groups (with the notable exceptions of medical and emergency services staff).[27] This contributes to the generally poorer, more health-damaging work environment experienced by manual compared to non-manual workers. It is plausible that CWW interventions which improve the health of shift workers may therefore, on the whole, help to reduce the gap in health between manual and non-manual workers caused by the differences in working conditions between the two groups. This possibility should be explored further.

There is also little evidence on the effects of CWW on the health behaviours of shift workers. Only four of the forty studies in this review examined health behaviours. Two studies reported on the effects on exercise with one reporting an increase,[34,35] whilst the other found no change;[50] one study reported an increase in alcohol consumption,[68] and another found no intervention effect on the consumption of social drugs.[52] Furthermore, there were only two studies on the Ottawa CWW system, [37,78] and so the effects of particular CWW systems is therefore another area which could be examined in future research.

In addition, the research studies reviewed were subject to a number of methodological limitations (see Box 4) such as inadequate control groups, lack of detail about implementation, small sample sizes and short follow ups. Perhaps most importantly, the majority of outcomes were self-reported and this may have led to confounding, particularly in

terms of whether employees were supportive or unsupportive of the imposed intervention. Therefore, in the future, prospective, well controlled studies, which measure objective health outcomes, and which describe the background to the study and the implementation of the intervention, are needed.[85] Studies which examine the mental health effects of CWW interventions and any interaction with changes in WLB would be the most useful.

Box 4: Methodological Limitations

Although the 40 studies reviewed represent the best available evidence on the health and work-life balance effects of Compressed Working Week (CWW) interventions, they were subject to a number of methodological and other limitations.

- No trials and only five prospective cohort studies with a control group were located. The control groups were not matched or randomised, and in at least one case there were significant differences in health at baseline between the intervention and control groups.[37]
- We elected to include all studies regardless of sample size. However, it needs to be noted that a number of studies were based on such small final sample sizes that their research value is limited. For example, nine studies[50],[52-58],[68],[79],[80],[82] had final sample sizes of 20 or fewer, and there was one study with only 3 participants.[55] Therefore, in our synthesis, we have highlighted the larger studies.
- Studies were often conducted in homogeneous populations. For example, three of the five controlled prospective cohorts were conducted amongst police officers.[34][35][37][39] The generalisablity of the results to other occupations is therefore limited.
- The number of small studies also raises the possibility that any positive findings may be due to publication bias, in which small studies with positive findings are more likely to be published (or are otherwise more easily located by reviewers) than those with negative findings. Similarly, bias may have arisen as we were only able to locate studies in the public domain thus excluding the majority of commercial studies.
- The health, work-life balance and organisational measures were usually self-reported and they varied greatly from study to study. Bias may therefore have occurred, as employees were aware of the intervention and in some cases highly involved in its design and implementation. There was a dearth of well validated questionnaires, such as the General Health Questionnaire[37],[39],[52],[65],[68] or the Standard Shift work Index.[39]
- The study follow ups were generally 12 months or less[34-55],[59],[62],[74],[76-80],[82] and so it was not possible to analyse the longer term health or work-life balance effects of the CWW interventions which may be particularly important in terms of accumulated fatigue and physical health. The short follow ups may also account for the lack of a health effect (either positive or negative) in the majority of the studies.
- There was also a lack of information provided in some studies about the background[38-40],[42-45],[52],[55-58],[65],[68],[72],[73],[75],[76] to the interventions or how they had been implemented.[34-46],[48],[50-53],[55-59],[61-68],[71-73],[75-79],[82] In those studies which reported background details, those in which the intervention was instigated by employees or the motivation was employee wellbeing,[34-37],[41],[47],[49],[50],[60],[62-64],[66],[69-71],[74],[79],[80],[82,83] tended to have more positive health and work-life balance effects, whilst the effects of those which were the most overtly driven by economic motives were often negative or negligible.[46],[51],[53],[54],[59],[61],[67],[77]

Policy Implications

The existing evidence, albeit somewhat methodologically limited, suggests that introducing the CWW may enhance the WLB of shift workers. There is also evidence to suggest that it is not detrimental to self-reported health in the short term. Importantly, CWW interventions tend to have either positive or negligible organisational effects and so employee health and WLB may be improved through the workplace without damaging company productivity or competitiveness. This message may be a useful aid in implementing the recent cross-departmental Health and Safety Executive, Department of Health and Department for Work and Pensions' 'Health, Work and Wellbeing' strategy[86] amongst employers. Changing shift work organisation and working practices to make them more conducive to a WLB does not necessarily need a warning caveat about the dangers to productivity or competitiveness.

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Competing interests

All authors declare that they have no competing interests.

What is already known on this subject

- A large number of observational studies suggest that shift work negatively effects employee health and work-life balance.
- Shift work is common: 1 in 5 European workers are involved in some form of shift work
- Shift work is socially patterned – less common amongst graduates and more common amongst manual workers.
- One hypothesis is that organisational level interventions such as the Compressed Working Week may be effective in reducing these negative health effects and perhaps also impact upon social inequalities in health and work-life balance.

What this study adds

- First study to systematically review 40 intervention studies of the effects on the health and work-life balance of shift workers of Compressed Working Week interventions.
- The methodologically limited evidence base suggests that the Compressed Working Week appears to improve the work-life balance of shift workers, and that it appears to do so with little or no adverse health or organisational effects.
- Unclear what the effects are on health inequalities, although as shift work is concentrated amongst lower occupational groups it is plausible that effective Compressed Working Week interventions could help reduce the health gap between manual and non-manual workers.

Policy implications

- The evidence suggests that introducing the Compressed Working Week may enhance work-life balance for shift workers. It does not appear to be detrimental to self-reported health in the short term.
- Importantly, Compressed Working Week interventions tend to have either positive or negligible organisational effects and so health and wellbeing may be improved through the workplace without damaging productivity or competitiveness.
- The Compressed Working Week could therefore be an important tool for both policymakers and employers in terms of promoting healthier work places and improving working practices.

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