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TABLE OF CONTENTS

1. Physical activity at work may not be health enhancing. A systematic review with metaanalysis on the association between occupational physical activity and cardiovascular disease mortality covering 23 studies with 655 892 participants 1

2. Associations of employment sector and occupational exposures with full and part-time sickness absence: random and fixed effects analyses on panel data 16

3. Trajectories of disability throughout early life and labor force status as a young adult: Results from the Longitudinal Study of Australian Children 27

4. Differential impact of working hours on unmet medical needs by income level: a longitudinal study of Korean workers 37

5. Working at home and expectations of being available: effects on perceived work environment, turnover intentions, and health 47

6. Estimating population burdens of occupational disease 58

7. How does accelerometry-measured arm elevation at work influence prospective risk of long-term sickness absence? 62

8. Professional cleaning and risk of asthma - a Danish nationwide register-based study 74

9. Global, regional and national burden of disease attributable to 19 selected occupational risk factors for 183 countries, 2000–2016: A systematic analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury 83

Bibliography 95

Physical activity at work may not be health enhancing. A systematic review with metaanalysis on the association between occupational physical activity and cardiovascular disease mortality covering 23 studies with 655 892 participants

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ABSTRACT (ENGLISH)

Objectives Emerging evidence suggests contrasting health effects for leisure-time and occupational physical activity. In this systematic review, we synthesized and described the epidemiological evidence regarding the association between occupational physical activity and cardiovascular disease (CVD) mortality. Methods A literature search was performed in PubMed, Embase, CINAHL, PsycINFO and Evidence-Based Medicine Reviews, from database inception to 17 April 2020. Articles were included if they described original observational prospective research, assessing the association between occupational physical activity and CVD mortality among adult workers. Reviews were included if they controlled for age and gender and at least one other relevant variable. We performed meta-analyses on the associations between occupational physical activity and CVD mortality. Results We screened 3345 unique articles, and 31 articles (from 23 studies) were described in this review. In the meta-analysis, occupational physical activity showed no significant association with overall CVD mortality for both males [hazard ratio (HR) 1.00, 95% confidence interval (CI) 0.87-1.15] and females (HR 0.95, 95% CI 0.82-1.09). Additional analysis showed that higher levels of occupational physical activity were non-significantly associated with a 15% increase in studies reporting on the outcome ischemic heart disease mortality (HR 1.15, 95% CI 0.88-1.49). Conclusions While the beneficial association between leisure-time physical activity and CVD mortality has been widely documented, occupational physical activity was not found to have a beneficial association with CVD mortality. This observation may have implications for our appreciation of the association between physical activity and health for workers in physically demanding jobs, as occupational physical activity may not be health enhancing.

FULL TEXT

Headnote

Objectives Emerging evidence suggests contrasting health effects for leisure-time and occupational physical activity. In this systematic review, we synthesized and described the epidemiological evidence regarding the association between occupational physical activity and cardiovascular disease (CVD) mortality. Methods A literature search was performed in PubMed, Embase, CINAHL, PsycINFO and Evidence-Based Medicine Reviews, from database inception to 17 April 2020. Articles were included if they described original observational prospective research, assessing the association between occupational physical activity and CVD mortality among adult workers. Reviews

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Key terms cardiovascular mortality; CVD.
Physical activity plays an important role in the prevention of cardiovascular disease (CVD) (1, 2). Physical inactivity accounts for 7% of the global health burden (3) and is accompanied by considerable economic costs (4). Until recently, the health effects associated with work and leisure-time physical activity were considered beneficial and alike, as shown in a meta-analysis on all-cause mortality of cohort studies published until 2010 (5).
Evidence for the beneficial health effects of physical activity has mostly been derived from studies addressing leisure-time physical activity, exemplified in a metaanalysis with 44 studies reporting a 27% reduction of cardiovascular mortality risk for people with high compared to low-intensity leisure-time physical activity (6). However, recent evidence suggests contrasting health effects for leisure-time and occupational physical activity (7, 8). Specifically, while beneficial health outcomes have been reported for high levels of leisure-time physical activity, detrimental health consequences have been observed for high levels of occupational physical activity (9-11). A recent systematic review showed that males with high occupational physical activity had an 18% increased mortality risk, compared to those engaging in low occupational physical activity (12). Although no clear (negative or positive) associations were observed among females, these findings suggest that we may need to revise the way we look at physical activity, as not all domains of physical activity may be health enhancing.
One explanation for domain-specific health effects from physical activity may be the differences in acute and chronic physiological cardio-respiratory responses to physical activity, since domains differ substantially regarding their physical activity frequency, intensity, type, duration and recovery time (13). In contrast to leisure-time physical activity, occupational physical activity is of low intensity and long duration typically below the physiological threshold for improvement or maintenance of cardiovascular health (8). For example, in a sample of cleaners, who were highly active at work, occupational physical activity levels did not reach the intensity levels needed for cardiorespiratory fitness improvements (14). Even more so, the moderate occupational physical activity intensity was maintained over a long duration, and probably with insufficient time to recover, which can lead to chronic fatigue and prolonged elevated resting blood pressure (11) and heart rate (15, 16). These are established hemodynamic risk factors for atherosclerosis (17) and CVD (18, 19). Together, these findings suggest that the potential differential mortality effects of occupational and leisure-time physical activity may be driven by cardiovascular mechanisms (13). It is therefore important to study the cardiovascular health consequences of occupational physical activity, in particular because CVD is the leading cause of death worldwide (20). Although these hypothesized mechanisms hold mainly for occupations involving manual materials handling, prolonged working postures and/or prolonged activity, they may not apply to all jobs with high level occupational physical activity (eg, elite athletes) (12).
A recent review showed a linear beneficial effect of leisure-time physical activity on CVD mortality (6). However, reviews on the associations between occupational physical activity and CVD have been inconclusive and conflicting and the most recent meta-analysis has been published in 2013. For instance, a review of 11 studies published until 2001 showed that being active at work was associated with a lower risk for stroke (21), whereas an earlier review showed no effect of occupational physical activity on hypertension risk (22). A later review included only four cohort studies with occupational physical activity measures and showed a protective effect of high (versus low)

occupational physical activity on CVD (23). However, the most recently published meta-analyses of seven cohort studies suggested that high (versus low) levels of occupational physical activity are associated with 24% and 25% increased risk of ischemic heart disease (IHD) and overall CVD, respectively (7).

Although these reviews examined the association between occupational physical activity and CVD risk, none of them specifically examined the association of occupational physical activity with CVD mortality. Therefore, the aim of our study was to systematically review the epidemiological evidence regarding the association between occupational physical activity and CVD mortality from prospective cohort studies.

Methods

Search for literature

This review was a priori registered (PROSPERO) (24) and executed according to the PRISMA guidelines (25). Systematic searches were performed in bibliographic databases PubMed, Embase, CINAHL, PsycINFO and the Cochrane Central Register of Controlled Trials, from database inception to 17 April 2020 using controlled key and free text search terms expressing physical activity, occupational and mortality (supplementary material, www.sjweh.fi/article/3993, table S1). Reference lists of included articles were screened for additional studies.

Two reviewers independently screened all potentially relevant titles and abstracts for eligibility and, if necessary, full-text articles. In case of disagreement, consensus was reached by consulting a third reviewer. Articles were included if they met the following criteria: English language, original peer-reviewed prospective cohort studies assessing the association between occupational physical activity and CVD mortality in adult workers selected from a general working population. Studies assessing occupational physical activity directly through self-report or wearable sensors (such as accelerometers or heart rate monitors) were included. Studies assessing occupational physical activity indirectly by task and/or job classification (eg, blue- versus white-collar workers, or manual versus non-manual work) were excluded. Studies on occupational sedentary behavior (rather than physical activity) were only included in cases with relevant reference groups engaging in at least moderate level occupational physical activity (excluding studies assessing various durations of sedentary behaviors).

