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Working from home, health and wellbeing consequences of a pandemic

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KEY WORDS: ***Working from Home; COVID-19; Active Travel; Physical Activity; Wellbeing***

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Highlights

- More people working more frequently from home during the pandemic
- Three distinct groups with different work, health and wellbeing responses
- Increase in sedentary behaviour when working from home
- Largest group report more sitting, less physical activity and worse wellbeing

Abstract

Drawing from a survey of 1,165 Sydney (Australia) workers conducted in late 2020, when restrictions from the first COVID-19 wave were easing across Australia, we explore the impact of the pandemic on perceived changes to working from home (WfH) and other travel behaviours. Based on this analysis, we identify three distinct segments of the population with differing physical activity (PA) and quality of life (QoL) outcomes: (1) '*Active but Anxious'* (22%) – younger, higher income, largest increase in WfH, sitting most of the day, sufficient PA; (2) *'Less Change, Less Worries'* (38%) – older and male, least change in WfH, sitting relatively less, largely sufficient PA; (3) *'Stressed and Sedentary'* (40%) – average age, lower income, largest loss of paid work, highest levels of sedentary behaviour, lowest PA and QoL. In a probable future of greater opportunities for WfH, understanding these heterogenous outcomes has implications for individuals, employers and policy-makers.

Keywords: Working from Home; COVID-19; Active Travel; Physical Activity; Wellbeing.

1.Introduction

Since the outbreak of the COVID-19 pandemic in early-2020, many countries have found that limiting the movement of people and preventing social contact is effective for slowing the virus spread (Chiba, 2021). This has been achieved through various non-pharmaceutical interventions (NPIs), including stay-at-home orders, restrictions on public gatherings, closures of shops, schools, gyms, bars and restaurants, and imposing or encouraging working from home (WfH) (De Vos, 2020). As much of the world emerged from the first wave of the pandemic and restrictions were eased, activity started to return to a level of relative normalcy. However, WfH in some form remained highly significant in some countries, including the UK, Sweden and Australia (OECD, 2021). Australia has attracted particular interest through its relative success in containing the first wave of the pandemic, largely by restricting movements into and within the country. A critical component of this success was

an employer-led response to mandate or strongly encourage employees who can WfH to do so, in response to government stay-at-home orders. This was retained in some form by many employers as restrictions from the first lockdowns eased and, as of late 2020, around 40% of employed Australians continued to work from home one or more times/week, up from 24% in March 2020 (Australian Bureau of Statistics, 2021b). Reasons included employer investment in remote working, potential cost savings from saved office space (Xiao et al., 2021), an acceptance that flexible working arrangements (FWAs) were an important component of staff hiring and retention strategies, and ongoing social distancing practices (Beck and Hensher, 2021, Beck and Hensher, 2020).

As more paid work is shifted to home for a greater proportion of the population, questions have grown around potential physical health and wellbeing impacts. Despite the negative connotations associated with commuting (e.g., stuck in traffic, wasting time) (Chatterjee et al., 2020), it provides opportunities for active travel/physical activity, while the workplace is an important source of interpersonal and social interaction. Evidence around physical health effects of WfH is inconclusive, with reports of positive (Chakrabarti, 2018, Henke et al., 2016) and negative (Fukushima et al., 2021, Koohsari et al., 2021b) effects. In terms of physical activity (PA), evidence suggests that people tend to make more non-work trips when WfH (He and Hu, 2015, De Abreu e Silva and Melo, 2018), although it appears highly context-dependent as to whether these non-work trips use motorised or active modes and thus contribute to sufficient PA (Bieser et al., 2021). Limited evidence suggests an increased likelihood of walking more than 1.61 km per workday when WfH at least four days a month (Chakrabarti, 2018), as well as an increased likelihood of taking active modes for daily trips when WfH (Lachapelle et al., 2018). Evidence is more conclusive that WfH increases overall time spent sitting and propensity for sedentary behaviour (Olsen et al., 2018, Brito et al., 2021, Fukushima et al., 2021, Koohsari et al., 2021a, Koohsari et al., 2021b), even when there is no impact on daily PA (McDowell et al., 2020).

Wellbeing outcomes attributable to WfH are particularly challenging to identify and measure. A recent meta-review assessed ten potential outcomes of WfH: changes in self-reported pain, health, safety, wellbeing, stress, depression, fatigue, quality of life, strain and happiness (Oakman et al., 2020). Taken overall, WfH can result in better QoL outcomes (Vittersø et al., 2003, Fincke et al., 2020), alongside greater job satisfaction (Gajendran and Harrison, 2007, Felstead and Henseke, 2017). However, WfH has been associated with an increase in feelings of stress and loneliness (Mann and Holdsworth, 2003), as well as social and workplace isolation (Cooper and Kurland, 2002, Daniel et al., 2018). More recent reports suggest an increased risk of conflict, as work or home/family duties interfere with one another due to co-location (Delanoeije et al., 2019), with blurred home/work boundaries leading to reduced happiness in some cases (Pluut and Wonders, 2020). WfH frequency appears significant, with individuals WfH two days a week reporting positive job satisfaction and reduced stress (Delanoeije and Verbruggen, 2020), and those WfH up to eight hours a month reporting reduced depression (Henke et al., 2016), but those WfH more than three days a week reporting more negative health impacts (Gajendran and Harrison, 2007). While there appears little consensus around age, gender and other demographic factors, important systemic moderators have been identified, including: demands of the home environment, level of organisational support, and social connections external to work (Oakman et al., 2020).

Much of the evidence on physical health and wellbeing impacts of WfH predates the COVID-19 pandemic, when WfH shifted from being largely optional to mandatory, and became more widespread in terms of both participation and frequency. This exacerbated known risks of ill-equipped home-working environments (trip hazards, ergonomics),

psychosocial (isolation, blurring of work/family boundaries), and behaviour (diet, sleep, addiction) (Bouziri et al., 2020). This also amplified aforementioned concerns around work-related sedentary behaviour, with employees reporting longer times sitting at their desks and less overall PA in the absence of commuting and work-related travel, accentuated by increasing use of virtual meetings (Xiao et al., 2021). The seismic shift in WfH during the pandemic, the (apparent) heterogenous experiences/responses of workers, and the likelihood it will remain an option in some shape or form as we move towards the 'next normal', necessitates further investigation of impacts on health and wellbeing. The aim of this study was therefore to examine how perceptions about the time spent WfH, sitting and engaging in general physical activity had changed during the first wave of the pandemic; and how those perceived changes map to reported PA and QoL outcomes. In turn, this gives insight into the potential contextual factors that may contribute to poorer health outcomes, particularly if WfH is to be an ongoing feature of a post-pandemic work environment.

2. Materials & methods

Study context

Australia's COVID-19 containment policies have been among the strictest in the world, with bans on international, interstate, and local travel featuring heavily in the first two years of the pandemic. While the federal government controls international borders, most of the day-to-day decisions around restrictions are made and enforced at the state level. For Australia's most populous state, New South Wales (NSW), the first lockdown in 2020 ran from mid-March to mid-May. Initial restrictions in mid-March applied social distancing rules, limits to indoor and outdoor gatherings, and travel bans. A national lockdown began on 23rd March, with closures of pubs, clubs, cafes and restaurants (excluding takeaway and delivery), as well as leisure, sporting and entertainment venues. 'Stay at home' orders were introduced the following day, other than for essential activities (Storen and Corrigan, 2020). Although this order was relaxed in May, companies were still required to allow WfH up until December 2020. WfH became the norm for highly digitised industry sectors (e.g., ICT, professional, scientific, technical, financial services) as part of infectious disease control strategies (Haug et al., 2020), with estimates of 47% of employees in Australia WfH at the peak of restrictions (OECD, 2021). This led to dramatic reductions in attending workplaces, with associated increases in the time spent at home (Figure 1). As restrictions eased in mid/late-2020, it was evident that WfH in some capacity would remain in both the short term – to reduce risk of transmissible diseases (Klein, 2020) and pressure on the transport network and high-density office spaces – and the longer term, as employers saw the benefits of providing greater flexibility without compromising productivity (Koehn and Irvine, 2021).

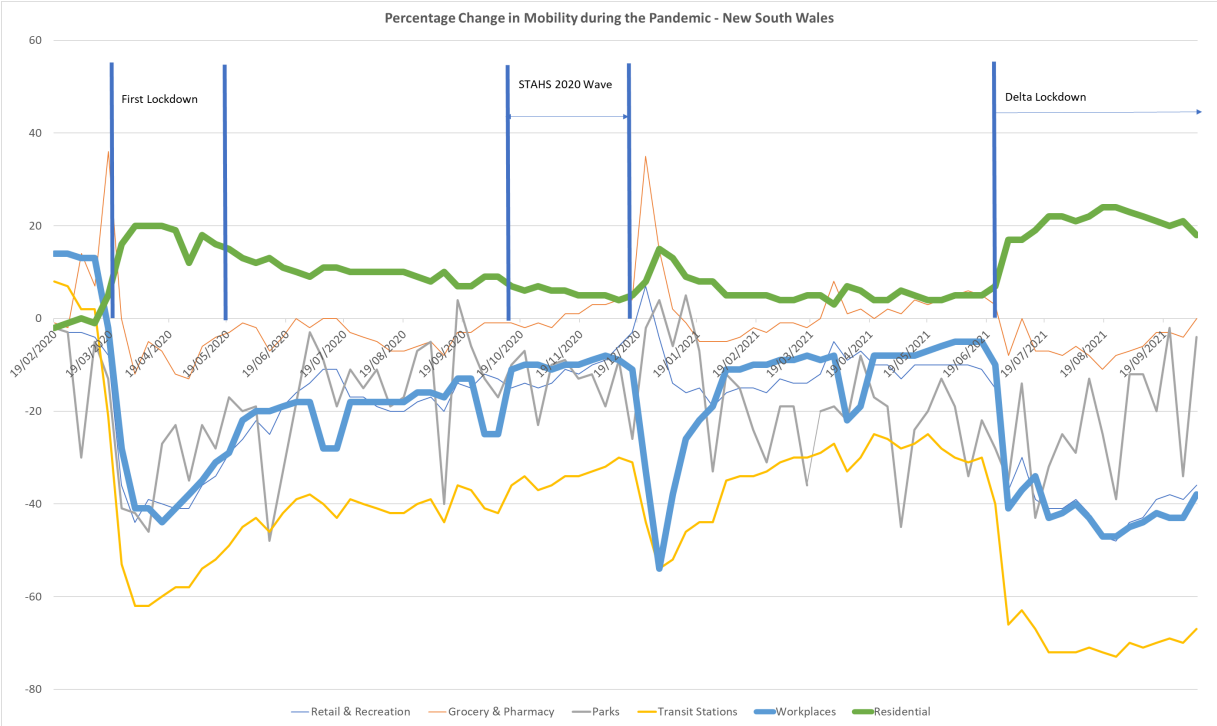

Figure 1: Mobility impacts of the pandemic in New South Wales Google mobility data available at *https://www.google.com/covid19/mobility/*)

Study design

A cross-sectional study using an online survey captured self-reported travel and work behaviour, local neighbourhood perceptions and attitudes, and self-reported PA and subjective wellbeing outcomes from 1,750 Sydneysiders. The survey was conducted in October–December 2020. This period marked a period of easing of restrictions following the first lockdown in March–May 2020. Previous iterations of the survey had been conducted in 2013–15, and again in 2019, as part of a longitudinal evaluation of transportation and wellbeing known as the Sydney Travel and Health Study (STAHS) (Crane et al., 2017). The survey took 10–15 minutes to complete.

Study participants

Participants were recruited with the assistance of a market research company using their online consumer panel, with additional participants recruited via email and social media platforms. We intentionally sought to over-sample professional, managerial, and clerical workers, given these were more representative of the industry sectors where WfH was known to be more prevalent.

Measures

Demographic measures included age, gender, level of education, household income, and occupation based on the Australian and New Zealand Standard Classification of Occupations – ANZSCO (Australian Bureau of Statistics, 2021a).

Travel measures included active travel (walking and cycling) in the local area in the last week.

Work measures included occupation (based on Australian Bureau of Statistics' classification (Australian Bureau of Statistics, 2021a)), and the number of days worked/WfH in a typical working week prior to COVID-19 and in the most recent working week.

Local neighbourhood perceptions used questions from a validated instrument assessing participants' perceptions of their local environment in terms of factors associated with active travel, such as safety, traffic noise, walking routes, green space, and general aesthetics (Ogilvie et al., 2008).

Physical activity used the validated Active Australia Survey (AAS), requiring participants to record frequency and duration of walking, moderate and vigorous PA lasting 10 minutes or more in the last seven days (Australian Institute of Health and Welfare, 2003). Sufficient PA for health was defined to be at least 150 minutes of PA (vigorous activity counts double) across at least five sessions per week. This instrument was appended with additional items on the frequency and duration of cycling activity lasting 10 minutes or more in the last seven days, and the amount of time spent sitting/reclining on a typical day, as an indication of sedentary behaviour. Highly sedentary behaviour was defined as sitting for more than 8 hours/day as proposed for Australian adults (Bennie et al., 2016).

Subjective wellbeing used the World Health Organization's abbreviated QoL assessment tool (WHOQoL-BREF), a 26-item self-rating of QoL and health satisfaction, covering four QoL domains: physical, psychological, social and environmental (Murphy et al., 2000).

Perceptions of change associated with the pandemic presented participants with twelve statements asking them to rate how much WfH, PA (overall PA, transport PA, recreational PA), anxiety, concern about the future, and use of active transport for commuting had changed relative to what they were experiencing before the pandemic.

Analysis

Descriptive statistics were initially used to describe the sample demographics, followed by an assessment of changes in work, WfH and the twelve statements of perceived changes associated with the pandemic. Given these statements were constructed to explore changes in work, active travel, PA and wellbeing, and that no existing constructs were available based on these measures, factor analysis was used to identify potential underlying constructs of the statements without imposing a preconceived structure on the outcome (Child, 2006). Principal component analysis with varimax rotation was used, with eigenvalues greater than one indicating the number of factors to be extracted. Using a quasi-stepwise process, the statements "*cycling for non-work purposes*" and "*I am working from home more often*" were removed due to cross-loading across multiple factors (cross-loaded variables are problematic when factors share the same variable(s), as the purpose of factor analysis is to reduce the number of dimensions into distinct and represent separate constructs). Three factors/latent constructs were identified. The Kaiser-Meyer-Olkin Test of sampling adequacy (0.820) indicated factor analysis was appropriate for the data, while the Bartlett's Test of Sphericity (3413.983, 45, 0000) showed the underlying correlation matrix differed significantly from an identity matrix.