Consistent with our previous review (12), we included only studies controlling for (either by adjustment or stratification) age, gender and at least one other potentially confounding factor, such as psychosocial job factors (eg, job stress, supervisor support, or shift work), socio-economic status (eg, education or income), lifestyle (eg, smoking, alcohol consumption or leisuretime physical activity), or biological factors (eg, body mass index, serum lipids, diabetes, or pre-existing cardiovascular conditions). In case there were more articles on the same study, then the article describing the longest follow-up period was used in the meta-analysis.

Data extraction and risk of bias assessment

Two reviewers independently extracted data and assessed risk of bias. In cases of disagreement, consensus was reached by consulting a third reviewer. Extracted data included: first author, publication year, study name and design, follow-up period, sample characteristics, assessment methods for mortality outcomes and occupational physical activity, effect estimates and adjustments. Corresponding authors were asked for additional information if needed.

Risk of bias was scored by 12 criteria related to reporting of study methods and results (supplementary table S2) (26). Summary scores >75% indicated high methodological quality, hence low risk of bias.

Data analysis

During consensus meetings, various differently defined occupational physical activity categories from different studies were harmonized by classifying them into one of four categories on the physical activity continuum: (i) occupational sedentary behavior, (ii) low level occupational physical activity, (iii) moderate level occupational physical activity, and (iv) high level occupational physical activity (supplementary table S3). Although the categories differ substantially, they roughly depict: (i) mainly sitting work (sedentary), (ii) mostly standing some walking (low), (iii) standing/walking and/or carrying light objects (moderate), and (iv) physically demanding work (high).

Participants across study samples were pooled according to their assigned harmonized exposure categories.

Occupational physical activity effects on mortality were estimated as hazard ratios (HR) with 95% confidence intervals (CI) derived from inverse variance random effects models (27), comparing the highest harmonized occupational physical activity category to the lowest. Sensitivity analyses investigated different effects contrasting sedentary or low levels of occupational physical activity with moderate and high levels of occupational physical activity.

Analyses were performed using Review Manager [RevMan, V.5.3 (computer program)]. Forest plots depicted individual study and pooled effect estimates. Heterogeneity was assessed by visual inspection of forest plots and Pstatistics (I2>50% indicating substantial heterogeneity) (28). Funnel plots were generated in R studio (R Development Core Team, 2015) to assess publication bias using packages 'robumeta', 'metafor' and 'dplyr' (29). Rank correlation (30) and regression tests (31) were used to calculate potential bias. Sensitivity analysis examined whether any study influenced the pooled effect size (>10%) by excluding one study at a time from the analysis pool. As stipulated in our a priori registered protocol (24), results were stratified by gender, mortality type (CVD in general or IHD), occupational physical activity measurement (quantitative versus qualitative) and adjustment (for other domains of physical activity/socio-economic status/diet and body mass index). We additionally stratified for sample size (< or >10 000), baseline examination (before or after median examination date) and follow-up duration (categorizing studies using tertiles according to follow-up duration).

Results

Data Sources

The literature search generated 3445 unique references (figure 1). After screening titles and abstracts 195 full text articles were retrieved; 166 of them were excluded for various reasons (supplementary table S4). Adding two papers from reference lists yielded 31 articles from 23 studies for our review (32-52) (supplementary table S5). Two articles described two study populations each (49, 52).

Supplementary table S6 summarizes descriptive data of reviewed studies. Five of the seven contacted authors provided additional data (33, 38, 50-52). Ten studies examined each gender separately, eight were limited to males, and five examined a mixed population. Occupational physical activity was assessed by self-report between 1960 and 2004, mortality by death registries as overall CVD mortality in sixteen studies, IHD in four, and three examined both. Nineteen studies originated from Europe, three from Asia and one from Australia. Nine of the nineteen European studies were from Nordic countries (Norway, Sweden, Denmark, Finland).

The average methodological quality was 90%, (range 71-100%), with 20 articles classified as low risk of bias (>75%; supplementary table S7). Important sources of risk of bias were participant selection, exposure assessment, controlling for confounding and analysis method.

Meta-analysis

The selected 23 studies included 655 892 participants with over 8.2 million person-years in follow-up. Pooled analyses contrasting highest versus lowest occupational physical activity levels indicated no association with overall CVD (HR 0.99, 95% CI 0.90-1.09, I2=71%; table 1) (Forest plot; supplementary figure S2), neither for males (HR 1.00, 95% CI 0.87-1.15) nor females (HR= 0.95, 95% CI 0.82-1.09). Effect estimates showed substantial heterogeneity (I2 >50%). Funnel plots, rank correlation test (z=1.19, P=0.14), and Egger's regression test (Kendall's tau=0.18, P=0.23) all indicated low risks of publication bias (supplementary figure S1). High levels of occupational physical activity were associated with statistically non-significant, 15% increased risk of IHD (HR 1.15, 95% CI 0.88-1.49).

High occupational physical activity was associated with an 11% increase of overall CVD mortality (HR 1.11, 95% CI 0.93-1.33) in studies with >22 follow-up years and a 12% decrease in studies with larger sample sizes (HR 0.88, 95% CI 0.80-0.97). Year of baseline assessment, adjustment for leisure-time physical activity, or adjustment for gender, age, socio-economic status (SES) together did not influence the results. However, studies adjusting for body mass index (BMI) or diet showed lower effect sizes. Exclusion of any study from the pooled data did not substantially influence effect size or heterogeneity.

Sensitivity analyses using different reference groups showed no effect changes between occupational physical activity and CVD mortality, nor did comparing moderate and low occupational physical activity with sedentary occupational physical activity (table 2). Comparisons based on the moderate rather than high occupational physical activity group showed differential effects, with a lower CVD risk estimate for moderate occupational physical activity versus low occupational physical activity (HR 0.85, 95% CI 0.77-0.94), compared to moderate versus sedentary (HR 1.03, 95% CI 0.92-1.15).

Discussion

Our meta-analyses of 655 892 participants with over 8.2 million person-years follow-up showed that occupational physical activity was not related to overall CVD mortality. These findings suggest that the beneficial health effects of physical activity that are frequently reported (6) and generally accepted for leisure-time physical activity may not apply to occupational physical activity with regards to CVD mortality. Further, given the non-significant 15% increase in IHD mortality risk, high occupational physical activity may even lead to detrimental effects. This opposing effect may require a revision of the way we look at physical activity and health for workers in jobs with high occupational physical activity because most physical activity guidelines do not differentiate between domains of physical activity. For a considerable fraction of the adult population, occupational physical activity constitutes the main portion of their overall daily physical activity (8, 53). These workers could potentially (easily) achieve the recommended amounts, without engaging in any type or amount of leisure-time physical activity. Workers who are highly active at work are known to be fairly inactive during their leisure-time (54), and they might not benefit from the work domain of physical activity in a way that has been observed for leisure-time physical activity (8). Exhaustion due to long work periods without sufficient breaks and recovery periods may be a reason that high volumes of occupational physical activity are negatively associated with leisure-time physical activity. The differential health effects of occupational and leisure-time physical activity, in the literature referred to as the 'physical activity paradox' (55), are suggested to be due to aforementioned physiological differences in the nature of the activity (12, 13).

There are conceptual differences between occupational and leisure-time physical activity. From an occupational health standpoint, occupational physical activity is often defined as consisting of exposure to demanding working postures, repetitive movements and manual materials handling. In public health, physical activity is more often captured by intensity, frequency and duration of aerobic activities and/or energy expenditure. This indicates the different conceptual ways in which physical activity is considered in both research fields. Future research should move beyond these differences and incorporate all aspects of occupational physical activity to get a better understanding of its health effects (56). In the supplementary text A, we elaborate on whether or not this review supports the physical activity paradox.