The next phase of analysis involved identifying homogeneous clusters/segments of participants based on the three constructs identified through the factor analysis. K-means cluster analysis was used, which partitions n observations into k clusters, with each observation belonging to the cluster with the closest cluster average. Ultimately, a three-cluster solution provided the largest number of clusters while still retaining statistical significance between the average factor score for each latent construct. Having established these three clusters, we determined their association with other attributes: socio-demographics; changes to work and WfH; sitting time; PA; QoL; and perceptions of the local environment. Significant differences between the sample profile clusters were assessed using F-tests (for continuous measures) or chi-square tests (for categorical measures).

3. Results

3.1 Participant characteristics

A sample of 1,707 participants resulted, after data checking. Given the focus on changing work practices, participants who primarily identified as paid workers (full-time, part-time, casual) were selected, resulting in a usable sample of 1,165 workers. Table 1 shows the composition of the sample. The gender split was equal with a reasonable distribution across age categories. Around two-thirds of participants had a tertiary education, with a median income of AU$130,000, with manager, professional and clerical/administration occupations dominating, as intended.

Table 1: Sample characteristics of participants identified as workers

n = 1,165	No.	%		No.	%
Gender			**Annual household income**		
Male	581	49.9	Less than A$80,000	264	22.7
Female	584	50.1	A$80,000–140,000	420	36.1
Age category			A$140,000 or more	350	30.0
18–24	79	6.8	Missing	134	11.2
25–34	252	21.6	**Occupation (ANZSCO)**		
35–44	366	31.4	Manager	283	24.3
45–55	265	22.7	Professional	368	31.6
56–64	164	14.1	Technicians and trades	72	6.2
65–69	39	3.3	Community and personal services	72	6.2
Highest level of education			Clerical and administration	237	20.3
Higher School Certificate/School Certificate	156	13.4	Sales	65	5.6
Trade or Technical and Further Education	213	18.3	Machine operators/drivers	25	2.1
Tertiary	788	67.6	Labourers	43	3.7
Missing	8	0.7			

3.2. Changes in work and working from home

Figure 2 indicates the relative difference in days worked and days WfH in a typical week prior to COVID-19 and in the last working week preceding the survey. Figure 3 indicates the proportion of days WfH/days worked in a week. Overall, the proportion of participants WfH at least one day/week increased from 33% to 58%, while the proportion of WfH/days worked increased from 19% to 48%. This suggests both an increase in those WfH in some capacity, and an increase in the proportion of work done at home – particularly notable is that one-third of the sample had shifted all their work to home, with one-fifth working full-time (taken as 5 days/week or more) at home.

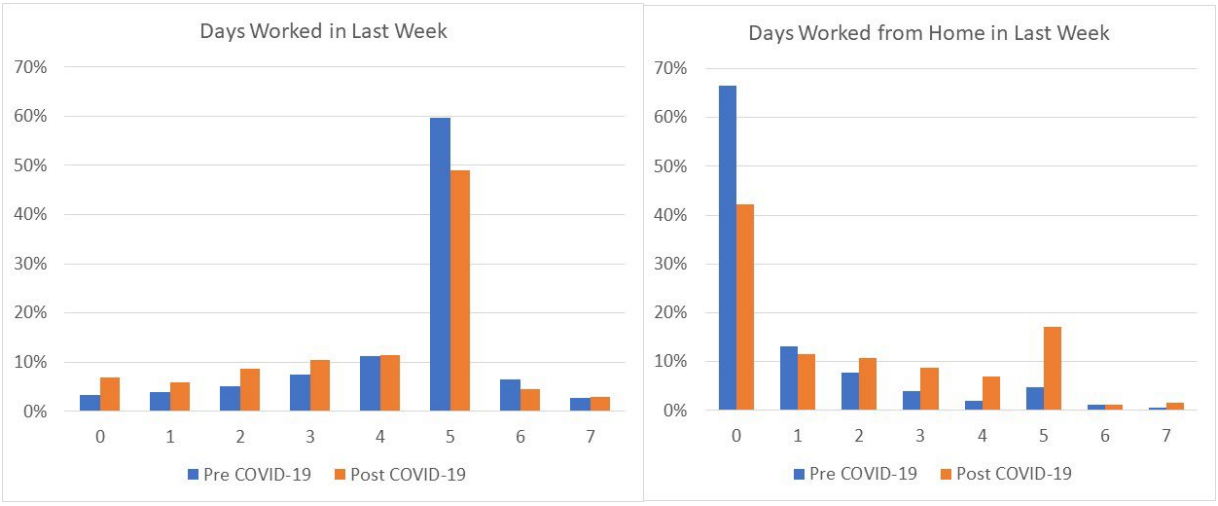

Figure 2: Changes in work pre-post first lockdown

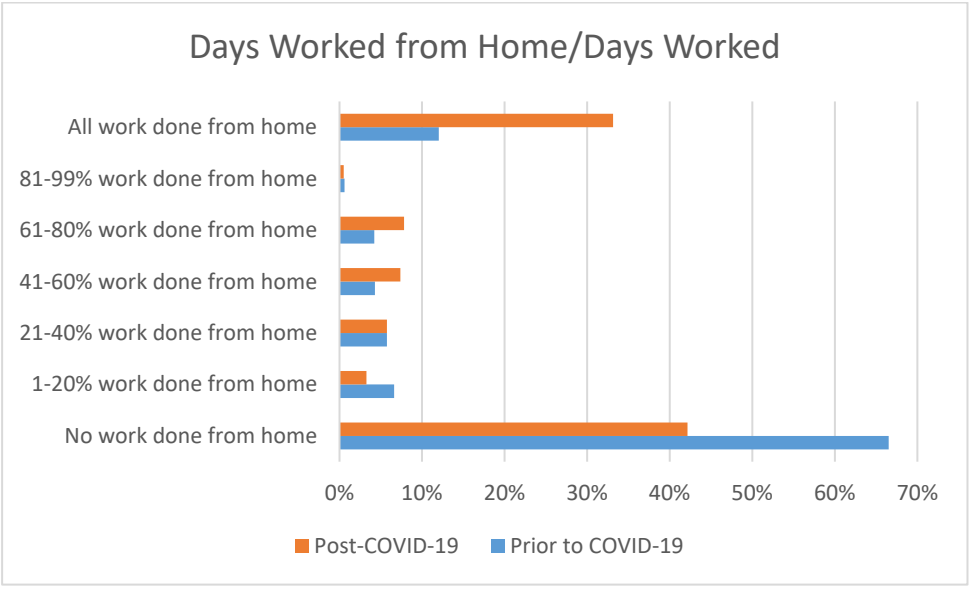

Figure 3: Proportion of days WfH/days worked

3.3 Perceived changes in working from home and activity levels

Based on the statements (Figure 4), 52% of participants perceived they were WfH more compared to before the pandemic. In terms of perceptions of changes in PA, 36% of the sample reported more, 32% reported the same and 30% reported less. Notably, some reported they had increased use of active modes for non-work purposes, particularly walking (37%) and to a lesser extent cycling (15%). In addition, one-third of the sample reported increases in walking/cycling for leisure (36%), and walking/cycling for exercise (31%). In terms of the wellbeing items, 43% reported more anxiety or depression, and almost two-thirds (65%) were more concerned about the future. Equally pronounced were perceptions of sitting more (55%), with only 8% reporting sitting less.

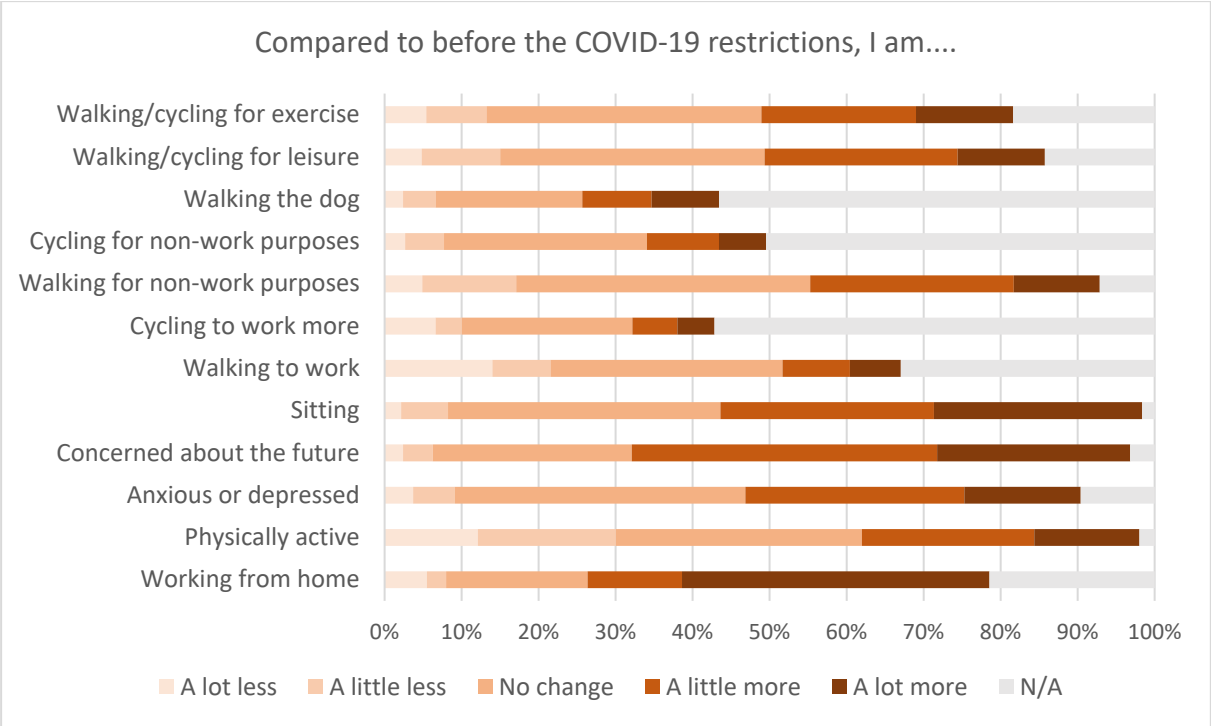

Figure 4: Perceived changes in activity levels

3.4 Factor analysis of perceived changes in activity levels associated with the pandemic

The final factor loadings of the set of perception variables are provided in Table 2. Each statement loaded strongly onto one factor, the exception being perceived changes in "walking the dog", which likely can be attributed to the fact that this activity was not engaged in by most participants. Three underlying constructs were identified as driving response patterns to the statements; namely, perceived changes to levels of what we identified as: "*General Activity*", "*Sitting and Stress*", and "*Active Commuting*".

Table 2: Rotated factor loadings

Perceived changes in activity levels	General Activity	Sitting and Stress	Active Commuting
Overall physically activity	0.716	-0.165	0.170
Walking for non-work purposes	0.713	0.080	0.177
Walking the dog	0.572	0.245	0.196
Walk/cycle for leisure (gentle pace)	0.846	0.045	0.106
Walk/jog/cycle for exercise (faster pace)	0.841	0.044	0.104
Anxious or depressed	0.085	0.803	0.119
Concerned about the future	0.157	0.793	-0.009
Sitting	-0.105	0.765	0.008
Walking to work	0.228	-0.038	0.846
Cycling to work	0.211	0.145	0.839

3.5 Cluster analysis to define segments of respondents based on factor analysis constructs

Figure 5 shows the average factor score for each construct across each of the three clusters – 39 participants were excluded from the clustering procedure as they did not complete all the questions required to develop the clusters, leaving 1,126 for further analysis. Note, the factor scores used in the cluster analysis were estimated using the regression method, meaning they are standardised scores with a mean of zero and a variance equal to the squared multiple correlation between the estimated factor scores and the true factor values. This standardisation implies the mean factor scores calculated within each cluster are relative to the mean factor score across the sample. In turn, discussion of cluster averages should be interpreted as relative to other cluster averages – for example, in a discussion of stress, a negative average factor score does not indicate low levels of stress for that cluster – rather, it indicates cluster members are relatively less stressed compared to others in the sample. It is also important to note the three latent constructs identified from the factor analysis were used as inputs into the cluster analysis and are not to be thought of as a direct one-to-one mapping of factor to cluster. Rather, participants within each cluster exhibit similar latent constructs, but these differ significantly between participants in different clusters. It is coincidence that the analysis identified three distinct clusters of participants based on the three underlying factors.

We term the first cluster "*Active but Anxious*", comprising 22% of the sample. Participants in this cluster report the lowest relative levels of active commuting and the second highest relative levels of sitting and stress, but, more positively, report the highest relative levels of PA. We term the second cluster "*Less Change, Less Worries",* comprising 38% of the sample. This group report the least relative change in levels of general PA and active commuting, and the lowest levels of relative stress. We term the final cluster "*Stressed and Sedentary*", comprising 40% of the sample. While members of this cluster report the highest relative levels of active commuting (noting this is moderated by the fact that active commuting has been perceived to increase from a low base of activity), they report the lowest relative levels of general PA and the highest relative levels of sitting and stress.

Figure 5: Average factor score by cluster

Association of these clusters with contextual variables (socio-demographics; changes to work and WfH; sitting time; PA levels; QoL; and perceptions of the local environment) are shown in Table 3 and described below. Note that Table 3 displays only variables that differed significantly between the clusters (i.e., if a variable was found to be statistically similar across each of the three clusters, it is not shown).