Comparison with previous literature reviews

This is the first review to systematically synthesize the evidence on occupational physical activity and CVD mortality. Other reviews examined the relationship between leisure-time physical activity or total physical activity, and CVD mortality and found higher levels of these physical activity domains to be associated with lower risk of CVD mortality (6, 57-59). A review of seven studies published between 2011 and March 2013 showed an inverse association of leisure-time physical activity and a positive association of occupational physical activity with overall CVD [risk ratio (RR) 1.24, 95% CI 1.05-1.47) and IHD incidence (RR 1.25, 95% CI 1.05-1.51; six out of seven studies) (7). In an earlier review (60) of three studies published between 1980 and 2010, the same authors had reported a protective effect of occupational physical activity on CVD incidence (RR 0.77, 95% CI 0.77-0.92). Our review differs from these reviews by type (mortality versus incidence) and specificity of CVD outcome (mostly overall CVD versus mostly IHD) and our null finding for overall CVD mortality risk. Our findings of a 15% increase in IHD mortality risk related to high occupational physical activity is consistent with the 25% IHD incidence risk reported in the most recent review by Li (7).

Results from our previous meta-analysis showed that men with high occupational physical activity had an 18% increased risk of all-cause mortality (12). A discussion paper suggested that the effects of occupational physical activity on all-cause mortality may be mostly driven by CVD mechanisms (13). This latter hypothesis, however, was not affirmed in our current study on CVD mortality. A possible explanation for this could be that effects regarding the association between occupational physical activity and all-cause mortality for men may not be solely the result of

CVD mechanisms.

The increased risk of all-cause mortality may potentially be caused by other agents and diseases that may co-occur with high levels of occupational physical activity, such as exposure to occupational carcinogens or radiation. A recent review reported a 15% increased risk of lung cancer in men with high occupational physical activity after adjustment for age and smoking (61). Exposure to various air pollutants at work may increase both cardiovascular, all-cause and cancer mortality among industrial workers with high occupational physical activity levels from low-income blue-collar communities. Work-related fatal injuries or non-cardiovascular illness may be another pathway for occupational physical activity towards increased all-cause mortality (12, 62).

The results could partly be explained by IHD mortality which showed a non-significant, 15% increase (HR 1.15, 95% CI 0.88-1.49). Most evidence about differential health effect of occupational and leisure-time physical activity are based on differentials in IHD risk (8, 13), which is understood to be the result of arteriosclerotic changes caused by CVD risk factors such as heart rate, blood pressure and associated inflammatory changes (55). The overall-CVD outcome measure is not limited to diseases caused by ischemia, but also include diseases that are caused by infection (eg, endocarditis, myocarditis) or those that are secondary to chronic pulmonary diseases that have not been hypothesized to be prevented or caused by any form of physical activity. Lumping those different diseases into a single outcome is likely to lead to misclassification bias, diluting the effect size of occupational physical activity compared to studies based solely on IHD or stroke, which share the same pathophysiological pathways that are thought to be affected by physical activity. If this hypothesis holds true, the increased risk of IHD mortality (which is part of overall CVD) and the null effect of overall CVD could indicate that other CVD outcomes show a beneficial effect.

Since 19 of our 23 reviewed studies included nonspecific CVD outcomes, with diagnostic subgroups that have not hypothesized to be related to occupational physical activity, lower effect estimates for overall CVD compared to IHD are to be expected. In addition to this outcome misclassification bias, residual confounding, exposure misclassification, and health-based selection effects may contribute to inconsistencies and the high heterogeneity in our pooled findings (I2=76%).

Residual confounding

Although most of the studies (61%) included in our review adjusted for at least gender, SES, age, leisuretime physical activity, smoking and BMI, residual confounding cannot be ruled out. It might be possible that unmeasured and/or residual confounding could lead to an overestimation of the presented findings, and therefore result in biased results (63). This notion is underlined in a recent publication in which the negative health effects of occupational physical activity presented in partially adjusted models, change to positive health effects when additionally adjusting for various socioeconomic variables (64). However, mutually adjusting for several measures of SES and their associated behavioral factors that are highly correlated with occupation physical activity, could also have methodological drawbacks and possibly lead to over adjusting (65). It might also be possible that the association between occupational physical activity and CVD outcomes is confounded by social and behavioral factors that occurred prior to entering the study or even the workforce (66).

It must be acknowledged that the current literature has not yet succeeded in identifying and evaluating all confounders, mediators and moderators in the relationship between occupational physical activity and health (56). Therefore, we recommend future research to use causal inference modelling and directed acyclic diagrams (DAG) on observational data to describe mechanistic pathways, or using alternative (eg, experimental) research designs that could address confounders, mediators and moderators in a better way (64).

We performed subgroup analyses comparing studies with and without controlling for key potential confounders to assess the potential impact of uncontrolled confounding for heterogeneity and observed effect sizes. Overall, different adjustments decreased heterogeneity very little and led to small changes (ie, increases or decreases) in effect sizes, indicating both negative and positive confounding, albeit of modest magnitude. Of note, studies adjusting for SES showed higher occupational physical activity risks for overall CVD mortality compared to unadjusted studies, suggesting negative confounding by SES and rendering mediation of occupational physical activity by uncontrolled SES-related factors unlikely, as has been discussed (63) and reported on in the literature (67). In contrast, adjustment for BMI or waist circumference or diet led to small reductions in occupational physical activity risks, indicating that these variables could be confounders, mediators or both.

Adjustment for leisure-time physical activity also resulted in a small increase of occupational physical activity risks on CVD mortality. This raises the concern that some of the evidence regarding beneficial effects of leisure-time physical activity may potentially be confounded by non-beneficial or even detrimental effects of occupational physical activity, since most studies on leisure-time physical activity did not adjust for occupational physical activity. Several studies that simultaneously analyzed or investigated interactions of leisure-time and occupational physical activity showed inconsistent results (40, 68-72).

Future research should therefore investigate what aspects of occupational physical activity as well as what combinations of occupational and leisure-time physical activity can be beneficial, not only for healthy young workers, but also for older workers and workers with pre-existing CVD or other comorbidities (73).

High occupational physical activity might also cooccur with other unmeasured occupational exposures, which may have a direct or indirect association with CVD disease and death, such as exposure to chemicals, environmental heat, noise, dust, air pollution and various psychosocial job stressors. It is possible that not controlling for these potentially modifying risks factors may have led to an over- or underestimation of the independent effect of occupational physical activity. Future research should evaluate these factors, not only as potential confounders but also as mediators and/or effect modifiers.

Exposure misclassification

A major limitation of the reviewed evidence is the likelihood of non-differential exposure misclassification leading to an underestimation of reported effect sizes. Non-differential exposure misclassification occurred not only in all reviewed original studies but additionally in our meta-analyses of these studies where we classified occupational physical activity dichotomously (74).