Table 3: Characteristics of cluster members

	Variable	Active but Anxious	Less Change, Less Worries	Stressed and Sedentary	F-stat[f] or chi-sq[x]	*p* value
	Cluster size (number of participants)	249	428	449		
	%	22%	38%	40%		
Socio-demographics	*Average age (years)*	**38.7**	**41.9**	40.6	4.942[f]	0.007
	Average household income (A$1,000s)	**137.9**	129.5	**115.0**	6.814[f]	0.001
	Male	47%	**58%**	46%	14.532[x]	0.007
Changes to work and working from home	*Avg. days worked/week before COVID-19*	**4.6**	4.3	**4.2**	4.611[f]	0.000
	Avg. days WfH/week before COVID-19	0.94	0.94	0.85	0.345[f]	0.708
	Proportion of days WfH before COVID-19	21%	26%	27%	2.197[x]	0.112
	Relative to before restrictions I am WfH more often	**4.20**	**3.40**	**3.90**	46.600[f]	0.000
	Avg. days WfH/week during COVID-19	1.90	1.80	**2.50**	10.769[f]	0.000
	Proportion of days WfH during COVID-19	**61%**	43%	48%	12.922[x]	0.000
	Avg. increase in number of days WfH	**1.65**	0.81	0.95	14.852[f]	0.000
	Increase in proportion of days WfH	**40%**	17%	22%	23.740[x]	0.000
	Avg. days of work/week lost during COVID-19	-0.35	**-0.16**	**-0.51**	6.324[f]	0.000
Sedentary behaviour	*Avg. hours spent sitting or reclining on a typical day*	6.5	**5.5**	6.8	4.611[f]	0.000
	Percent sitting 8 hours or more per day (i.e., highly sedentary people as proposed for Australian adults by Bennie et al. (2016))	41%	**29%**	45%	27.750[x]	0.000
Measures of physical activity	*Avg. minutes spent walking in last 7 days*	**276.6**	236.1	211.3	6.946[f]	0.001
	Suff. PA for health (>= 150 mins/week)	**89%**	**79%**	**70%**	33.469[x]	0.000
	Suff. PA for health (>= 150 mins across >= 5 sessions/week)	**86%**	**72%**	**62%**	46.738[x]	0.000
Quality of life measures	*How would you rate your quality of life?*	3.84	3.94	**3.67**	11.281[f]	0.000
	How satisfied are you with your health?	**3.39**	**3.86**	**3.39**	27.246[f]	0.000
	QoL: Avg. physical domain score	**72.0**	**75.2**	**68.2**	22.030[f]	0.000
	QoL: Avg. psychological domain score	**63.5**	**70.5**	**59.5**	41.041[f]	0.000
	QoL: Avg. social domain score	65.0	**71.5**	62.4	19.567[f]	0.000
	QoL: Avg. environmental domain score	**70.6**	**73.8**	**67.1**	18.491[f]	0.000
Perceptions of local environment *(1=strongly disagree….5 = strongly agree)*	*There is a lot of traffic noise*	3.37	**3.30**	**3.49**	3.629[f]	0.027
	There is little green space	2.89	2.92	**3.17**	6.462[f]	0.002
	Safe to walk after dark	3.53	**3.71**	3.48	5.964[f]	0.003
	Surroundings are unattractive	**2.55**	2.62	**2.82**	5.514[f]	0.004

Note: bolded numbers highlight significant differences. The darker shaded numbers refer to higher values (darker blue) versus lower values (lighter blue). x = chi-square statistics, f = F values (ANOVA).

Socio-demographics: The "*Active but Anxious*" cluster are generally younger (significantly more so than those in the "*Less Change, Less Worries*" cluster), female and have higher household incomes. The "*Less Change, Less Worries*" cluster are generally older and are more likely to be male. The "*Stressed and Sedentary*" cluster have lower household incomes and are slightly more likely to be female. There are no differences exhibited across these clusters with respect to occupation, taken at the level of the ANZSCO major group level specified in Table 1.

Changes in work: The "*Active but Anxious*" cluster report they worked significantly more days per week prior to COVID-19 compared to those classified as "*Stressed and Sedentary*" – though there were no differences between clusters in the number of days WfH, nor the proportion of total work that was done from home. This indicates that each of the three clusters perceived they were working at a roughly similar "base" prior to the pandemic. However, following the COVID-19 restrictions, several significant differences between clusters emerge:

- The "*Less Change, Less Worries*" cluster perceive the least relative change in WfH following COVID-19 restrictions, which is matched by having the lowest absolute number of days WfH, the lowest proportion of days WfH, the smallest increase in days WfH and smallest increase in the proportion of workdays WfH. This cluster also report the lowest average number of days of work lost following COVID-19 restrictions.
- The "*Active but Anxious*" cluster perceive the most relative change in WfH following restrictions, which is supported by having the highest proportion of current work being completed at home, the largest increase in the number of days WfH, and consequently the largest proportional increase in days WfH.
- The "*Stressed and Sedentary*" cluster perceive the second-highest relative change in WfH and the largest number of days WfH following restrictions. An important differentiator for this cluster is they report the highest average number of days of work lost following restrictions.

Sedentary behaviour: Differences in the average time spent sitting are apparent. The "*Less Change, Less Worries*" cluster report the lowest average hours sitting and the lowest proportion who are highly sedentary (sitting for 8 or more hours/day), with only 29% who are highly sedentary. In contrast, the "*Stressed and Sedentary*" cluster reports the longest average number of hours sitting, with almost half the cluster members (45%) classed as highly sedentary. The "*Active but Anxious*" cluster report similar levels of sitting overall to those in "*Stressed and Sedentary*", with 41% highly sedentary.

Physical activity: The "*Active but Anxious*" cluster report significantly more time spent walking over the week and have the highest proportion of members who would be classified as sufficiently physically active for health across two measures with different stringencies for what is deemed to be sufficient. The "*Less Change, Less Worries*" cluster sits in the middle of the three clusters on each of these measures, while the "*Stressed and Sedentary*" cluster is characterised by the lowest amount of time spent walking in the last 7 days along with the lowest proportion of members who would be deemed physically active.

Quality of life: Self-reported QoL measures also vary significantly across the three clusters. The "*Less Change, Less Worries*" cluster report a significantly higher overall QoL, higher health satisfaction and higher QoL scores across the four domains. The "*Stressed and Sedentary*" cluster is revealed to have the lowest QoL outcomes in almost every regard, the exception being the social QoL domain, where the score is the same as the "*Active but Anxious*" cluster (the cluster with the middle scores across all dimensions).

Local neighbourhood: Perceptions of the local neighbourhood varied across the three clusters. The "*Stressed and Sedentary"* cluster had the strongest negative perceptions around traffic noise, and to a lesser extent lack of green space and unattractive surroundings. The "*Less Change, Less Worries*" had significantly higher agreement that their local neighbourhood was safe to walk in after dark.

4. Discussion

This study explores perceptions around WfH and health behaviours through the first wave of the pandemic, examines how these perceived changes map to reported levels of PA, sedentary behaviour and QoL measures, and consequently identifies contextual factors that may be contributing to poorer health outcomes. The analysis revealed three underlying factors driving perceptions of changed behaviour. Based on these underlying factors, three clusters/segments of participants were identified, with each cluster exhibiting a uniquely different perspective on how their behaviour had changed. Subsequent examination confirmed these perceived differences manifested through revealed differences in sedentary behaviour, PA and QoL and, further, identified demographic factors associated with these changes.

A summary of these cluster groupings capturing key characteristics is presented as a vignette in Figure 6. While COVID-19 and associated restrictions have been disruptive for all, they have evidently had disproportionate impacts across the sample. Those in the second largest cluster, "*Less Change, Less Worries*", report lower average changes to stress (albeit a small relative increase overall), are predominantly male, and have seemingly limited impacts to their work and PA. While there has been a small increase in WfH, this has been minor compared to the other clusters. This cluster reports the lowest amount of sitting and highest QoL scores.

The smallest cluster, "*Active but Anxious*", are slightly younger and have higher household incomes. They report the largest increase in WfH following restrictions and are sitting for long periods of time. However, this cluster has the highest level of PA, which together with the strongest perception of increased activity based on factor loadings (Figure 5), suggests that while WfH more than before, they may have become conscious of sitting more, and are attempting to offset this with higher levels of PA. This, in turn, seems to be associated with higher QoL outcomes. While this high amount of PA may be somewhat moderating, anxiousness and stress have increased, possibly a reflection of the pandemic itself.

The third and final cluster, "*Stressed and Sedentary*", is arguably the most concerning from a population health standpoint. It represents the largest proportion of participants, with those in this cluster exhibiting the highest levels of relative stress and lowest levels of relative PA. While increasing the days WfH, this cluster has experienced the largest drop in overall employment. Cluster members are sitting on average almost 7 hours a day and have the highest proportion who are sitting an excessive amount. This cluster also has the lowest proportion of members who are sufficiently physically active for health, with around one-third failing to meet this criterion. This cluster also has the lowest QoL scores on all measures.

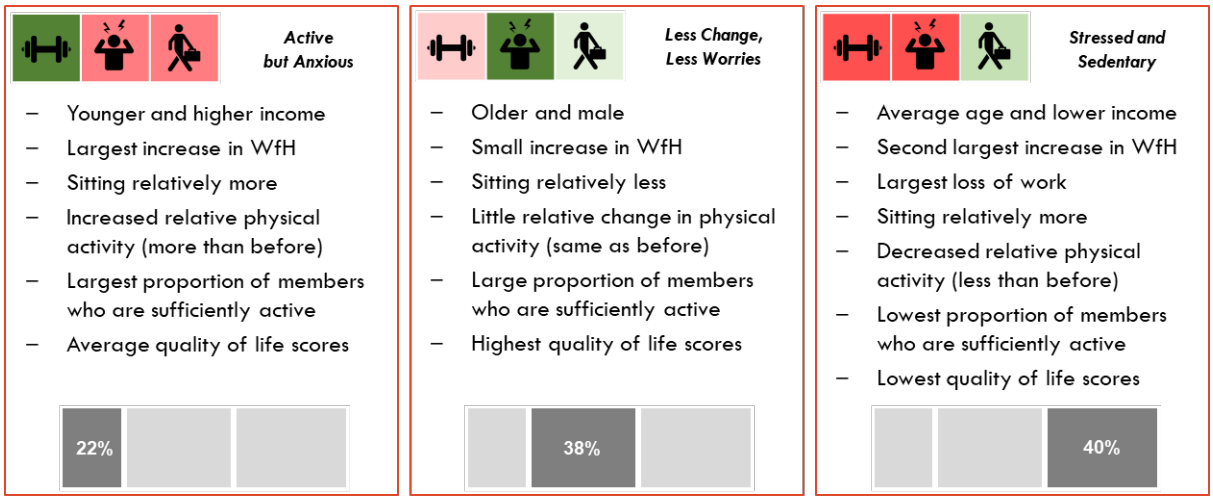

Figure 6: Vignette of segment characteristics

An important area of concern is the large increase in sitting, corroborated by evidence elsewhere also in connection with an originally forced large-scale move to WfH due to the pandemic (Koohsari et al., 2021b). In this study, we have seen that almost two-thirds of the sample report higher levels of sitting, alongside higher levels of stress and anxiety. The interesting contrast in these data is that those in one cluster (*Active but Anxious*) are seemingly making a deliberate effort to increase their level of PA, and this may be having a moderating effect on reductions to measures of wellbeing, relative to the larger cluster (*Stressed and Sedentary*) – which has lower average PA and worse scores across all QoL measures.

The consequences of insufficient physical inactivity are well documented (Powell et al., 2019). In addition, sitting for extended periods of time independently contributes to the development of chronic diseases, such as type 2 diabetes and cardiovascular diseases, as well as all-cause mortality (Wilmot et al., 2012, Ekelund et al., 2019) and a higher risk of depression and anxiety (Zhai et al., 2015). The 2020 World Health Organization guidelines for adults recommend reducing sedentary behaviour across all age groups and abilities (Bull et al., 2020). Even before the pandemic, the majority of Australians were not meeting PA guidelines and were reporting excessive sedentary behaviour (Bennie et al., 2016). As the need to travel to work and move during the day to attend meetings, etc. has been replaced by a laptop on the kitchen table and virtual meetings, people are invariably sitting more. The loss of the daily commute and intra-day travel at work are clearly lost opportunities for incidental active travel and associated PA benefits that need to be recovered.

While the onus has primarily been on the individual to take responsibility for their health and wellbeing while WfH, the level of organisational support provided by employers has been shown to be critical (Oakman et al., 2020). In Australia, employees, whether working in the office or from home, are protected under the *Work Health and Safety Act 2011*, which places the onus on employers to provide a workplace designed to eliminate or minimise health and safety risks (Safe Work Australia, 2019). Arguably, the legislation and guidelines need updating to provide more explicit guidance about the need for regular interruptions to sitting and encouragement of more PA. In the absence of legislation, responses by employers have been largely ad hoc and there is still much work required to ensure that workers have appropriate support and workplace health and safety protections (Pennington and Stanford, 2020). Equally, there is an onus on those responsible for land use/transport planning and policy to respond to the impacts of this shift in work to the home. Forward-thinking

sustainability policies, such as the 20-minute neighbourhood (Stanley et al., 2015), provide opportunities to build on the momentum for liveable local urban environments. Some governments have made actions to implement and expand active travel infrastructure networks to support walking and cycling in urban areas, but these need to be scaled up across all urban areas (Musselwhite et al., 2020), reducing current inequalities in access to infrastructure for achieving PA (Jáuregui et al., 2021).

The COVID-19 pandemic presents a significant opportunity for urban change for health and urban sustainability (Crane et al., 2021). This needs to be harnessed so that these short-term findings do not eventuate into long-term worsening of chronic diseases. We also need to learn from a health policy angle how we move from here. Individual and community health is largely determined by local and national policy decisions outside health – such as in urban planning and transport sectors (Giles-Corti et al., 2020). The connection between our neighbourhoods, workplaces and health is deeply interconnected and, as neighbourhoods become places for work, rest and play, we need a stronger commitment to implementing health in all policy frameworks to address physical and mental health issues.