All studies used self-report measures of occupational physical activity; some studies were limited to indicators of strenuous activities (eg, heavy lifting, climbing stairs, sweating, tiredness after work), others focused on body postures or movements (eg, sitting, standing, walking), or calculated absolute measures of energy expenditure (eg, metabolic equivalent of tasks (hours/ week, kcal/day). Only one study used relative aerobic strain measures, taking individual levels of cardiorespiratory fitness into account which is relevant for the actual strain on the cardiovascular system (40). Specifically, occupational physical activity measured as relative aerobic strain [ie, energy expenditure at work relative to maximal oxygen uptake (%VO2max)] yielded 13% and 21% higher all-cause and IHD mortality risks, respectively, than occupational physical activity expressed as absolute energy expenditure at work (kcal/workday) (40). Similar differences were reported for IHD incidence in the same study population (70). This indicates that ignoring the individual workers maximal oxygen uptake capacity (ie, the actual aerobic work capacity) can lead to substantive conservative bias, as was demonstrated in these studies were effect estimates based on absolute measures of workload were less predictive of risk. In our meta-analyses, we did not find a substantial difference between studies that used more quantitative self-rated measurements (eg, amount of stairs/hours/frequency) compared to studies that used more qualitative measurements (eg, sitting, standing, walking) (table 1).

Most studies used crude dichotomous measures or collapsed continuous measures of occupational physical activity into broad categories, typically defined as population frequencies (eg, sample tertiles or quartiles). Combining highest occupational physical activity intensities with much lower intensities could lead to a dilution of the effects, especially among women who compared to men are less frequently working at the highest occupational physical activity categories. This may explain why substantial effects of high occupational physical activity are mostly based on male cohorts and have rarely been described among females.

Choice of comparison categories and current job versus previous job may also determine results as reported in a recent large cohort study on occupational physical activity and stroke (75). The effect estimates of the lowest occupational physical activity category (mostly sitting) with the highest (heavy manual labor, HR 0.87, 95% CI 0.36-

2.13) were smaller, more imprecise, and changed direction compared to the second-highest category (continuous walking/movement, HR 1.53, 95% CI 1.14-2.07). Comparing the longest held job with the estimates based on current job also showed a 11% difference in effect estimates.

In future studies, more sophisticated assessments of occupational physical activity less prone to misclassification, could lead to more accurate results. Future research should use physical activity measurements using heart rate monitors, accelerometers, inclinometers and/or other observational ergonomic methods to assess the repetitive or continuous duration and intensity of physical activity, work postures, relative aerobic workload, breaks, and recovery time (76).

Improved observational measures of occupational physical activity through modern sensor technology alone may not be sufficient to overcome other important sources of misclassification of occupational physical activity. It is also necessary to arrange repeated measurements during follow-up, preferably with work history and other relevant factors starting from baseline as well as factors before entering the workforce and to collect a combination of administrative, self-reported and expert- based data that can be utilized to construct a detailed job and health history, capturing changes in physical job demands, comorbidity, cardiovascular fitness, and important confounders and effect modifiers during follow-up. Future research also needs to determine precise dose-response relationships and explore threshold effects that can be used for the development for specific physical activity guidelines (77). Further, more studies need to use relative physical activity measures that account for workers physical capacities to guide the development of appropriate ergonomic work modifications, effective workplace health promotion exercise programs, and safe and effective clinical, rehabilitation, and public health physical activity guidelines.

Selection bias

Another potential bias, which can cause inconsistencies in the literature regarding the cardiovascular health effects of occupational physical activity is due to the selection of healthy workers into physically demanding jobs and of diseased workers with activity-related symptoms (such as angina pectoris) moving into less strenuous jobs or leaving the workforce (70, 78). This deflates CVD risks among workers found in these demanding jobs at the time of the study (79) and could have led to an underestimation of the true occupational physical activity effect in our review. Future research should quantify the magnitude of such biases and account for it in effect estimation. Gathering complete life work histories is a prerequisite for accounting for changes in the nature of work and cumulative occupational physical activity exposures that are most relevant for the development of chronic diseases such as CVD and associated mortality outcomes.

Most methods proposed to address healthy worker biases, however, do not consider that it may be caused by time-varying confounders affected by prior exposure. G-estimation of accelerated failure-time models have been developed to handle this issue but has never been applied to account for the healthy-worker survivor effect in studies of occupational physical activity and mortality (80).

Comparing early stage non-symptomatic CVD outcomes such as sonographically measured progression of intima media thickness of arterial walls with symptomatic CVD disease outcomes such as CHD with activity-related angina pectoris in the same study population can also be used to identify the likelihood and potential extent of healthy worker biases as demonstrated by a series of Finnish cohort studies on progression of atherosclerosis (68, 81), acute myocardial infarction (70), and mortality (40).

Strengths and limitations

Restriction to studies of high methodological quality including only prospective cohort studies with adjustment for key confounders, collection of additional unpublished data, pooling of data from 655 794 participants in a meta-analysis with additional subgroup analyses are methodological strengths of this review.

We mentioned the potential influence of residual confounding, exposure misclassification and healthbased selection effects on our study results in the above. An additional limitation is that our meta-analysis was based nearly exclusively on high-income countries, and are not readily generalizable to low- and middle-income countries where occupational physical activity may constitute a higher proportion of the total physical activity (82). Although we prospectively registered mortality by stroke as a condition, we could not perform analyses because only one included study reported on this specific outcome (50).

Another limitation is that, although all eligible studies adjusted for age, we could not perform a subgroup analysis by age groups or physical fitness level. Although overall physical job demands in high-income countries may have been reduced through regulation of maximum regular work hours, mechanization, and global redistribution of manufacturing, the average absolute physical energy spent at work has remained rather stable for the individual aging worker, as has been demonstrated in one of the reviewed study cohorts, where energy expenditure on average decreased only by about 0.16% kcal per year over a four-year period (68), while cardiorespiratory fitness decreased 8.5 times faster by 1.36% per year (83). Cardiorespiratory fitness decreases with age (84), and therefore identical work tasks become relatively more strenuous for older workers. Ignoring the role of aerobic fitness in assessing the effect of physical workload on health may have led to a conservative bias in our current study and previous literature (12). The a-priory registered methodological quality scale we used,may retrospectively not be the best tool in detecting risk of bias (26), we recommend future reviews to use a more appropriate instrument.

Concluding remarks

This meta-analyses of 23 prospective studies, with 655 892 participants, showed that higher occupational physical activity was not related with overall CVD mortality (HR 0.99, 95% CI 0.89-1.10), but was positively associated with IHD mortality risk (HR 1.15, 95% CI 0.88-1.49). The findings are mostly compatible with the hypothesis that high levels of occupational physical activity do not confer cardiovascular health benefits, in contrast to beneficial leisure-time physical activity effects often reported in the literature. Study design features, such as country, historical time and duration of follow-up period, had no substantial effect on the Scand J Work Environ Health 2022, vol 48, no 2 93 effect estimate. However, due to the lack of understanding on the complex role of socioeconomic status in the association of occupational physical activity and health, and the lack of measuring environmental occupational exposures, the risk of residual confounding cannot be ruled out based on the current evidence. The high likelihood of non-differential exposure misclassification of occupational physical activity and healthy worker effects most likely led to an underestimation of any effect of high occupational physical activity.

Future research should differentiate between different physical activity domains, reduce occupational physical activity exposure misclassification, and examine potential interactions with pre-existing CVD, cardiorespiratory fitness, leisure-time physical activity, SES, and other CVD risk factors in the working environment.

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Disclosures

Willem van Mechelen is a non-executive board member of Arbo Unie BV. Willem van Mechelen and Allard J van der Beek are director and advisor, respectively, of Evalua Nederland BV. Both Arbo Unie BV and Evalua Nederland BV operate in the Dutch occupational healthcare market. There are no conflicts of interest reported by any other authors.