Limitations: As with all studies of human behaviour relying on self-participation and reporting, limitations exist with the analysis presented here. First, the sample was skewed towards highly educated, higher-income, office-based workers, which, for the purposes of the current analysis, captured people most likely to switch to significant levels of WfH, but clearly results must be interpreted accordingly. Second, the sample was more physically active/less sedentary than the general population (Australian Bureau of Statistics, 2018), which suggests the findings are conservative. Third, data were cross-sectional, with statements requiring participants to retrospectively consider their activities before the COVID-19 restrictions. Clearly, we do not know how long these effects last, but the fact they occurred should provide pause for thought. Fourth, we appreciate that increased sitting and less PA do not necessarily translate directly to the negative outcomes of the "*Stressed and Sedentary*" group; however, we do know this group exists, is sizeable (40%) and a concern. Finally, we acknowledge the potentially confounding effect of the pandemic, particularly around the prevalence of WfH and the responses to subjective wellbeing questions. However, at this stage in the pandemic, other than international and some interstate travel bans, restrictions had largely been eased in Australia.

5. Conclusions

Working from home was widely adopted during the COVID-19 pandemic and is likely to remain more prevalent in many countries. This has exacerbated concerns around potential impacts of WfH on sedentary behaviour, PA and QoL. Drawing from a survey of workers, conducted as restrictions from the first wave of the pandemic were easing in Australia, we have identified three distinct clusters of perceived impacts, consistent among which has been more sitting – with one cluster offsetting increased the negative impacts of increased sitting with increased PA and reporting better QoL than other clusters. Faced with a future of expanded WfH, it is critical that individuals, employers and policy-makers understand the potential health outcomes and plan timely interventions to mitigate the impacts.

6. References

Australian Bureau of Statistics. 2018. *National Health Survey: First Results, 2017–2018* [Online]. Available: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release [Accessed 28 Jan 2022].

Australian Bureau of Statistics. 2021a. *ANZSCO - Australian and New Zealand Standard Classification of Occupations* [Online]. Available:

https://www.abs.gov.au/statistics/classifications/anzsco-australian-and-new-zealand-standard-classification-occupations/latest-release [Accessed 15 Dec 2021].
Australian Bureau of Statistics. 2021b. *Household Impacts of COVID-19 Survey* [Online]. Available: https://www.abs.gov.au/statistics/people/people-and-communities/household-impacts-covid-19-survey/latest-release [Accessed 15 Nov 2021].
Australian Institute of Health and Welfare 2003. *The Active Australia Survey: a guide and manual for implementation, analysis and reporting,* Canberra, AIHW.
Beck, M. J. & Hensher, D. A. 2020. Insights into the impact of COVID-19 on household travel and activities in Australia – The early days of easing restrictions. *Transport Policy,* 99**,** 95-119.
Beck, M. J. & Hensher, D. A. 2021. Australia 6 months after COVID-19 restrictions part 2: The impact of working from home. *Transport Policy*.
Bennie, J. A., Pedisic, Z., van Uffelen, J. G. Z., Gale, J., Banting, L. K., Vergeer, I., Stamatakis, E., Bauman, A. E. & Biddle, S. J. H. 2016. The descriptive epidemiology of total physical activity, muscle-strengthening exercises and sedentary behaviour among Australian adults – results from the National Nutrition and Physical Activity Survey. *BMC Public Health,* 16**,** 73.
Bieser, J. C. T., Vaddadi, B., Kramers, A., Höjer, M. & Hilty, L. M. 2021. Impacts of telecommuting on time use and travel: A case study of a neighborhood telecommuting center in Stockholm. *Travel Behaviour and Society,* 23**,** 157-165.
Bouziri, H., Smith, D. R. M., Descatha, A., Dab, W. & Jean, K. 2020. Working from home in the time of COVID-19: how to best preserve occupational health? *Occupational and Environmental Medicine,* 77**,** 509.
Brito, L. M. S., de Lima, V. A., Mascarenhas, L. P., Mota, J. & Leite, N. 2021. Physical activity, eating habits and sleep during social isolation: From young adult to elderly. *Revista Brasileira de Medicina do Esporte,* 27**,** 21-25.
Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J.-P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., Lambert, E., Leitzmann, M., Milton, K., Ortega, F. B., Ranasinghe, C., Stamatakis, E., Tiedemann, A., Troiano, R. P., van der Ploeg, H. P., Wari, V. & Willumsen, J. F. 2020. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine,* 54**,** 1451.
Chakrabarti, S. 2018. Does telecommuting promote sustainable travel and physical activity? *Journal of Transport & Health,* 9**,** 19-33.
Chatterjee, K., Chng, S., Clark, B., Davis, A., De Vos, J., Ettema, D., Handy, S., Martin, A. & Reardon, L. 2020. Commuting and wellbeing: a critical overview of the literature with implications for policy and future research. *Transport Reviews,* 40**,** 5-34.
Chiba, A. 2021. The effectiveness of mobility control, shortening of restaurants' opening hours, and working from home on control of COVID-19 spread in Japan. *Health & Place,* 70**,** 102622.
Child, D. 2006. *Essentials of factor analysis,* New York, Continuum.
Cooper, C. D. & Kurland, N. B. 2002. Telecommuting, professional isolation, and employee development in public and private organizations. *Journal of Organizational Behavior,* 23**,** 511-532.
Crane, M., Lloyd, S., Haines, A., Ding, D., Hutchinson, E., Belesova, K., Davies, M., Osrin, D., Zimmermann, N., Capon, A., Wilkinson, P. & Turcu, C. 2021. Transforming cities for sustainability: A health perspective. *Environment International,* 147**,** 106366.
Crane, M., Rissel, C., Standen, C., Ellison, A., Ellison, R., Wen, L. M. & Greaves, S. 2017. Longitudinal evaluation of travel and health outcomes in relation to new bicycle infrastructure, Sydney, Australia. *Journal of Transport & Health,* 6**,** 386-395.
Daniel, E., Di Domenico, M. & Nunan, D. 2018. Virtual Mobility and the Lonely Cloud: Theorizing the Mobility-Isolation Paradox for Self-Employed Knowledge-Workers in the Online Home-Based Business Context. *Journal of Management Studies,* 55**,** 174-203.
De Abreu e Silva, J. & Melo, P. C. 2018. Home telework, travel behavior, and land-use patterns: A path analysis of British single-worker households. *Journal of Transport and Land Use,* 11**,** 419-441.

De Vos, J. 2020. The effect of COVID-19 and subsequent social distancing on travel behavior. *Transportation Research Interdisciplinary Perspectives,* 5**,** 100121.
Delanoeije, J. & Verbruggen, M. 2020. Between-person and within-person effects of telework: a quasi-field experiment. *European Journal of Work and Organizational Psychology,* 29**,** 795-808.
Delanoeije, J., Verbruggen, M. & Germeys, L. 2019. Boundary role transitions: A day-to-day approach to explain the effects of home-based telework on work-to-home conflict and home-to-work conflict. *Human Relations,* 72**,** 1843-1868.
Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A. E. & Lee, I. M. 2019. Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *British Journal of Sports Medicine,* 53**,** 886.
Felstead, A. & Henseke, G. 2017. Assessing the growth of remote working and its consequences for effort, well-being and work-life balance. *New Technology, Work and Employment,* 32**,** 195-212.
Fincke, I., Hieb, A., Harth, V. & Mache, S. 2020. Activity-based working: Qualitative analysis of working conditions and health-related outcomes. *Work,* 67**,** 625-639.
Fukushima, N., Machida, M., Kikuchi, H., Amagasa, S., Hayashi, T., Odagiri, Y., Takamiya, T. & Inoue, S. 2021. Associations of working from home with occupational physical activity and sedentary behavior under the COVID-19 pandemic. *Journal of occupational health,* 63**,** e12212.
Gajendran, R. S. & Harrison, D. A. 2007. The good, the bad, and the unknown about telecommuting: meta-analysis of psychological mediators and individual consequences. *J Appl Psychol,* 92**,** 1524-41.
Giles-Corti, B., Lowe, M. & Arundel, J. 2020. Achieving the SDGs: Evaluating indicators to be used to benchmark and monitor progress towards creating healthy and sustainable cities. *Health Policy,* 124**,** 581-590.
Haug, N., Geyrhofer, L., Londei, A., Dervic, E., Desvars-Larrive, A., Loreto, V., Pinior, B., Thurner, S. & Klimek, P. 2020. Ranking the effectiveness of worldwide COVID-19 government interventions. *Nature Human Behaviour,* 4**,** 1303-1312.
He, S. Y. & Hu, L. 2015. Telecommuting, income, and out-of-home activities. *Travel Behaviour and Society,* 2**,** 131-147.
Henke, R. M., Benevent, R., Schulte, P., Rinehart, C., Crighton, K. A. & Corcoran, M. 2016. The effects of telecommuting intensity on employee health. *American Journal of Health Promotion,* 30**,** 604-612.
Jáuregui, A., Lambert, E. V., Panter, J., Moore, C. & Salvo, D. 2021. Scaling up urban infrastructure for physical activity in the COVID-19 pandemic and beyond. *The Lancet,* 398**,** 370-372.
Klein, A. 2020. *Australia sees huge decrease in flu cases due to coronavirus measures* [Online]. New Scientist. Available: https://www.newscientist.com/article/2242113-australia-sees-huge-decrease-in-flu-cases-due-to-coronavirus-measures/ [Accessed 06 June 2020].
Koehn, E. & Irvine, J. 2021. *The five-day office week is dead, long live the hybrid model, says productivity boss* [Online]. The Sydney Morning Herald. Available: https://www.smh.com.au/business/companies/the-five-day-office-week-is-dead-long-live-the-hybrid-model-says-productivity-boss-20210706-p587d4.html [Accessed 13 Dec 2021].
Koohsari, M. J., Nakaya, T., McCormack, G. R., Shibata, A., Ishii, K. & Oka, K. 2021a. Changes in workers' sedentary and physical activity behaviors in response to the COVID-19 pandemic and their relationships with fatigue: Longitudinal online study. *JMIR Public Health and Surveillance,* 7.
Koohsari, M. J., Nakaya, T., Shibata, A., Ishii, K. & Oka, K. 2021b. Working from home after the COVID-19 pandemic: Do company employees sit more and move less? *Sustainability (Switzerland),* 13**,** 1-8.
Lachapelle, U., Tanguay, G. A. & Neumark-Gaudet, L. 2018. Telecommuting and sustainable travel: Reduction of overall travel time, increases in non-motorised travel and congestion relief? *Urban Studies,* 55**,** 2226-2244.

Mann, S. & Holdsworth, L. 2003. The psychological impact of teleworking: Stress, emotions and health. *New Technology, Work and Employment,* 18**,** 196-211.
McDowell, C. P., Herring, M. P., Lansing, J., Brower, C. & Meyer, J. D. 2020. Working From Home and Job Loss Due to the COVID-19 Pandemic Are Associated With Greater Time in Sedentary Behaviors. *Frontiers in Public Health,* 8.
Murphy, B., Herrman, H., Hawthorne, G., Pinzone, T. & Evert, H. 2000. *Australian WHOQoL instruments: User's manual and interpretation guide*.
Musselwhite, C., Avineri, E. & Susilo, Y. 2020. Editorial JTH 16 –The Coronavirus Disease COVID-19 and implications for transport and health. *Journal of Transport & Health,* 16**,** 100853.
Oakman, J., Kinsman, N., Stuckey, R., Graham, M. & Weale, V. 2020. A rapid review of mental and physical health effects of working at home: how do we optimise health? *BMC Public Health,* 20**,** 1825.
OECD 2021. Teleworking in the COVID-19 pandemic: Trends and prospects.
Ogilvie, D., Mitchell, R., Mutrie, N., Petticrew, M. & Platt, S. 2008. Perceived characteristics of the environment associated with active travel: Development and testing of a new scale. *International Journal of Behavioral Nutrition and Physical Activity,* 5.
Olsen, H. M., Brown, W. J., Kolbe-Alexander, T. & Burton, N. W. 2018. Flexible work: The impact of a new policy on employees' sedentary behavior and physical activity. *Journal of Occupational and Environmental Medicine,* 60**,** 23-28.
Pennington, A. & Stanford, J. 2020. Working from home: opportunities and risks. The Australia Institute: Centre for Future Work.
Pluut, H. & Wonders, J. 2020. Not Able to Lead a Healthy Life When You Need It the Most: Dual Role of Lifestyle Behaviors in the Association of Blurred Work-Life Boundaries With Well-Being. *Frontiers in Psychology,* 11.
Powell, K. E., King, A. C., Buchner, D. M., Campbell, W. W., DiPietro, L., Erickson, K. I., Hillman, C. H., Jakicic, J. M., Janz, K. F., Katzmarzyk, P. T., Kraus, W. E., Macko, R. F., Marquez, D. X., McTiernan, A., Pate, R. R., Pescatello, L. S. & Whitt-Glover, M. C. 2019. The Scientific Foundation for the Physical Activity Guidelines for Americans, 2nd Edition. *Journal of Physical Activity and Health,* 16**,** 1-11.
Safe Work Australia 2019. Model Work Health and Safety Bill. Parliamentary Counsel's Committee.
Stanley, J. K., Stanley, J. R. & Davis, S. 2015. Connecting Neighbourhoods: The 20 minute city. *Moving People.* Canberra, Australia: Bus and Coach Industry.
Storen, R. & Corrigan, N. 2020. COVID-19: a chronology of state and territory government announcements (up until 30 June 2020).
Vittersø, J., Akselsen, S., Evjemo, B., Julsrud, T. E., Yttri, B. & Bergvik, S. 2003. Impacts of Home-Based Telework on Quality of Life for Employees and Their Partners. Quantitative and Qualitative Results From a European Survey. *Journal of happiness studies,* 4**,** 201-233.
Wilmot, E. G., Edwardson, C. L., Achana, F. A., Davies, M. J., Gorely, T., Gray, L. J., Khunti, K., Yates, T. & Biddle, S. J. H. 2012. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia,* 55**,** 2895-2905.
Xiao, Y., Becerik-Gerber, B., Lucas, G. & Roll, S. C. 2021. Impacts of Working from Home during COVID-19 Pandemic on Physical and Mental Well-Being of Office Workstation Users. *Journal of Occupational and Environmental Medicine,* 63**,** 181-190.
Zhai, L., Zhang, Y. & Zhang, D. 2015. Sedentary behaviour and the risk of depression: a meta-analysis. *British Journal of Sports Medicine,* 49**,** 705.