Sidebar

Cillekens B, Huysmans MA, Holtermann A, van Mechelen W, Straker L, Krause N, van der Beek AJ, Coenen P. Physical activity at work may not be health enhancing. A systematic review with meta-analysis on the association

between occupational physical activity and cardiovascular disease mortality covering 23 studies with 655 892 participants Scand J Work Environ Health. 2022;48(2):86-98. doi:10.5271/sjweh.3993
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DETAILS

Subject:	Physiology; Physical activity; Epidemiology; Confidence intervals; Job classification; Mortality; Leisure; Heart diseases; Employment; Cardiovascular diseases; Ischemia; Cardiovascular disease; Meta-analysis; Reviews; Systematic review; Coronary artery disease; Heart rate; Bias
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Associations of employment sector and occupational exposures with full and part-time sickness absence: random and fixed effects analyses on panel data

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ABSTRACT (ENGLISH)

Objective We aimed to investigate the influence of unobserved individual characteristics in explaining the effects of work-related factors on full (fSA) and part-time sickness absence (pSA). Methods We used register-based panel data for the period 2005-2016 on a 70% random sample of the Finnish working-age population. The relationships between employment sector and occupational exposures (% exposed to physically heavy work and job control score based on job exposure matrices) and the annual onset of fSA and pSA were investigated among men and women. First, random effects (RE) models were applied controlling for observed sociodemographic factors and then fixed effects (FE) models that examine within-individual changes over time and thereby further account for unobserved time-invariant individual characteristics. Results In the RE analyses, public employment sector, physically heavy work and lower job control each increased the use of fSA and pSA among both genders. When unobserved individual characteristics were controlled for with the FE models, the effects on fSA attenuated. For pSA, the effects of employment sector and physical heaviness of work among women even reversed. The effect of lower job control on pSA remained especially among women. Conclusions The role of individuals' unobserved characteristics in explaining the effects of work-related factors on SA should not be neglected. The effects of work-related factors are likely to be overestimated when using traditional approaches that do not account for unobserved confounding, ie, selection of individuals with a high likelihood of SA into particular work environments.

FULL TEXT

Headnote

Objective We aimed to investigate the influence of unobserved individual characteristics in explaining the effects of work-related factors on full (fSA) and part-time sickness absence (pSA).

Methods We used register-based panel data for the period 2005-2016 on a 70% random sample of the Finnish working-age population. The relationships between employment sector and occupational exposures (% exposed to physically heavy work and job control score based on job exposure matrices) and the annual onset of fSA and pSA were investigated among men and women. First, random effects (RE) models were applied controlling for observed sociodemographic factors and then fixed effects (FE) models that examine within-individual changes over time and thereby further account for unobserved time-invariant individual characteristics.

Results In the RE analyses, public employment sector, physically heavy work and lower job control each increased the use of fSA and pSA among both genders. When unobserved individual characteristics were controlled for with the FE models, the effects on fSA attenuated. For pSA, the effects of employment sector and physical heaviness of work among women even reversed. The effect of lower job control on pSA remained especially among women.

Conclusions The role of individuals' unobserved characteristics in explaining the effects of work-related factors on SA should not be neglected. The effects of work-related factors are likely to be overestimated when using traditional approaches that do not account for unobserved confounding, ie, selection of individuals with a high likelihood of SA into particular work environments.

Key terms absenteeism; confounding; graded return to work; individual characteristics; longitudinal study; random effect; sick leave; sickness benefit; working condition.

Sickness absence (SA) is known to be influenced by various individual characteristics, being more common, eg, among women than men (1, 2) and those with poorer health or chronic disease (3-6). Furthermore, the contribution of work-related factors is strong. SA rates have been found to be higher among those who work in manual occupations (7-12), are employed in the public sector (9, 13-15), participate in health and social work (11, 14, 16), and are exposed to unfavorable physical and psychosocial working conditions, such as physically heavy work and low job control (17-22).

Previous literature has not been able to fully explain why certain groups of employees have higher rates of SA than others, eg, the differences are especially large between employment sectors, SA rates being clearly higher in the public sector. This difference has been shown to remain even when many important factors that are known to affect SA, such as gender, age, occupational class, education, and income, are being controlled for. The difference in SA has shown to be clear even when comparing the employment sectors within same field of industry, such as health and social work (23).

Partial sickness allowance is a benefit that enables employees with work disability to be absent from work for rest, treatment or rehabilitation and still remain working for a proportion of the time. Partial sickness benefits and graded retum-to-work have been increasingly used in the Nordic countries (24) and continental European countries such as Germany and Austria (25) to support part-time work participation during sickness and to facilitate faster full work resumption. There are yet only a few studies concerning the use of partial sickness benefits in different groups of employees (26, 27). In Finland, it has been shown that among employees using any sickness benefits, the use of the partial compared to full benefit was more common in the private than public sector. Occupational exposures, including physical heaviness of work and job control, instead were detected to have only faint and inconsistent associations with the use of partial sickness benefits (26). The association of work-related factors with work ability and the overall need for SA therefore appear to be a different matter from their association with being able to take the leave as part-time. The effects of work-related factors on full and part-time SA (fSA and pSA, respectively) may thus be very different.

In addition to the potential causal mechanisms between work-related factors and SA, the associations may also be affected by selection, ie, individuals with characteristics associated with a high likelihood of fSA or pSA ending up in particular types of jobs. Most previous studies, however, have not been able to adequately control for such confounding, as many individual-level characteristics that are known to affect SA, eg, personality factors such as neuroticism (28, 29), remain unobserved.

One way of accounting for unobserved confounding is to examine the associations of work-related factors with SA among individuals moving between different work environments. By examining within-individual changes in work-related factors over time, the individuals can serve as their own controls accounting for all of their unobserved time-invariant characteristics.

In this article, we apply random effects (RE) and fixed effects (FE) analyses using register-based panel data from Finland to study the relationship between work-related factors, including employment sector and occupational exposures, with the onset of fSA and pSA. The RE model uses both between- and within-individual variations, whereas the individual FE model uses only within-individual variation over time, ie, examines individuals' movements between employment sectors or occupations with different exposures. To investigate unobserved confounding, we assessed how the examined relationships differed when not only observed timevariant and -invariant individual characteristics were controlled for, as was done in the RE model, but also unobserved time-invariant individual characteristics were controlled for by using the FE model. As far as we are aware, this type of approach has not been used before to investigate the associations of employment sector and occupational exposures with SA. However, Melsom &Mastekaasa (30) applied a similar methodological approach using Norwegian register data to study the association between occupational gender composition and SA, indicating that the higher number of SA days in female-dominated occupations was fully explained by selection based on individual characteristics. Longitudinal individual-level register data enable the use of this method, since it requires panel data with a large number of subjects followed up over several repeated measurements.

In this study, our aim was therefore to discover whether unobserved time-invariant individual characteristics explain the associations of work-related factors with the onset of fSA and pSA, ie, whether the differences by employment sector and occupational exposures are related to selection of individuals into working in these circumstances, in addition to potential systembased or work-driven reasons.

Methods

Study design

We used a large, 70% random sample of the working-age population living in Finland on the last day of year 2004. The register-based data included individual-level information on episodes of compensated SA and national pensions obtained from the Finnish Social Insurance Institution, episodes of employment and earnings-related pensions from the Finnish Centre for Pensions, as well as on sociodemographic and employment-related factors from the FOLK data of Statistics Finland. In the analyses of fSA, the study period covered 2005-2016. pSA has only been available since 2007 and the study period therefore started two years later.

For this study, we included wage earners who (i) turned 30-62 years during a study year, (ii) did not receive any pension or vocational rehabilitation allowance, and (iii) were employed in the private or public sector on the first day of that year. It was also required that the individual was not employed in both sectors during a study year and had information on work-related factors available. We only included individuals who, at the beginning of the study year, were not already on either fSA or pSA, depending on the analysis. The individual nevertheless could have had SA in the preceding years. The criteria for being included in the study population were applied separately to each study year. An individual could thus be excluded in one year and included in others. Because of the panel design, however, it was required that a person was eligible in at least two study years to be included in the study population [fSA analyses: 2-12 (mean 7.8) years; pSA analyses: 2-10 (mean 6.9) years].

Full- and part-time sickness absence

In Finland, the Social Insurance Institution of Finland compensates permanent residents for SA after a waiting period of ten working days (including Saturday) that is typically paid by the employer (31). The outcome of this study was therefore based on longer-term SA that lasted around two calendar weeks or more. We examined whether a study person had a new onset of fSA or pSA during each study year. pSA is a voluntary option for persons who are eligible for fSA if medical assessment shows they can work without harm to their health and their employer can arrange part-time work. Between 2007 and 2009, pSA could only start after 60 compensated fSA days. Since 2010, it has been possible to have pSA immediately from the first compensated day, but it has still typically been preceded by a compensated fSA episode. A person can also transition into fSA from pSA.

Because of the different inclusion criteria and the different lengths of the study periods, the final study populations of the fSA and pSA analyses were not fully the same, although very similar (table 1). The fSA analyses were based on 1 460 086 individuals with a total of 11 383 552 person years, ie, observation years, in the period 2005-2016, while the pSA analyses included 1 379 446 individuals with 9 581 811 person years in the period 2007-2016. This resulted in around 900 000 to almost 1 000 000 individuals per study year (supplementary material, www.sjweh.fi/article/4003, tables S1 and S2).

Work-related factors

Employment sector during the study year was classified into private and public sector based on the sector of the pension-insured employment (32).

Occupational exposures were estimated by linking information from job exposure matrices (JEM) that were developed earlier in a large population surveyand interview-study and have been described in more detail elsewhere (33, 34). We chose to examine physical heaviness of work as a general measure encompassing various specific physical exposures. With respect to psychosocial exposures, we chose to examine job control, for which the JEM had better validity than, eg, for job demands. The JEM provide information on the proportion reporting physically heavy work (range 0-100%) and the mean job control score (range 1-5, with higher value indicating higher control based on the Karasek concept) (35) in men and women holding a specific occupational title.

Occupational exposures were used as continuous variables in the regression analyses. For descriptive purposes they were dichotomized using 40% exposed to physically heavy work and gender-specific median job control score as cut-off points. The information is available for most occupations, almost 400 in total. The previously developed JEM information was linked to occupational titles of the individuals in the present register data, using a classification by Statistics Finland (36), based on the International Standard Classification of Occupations (ISCO-88). Information on occupational titles was available in the register data at the end of each calendar year since 2004. We used the most recent recorded information before each study year.

Statistical methods

The relationships of the three work-related factors (employment sector, physical heaviness of work and job control) and the two different outcomes (fSA and pSA) were analysed using panel regression with RE and FE analysis. The RE regression model was considered as our baseline model since it uses all observed information (ie, both between and within variations, accounting for clustering of observations within individuals), whereas the individual FE regression uses only within-individual observations that change over time. As it is, FE regression controls for all observed time-variant and -invariant as well as unobserved time-invariant individual characteristics in the measurement period (37, 38). By comparing the FE results with the ones from the RE regression model, which only controls for the observed time-variant and -invariant individual characteristics, the role of unobserved time-invariant characteristics in the associations of employment sector and occupational exposures with fSA and pSA could be assessed.

We used linear probability models for analysing the binary outcome instead of logistic regression models since the logistic regression FE models do not include in its analytic sample study subjects whose outcome remains unchanged over time (ie, those whose response variable is always coded as 0 or as 1). Using the latter model would make the comparison of results from the RE and FE models to assess the role of unobserved timeinvariant individual characteristics problematic. In linear probability models, the regression coefficients are on an absolute scale, which can be interpreted as the absolute difference in the share of the occurrence of the outcome in terms of the explanatory variable. We present the results as percentage point differences.

The RE and FE models were estimated for the onset of both fSA and pSA so that employment sector and occupational exposures were considered as explanatory variables. The work-related factors were mutually controlled for and additionally controlled for other background variables that are known to be associated with SA: gender, age (age-groups between five years), living arrangements (alone, with partner only, with partner and >1 child, lone parent with >1 child and other), inflation-corrected taxable total income earned by the individual (continuous variable), educational level (with three classes), region of residence and calendar year. The analyses were performed also stratifying by gender.

Since the FE analyses only uses information on the study subjects whose work-related factors changed over the study period, we present sensitivity analyses in which we performed the RE analyses among the subpopulations of "changers". By doing so we could assess whether the associations of work-related factors with fSA and pSA differed between the "changers" and the general population. In addition, we tested the assumption of linear associations of physical heaviness of work and job control score with the outcomes by repeating the main analyses using categorised exposure variables.

All analyses were performed using STATA15 (StataCorp, College Station, TX, USA).

Results

Sociodemographic and work-related factors were very similar between the observations included in the fSA and pSA analyses (table 1). In both the fSA and pSA datasets, working in the private sector was clearly more common than working in the public sector, the former occurring in 66% of the observation years. Overall, physically heavy work was common (>40% in the occupation exposed) in approximately 29% of the observation years. The prevalence of job control below median was 57% of the observation years.

The proportions of onset of both fSA and pSA were higher among those who worked in the public sector or had physically heavy work or low job control (table 2). Overall, an onset of fSA and pSA occurred in 12.5% and 0.44% of the observation years, respectively. There was, nevertheless, variation in these proportions over the study period. The annual proportions of onset of fSA decreased (supplementary table S1) whereas the annual proportions of onset of pSA largely increased (supplementary table 2) in all variable groups. The proportions of onset of both fSA and pSA also differed between genders (table 2) being clearly greater among women than among men.

In the dataset used for the fSA analyses, 7.3% (N=105 894) of the individuals changed their employment sector at least once during the study period. In the pSA data, the amount was 6.2% (N=85 189). Both physical heaviness of work and job control score changed for around 60% of employees (physical heaviness: 60.0%, N=875 699 in fSA data; 57.3%, N=790 326 in pSA data; job control score: 62.0%, N= 906 466 in fSA data; 59.8%, N=824 423 in pSA data).

Results from the regression analyses on the associations of employment sector and the two examined occupational exposures with fSA and pSA, adjusted for sociodemographic factors and mutually for the work-related factors, are presented in tables 3 and 4, respectively, addressed below. The supplementary material provides corresponding results, but with adjustment only for age and gender (supplementary tables S3 and S4) and adjustment for all sociodemographic factors but without mutual adjustment for the work-related factors (supplementary tables S5 and S6). The comparison of the results from the RE and FE models was largely similar regardless of the used adjustments.

The relation of employment sector with full and part-time sickness absence

Using RE panel regression that uses all observed information (ie, both between and within variations) and controlling for background variables, fSA was more common in the public sector compared to the private sector (3.890, table 3) among the overall study population. The coefficient can be interpreted as the absolute percentage point difference in the share of fSA for study subjects working in the public compared to private sector. With pSA, the difference was in the same direction, being approximately 0.10 percentage points (table 4). The relative magnitude of these differences can be addressed in relation to the average shares of fSA and pSA in the data, 12.5% and 0.44%, respectively. The effect of employment sector was greater among women than men in both the fSA and pSA analyses, which is understandable, since the average shares of these outcomes in the data were much higher among women (table 2).

In the FE model, when all observed and unobserved time-invariant individual characteristics were controlled for, the percentage point difference between the employment sectors among the overall study population was clearly smaller (0.392) than in the RE results. This FE coefficient indicates that the share of fSA was around 0.4 percentage points larger in the observation years during which a study person was employed in the public sector compared to the years in private sector employment. Using FE analysis within gender groups, this relation was found only among women. In turn, among the overall study population, the share of pSA was 0.13 percentage points smaller during employment in the public than in the private sector, being contrary to the results from RE model, where the relation was the reverse. This relation was clearly greater among women than men.

The relation of occupational exposures with full and parttime sickness absence

According to our RE analyses, a 20 percentage point increase in the proportion exposed to physically heavy work increased the share of fSA by 1.22 percentage points (table 3) and pSA by 0.04 percentage points (table 4). Again, the effect on fSA was larger among women, whereas the effect on pSA was found only among women. In the FE analysis performed for the overall study population, the effect of physically heavy work on fSA largely attenuated, ie, to 0.19 percentage points. This effect was still larger among women than men. A 20 percentage point increase in physically heavy work had a decreasing, yet faint (approximately 0.02 percentage points), effect on pSA. The association was contrary to the RE result, but again only found among women.

In the RE analyses, a one unit decrease in the job control score increased the share of both fSA and pSA with 1.89 and 0.15 percentage points, respectively. With fSA the effect was clearly larger among men than women, whereas with pSA the differences between the genders were minor. In the FE analyses, the effect of decreasing job control score on both fSA and pSA attenuated, being still positive, yet fainter compared to the RE model (ie, being 0.37 percentage points with fSA and 0.10 percentage points with pSA). The effect on fSA was still larger among men than women, whereas the effect on pSA attenuated less among women than men, being now larger among the former.

Sensitivity analyses

The associations of physical heaviness of work and job control with fSA and pSA in the RE analyses including the subpopulation whose work-related factors changed over the study period (supplementary table S7) were in line with those in the main RE analyses (tables 3 and 4). The effects of public sector employment with fSA were smaller in the RE analyses including the "changers" than in the main RE analyses, but nevertheless explained further in the FE analyses. The effects of employment sector on pSA reversed in the RE analyses including the "changers" compared to the main RE analyses, but among women became even more reversed in the FE analysis.

Supplementary tables S8 and S9 showed linearity in the associations of categories of physical heaviness of work and job control score with fSA and pSA in our baseline RE analyses.

Discussion

The observed associations between work-related factors and SA may be related to factors that are characteristic to the individual. To address this, we used large registerbased panel data and applied RE models controlling for sociodemographic factors, both changing and unchanging over time. FE models were then used to further account for unobserved individual characteristics that are unchanged over time.

Based on the RE models, our findings showed that the onset of both fSA and pSA was more common in the public than the private employment sector for both genders. Physically heavy work and lower job control increased the likelihood of both fSA and pSA, although the effect of physically heavy work on pSA was found only among women. It was also noticeable that in the fSA analyses, the effect of physically heavy work was greater among women, whereas lower job control had a greater effect among men.

After additionally adjusting for unobserved individual characteristics that were unchanged over time (using the FE models), the associations largely attenuated for fSA. Among men fSA no longer varied by employment sector. For pSA some of the associations even became reverse, the onset of pSA being more common in the private than public sector specially among women. Furthermore, among women the onset of pSA became more common as the likelihood of being exposed to physically heavy work decreased. Finally, the effect of lower job control on pSA attenuated specially among men.

Our results on fSA, based on the traditional approach adjusting for observed factors (RE model), were parallel with previous findings on the effects of public sector employment (9, 13-15), physically heavy work (17-19) and low job control (17, 20-22) on SA. Factors associated with pSA have been investigated less, the focus being eg, on the use of the partial compared to the full benefit (26, 27).

Our novel results based on the comparison of the FE models with the RE models suggest that the typically observed associations of employment sector and occupational exposures with SA may to a large extent be explained by unobserved individual characteristics. Underlying personal factors, eg, certain personality traits appear to influence both selection into particular work environments (39-42) and having a high likelihood of SA (28, 29, 43). In addition, work attitudes and values have been found to influence selection into particular employment sectors (44-46) and these factors may also be associated with the use of SA. The method applied and our findings, together with previous ones (30), underline the importance of considering how unmeasured confounding by individual-level factors can affect the results. Register data, in particular, have limited information on important personal factors, and its use may therefore lead to an overestimation of the effect of work-related factors on SA.

The role of unobserved individual characteristics was generally larger in pSA compared with fSA. This finding can be understood by the voluntary choice of pSA instead of fSA in Finland. The remaining impact of work-related factors may relate to differences between work environments in the feasibility and benefit of the use of pSA (27). Our finding on the remained importance of lower job control in pSA, particularly among women, could be interpreted as the use of pSA being an employee's way to increase the time control in the job.

The more common use of pSA in the private than the public sector after controlling for unobserved individual factors suggests that the private sector might be more capable of making use of part-time work during pSA. Providing the possibility for pSA would also be an economic incentive for the employer, who will in most cases pay full salary to the employee at least during the first months of fSA.

After controlling for unobserved individual factors, the use of pSA was common among women with physically less heavy jobs. Reducing the heaviness of exposure by work modifications might enhance the use of pSA. However, these modifications may not be easily implemented in physically heavy jobs, which could explain the reverse association between physically heavy work and the use of pSA.

The use of pSA and graded return to work have been found to increase work participation (47-56) ie, promote the recovery and full return to work. In addition to the financial implications, reduced work participation at working age has adverse individual- and populationlevel effects on health and wellbeing (57), and pSA as an alternative for fSA is an effective way to decrease those effects. Future studies should investigate further why certain groups of employees are better able to return to part-time work while being sick.

Our study has several important strengths. Our findings were drawn from rich data of a very large and nationally representative register-based sample, which included sufficient within-individual changes in workrelated factors that enabled us to apply the individual FE model alongside of the RE model. Also, with the register-based data there is no problem of non-response or loss to follow-up.

In our analyses, we estimated occupational exposures using JEMs, which offer information of exposures on the occupational level. Linking the JEMs to occupational titles in the register data enabled us to assess work-related factors on which individual-level information was unavailable.

We also acknowledge that there are some limitations. First of all, the FE models do not control for timevarying individual factors such as changes over time in life situations that were unmeasured in our study but could affect both working-career choices and having SA. As it is, the role of these factors as confounders cannot be estimated. Secondly, the FE models do not use information from study subjects whose work-related factors remained the same over the study period. The FE model provides subject-specific estimates for the subpopulation that experienced a change in work-related factors, whereas RE models are based on the effects of the total population average. Since the results derived from the FE analysis are based on a subgroup that is prone to move between employment sectors or occupations and might therefore differ from the overall working population, we performed sensitivity analyses limiting the RE analyses to the subpopulations whose work-related factors changed over the study period. These analyses indicated that the associations of physically heavy work and job control with the SA outcomes among the "changers", covering around 60% of the study population, were in line with those in the total study population. Only 6-7% of the study population changed their employment sector, this subpopulation therefore being more selected and withinindividual changes weighing more in the analyses. The effects of employment sector were smaller for fSA and reversed for pSA among the "changers" compared to the total study population but - with the exception of pSA for men - were explained further in the FE analyses. Both public sector employment and the use of pSA are relatively uncommon among men, the group therefore being very selected. Overall, our findings indicate that at least among employees who have relatively high mobility in the labor market, work-related factors appear to affect SA to a limited extent.

It is also noticeable that since the JEM are based on aggregated occupation-level information, they do not capture variation in the occupational exposures within an occupation. We therefore observed changes in the exposures resulting from a change in the individual's occupation, but not from eg, work modifications or changes in work tasks made within one's current occupation. In general, the effects of exposures measured by JEM have a tendency towards null association. Taking into consideration the factors mentioned above, the influences of occupational exposures on SA are likely to have been somewhat underestimated in both approaches of our study.

Concluding remarks

The findings of the current study suggest that the role of individuals' unobserved characteristics in explaining the effect of work-related factors - employment sector, physical heaviness of work and job control - on SA should not be neglected. The effects of work-related factors are likely to be overestimated when using traditional approaches that do not account for unobserved confounding, ie, selection of individuals with a high likelihood of SA into particular work environments.

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Sidebar

Hartikainen E, Solovieva S, Viikari-Juntura E, Leinonen T. Associations of employment sector and occupational exposures with full and part-time sickness absence: random and fixed effects analyses on panel data. Scand J Work Environ Health. 10.5271/sjweh.4003

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Trajectories of disability throughout early life and labor force status as a young adult: Results from the Longitudinal Study of Australian Children

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ABSTRACT (ENGLISH)

Objectives Young people with disabilities have poorer labor force outcomes than their peers without disabilities. These understandings, however, are largely based on research assessing disability at one time point only, an approach that potentially obscures variation in disability over time. We aimed to identify trajectories of disability during childhood/adolescence and assess associations between trajectory membership and labor force status in young adulthood. Methods We conducted group-based trajectory modeling of disability status information from six waves [waves 2-7 (age 4/5 to 16/17 years)] of the Longitudinal Study of Australian Children. The trajectories were used to predict labor force participation (employed, unemployed, not in the labor force) at wave 8 (18/19 years), adjusted for confounders. Results We identified four trajectory groups of the prevalence of disability: low (75.5% of cohort), low increasing (9.7%), high decreasing (10.9%), and consistently high (3.9%). Individuals in the low increasing trajectory were nearly three times as likely to be unemployed at age 18/19 years compared to individuals in the low trajectory [risk ratio (RR) 2.96, 95% confidence interval (CI) 1.94-4.53]. Individuals in the consistently high trajectory had a greater RR of not being in the labor force at age 18/19 years compared to individuals in the low group (reference) (RR 3.65, 95% CI 2.21-6.02). Conclusions Results suggest that prolonged and increasing experiences of disability among young Australians may be differentially associated with future labor force outcomes. Additional support to prepare young people for the labor force should focus on individuals who consistently or increasingly report a disability.

FULL TEXT

Headnote

Objectives Young people with disabilities have poorer labor force outcomes than their peers without disabilities. These understandings, however, are largely based on research assessing disability at one time point only, an approach that potentially obscures variation in disability over time. We aimed to identify trajectories of disability during childhood/adolescence and assess associations between trajectory membership and labor force status in young adulthood.

Methods We conducted group-based trajectory modeling of disability status information from six waves [waves 2-7 (age 4/5 to 16/17 years)] of the Longitudinal Study of Australian Children. The trajectories were used to predict labor force participation (employed, unemployed, not in the labor force) at wave 8 (18/19 years), adjusted for confounders.

Results We identified four trajectory groups of the prevalence of disability: low (75.5% of cohort), low increasing (9.7%), high decreasing (10.9%), and consistently high (3.9%). Individuals in the low increasing trajectory were nearly three times as likely to be unemployed at age 18/19 years compared to individuals in the low trajectory [risk ratio (RR) 2.96, 95% confidence interval (CI) 1.94-4.53]. Individuals in the consistently high trajectory had a greater RR of not being in the labor force at age 18/19 years compared to individuals in the low group (reference) (RR 3.65, 95% CI 2.21-6.02).

Conclusions Results suggest that prolonged and increasing experiences of disability among young Australians may be differentially associated with future labor force outcomes. Additional support to prepare young people for the labor force should focus on individuals who consistently or increasingly report a disability.

Key terms employment; group-based trajectory modeling; young people.

Disability is a common experience among young Australians, with nearly one in ten (9.3%) 15-24 year-olds estimated to have a disability, including sensory, cognitive, physical and psychosocial disabilities (1). Australian data show that unemployment rates among young people with disabilities (25%) are higher than both their peers without disabilities (11.5%) and the general working age population (4.6%) (2). Rates of participation in the labor force (ie, being employed or unemployed) are also lower among young Australians with disabilities: nearly half (48.5%) are not in the labor force compared to 28.4% of young people without disabilities (2).

These statistics are concerning as experiences of unemployment are associated with ongoing and future unemployment (3), a reduction in the quality of future work (4), and poorer physical and mental health (5, 6). Similarly, people with disabilities who are not in the labor force may have poorer mental health than their peers who are engaged in work (7). Time spent out of the labor force may exacerbate the barriers to entering the workforce, and therefore increase total time out of the labor force among young people with disabilities (8). As such, entering the labor force and gaining and maintaining employment when young is critical to establishing improved health and labor force outcomes in adult life.

Despite being a common experience, disability is a complex phenomenon. As defined by the International Classification of Functioning, Disability and Health (ICF), disability is the result of an interaction between a person's health condition, environmental factors, and personal characteristics (9). Although previous research shows that young people with disabilities are more likely to be unemployed or not in the labor force than young people without disabilities, these studies typically assess disability at one time point [eg, (10, 11)]. Given that disability status may vary over time, treating disability as a fixed category may mask variation in the experience of disability among young people, and the individual and household factors that are characteristic of different patterns of disability. Additionally, changing disability status likely has ramifications for the barriers to gaining and maintaining work that young people with disabilities may experience. Individuals who acquire a disability during childhood may have different needs to enable labor force participation compared to peers who consistently report disabilities. Therefore, identifying patterns (or trajectories) of disability throughout childhood and adolescence and their associations with early labor force status will identify individuals who may benefit from enhanced supports and interventions to improve their education to work transition, and future working lives.

This study uses group-based trajectory modeling (GBTM) to assess how distinct trajectories of disability experienced from age 6/7 years to 16/17 years are associated with labor force status at age 18/19 years among young people in the Longitudinal Study of Australian Children (LSAC). The aims of this study were to: (i) identify trajectories of disability throughout childhood and adolescence (age 6/7 to 16/17 years); (ii) describe the characteristics of individuals within each trajectory of disability; and (iii) explore the relationship between these trajectories and labor force status at age 18/19 years.

Methods

Data source

Data for this study were taken from the nationally representative LSAC, which began in 2004. Participating families have been interviewed every two years, with the most recent wave of data, wave 8, collected in 2018. The selection of the baseline LSAC sample has been described in more detail elsewhere (12), but briefly a two-stage clustered sample design was employed, first selecting postcodes and then children enrolled in the Medicare Australia database. Apart from some remote areas, the sample was selected to be representative of all Australian children in each of the two selected age cohorts, cohort B (age <1 year in 2004) and cohort K (age 4-5 years in 2004) (13). LSAC is a rich data source, combining information from parents, teachers, and other caregivers and study children themselves when appropriate. LSAC participants and their families are interviewed once per wave, with data collection for the entire cohort conducted over an average period of 11 months (eg, wave 1 was collected from March 2004 to January 2005) (13). The Australian Institute of Family Studies Ethics Committee approved LSAC research methodology and survey content (wave 8 application number 17-01).

This analysis uses data from cohort K waves 1-8, encompassing ages 4/5 years to 18/19 years. Information reported by parents and the study child in face-to-face, computer assisted interviews, or self-completed surveys was used. A total of 4983 study children comprised the wave 1, cohort K participants (13).

Measures

Disability. Disability status was ascertained at each wave from wave 2-7 using information provided by the primary parent informant (typically the child's mother). The respondent was asked "Does the study child have a medical condition or disability that has lasted for 6 months or more?" If the reply was yes, the respondent was able to select from 11 different conditions, see appendix S1 in the supplementary material (www. sjweh.fi/article/3994).

There was slight variation in the disability question and included conditions over time. In waves 2-4, mental illness was not included as one of the disabilities or long-term conditions respondents could select. However, mental illness was asked about as a restriction to everyday activities. For waves 2-4, we therefore included individuals who reported a mental illness as a restriction in the disability variable. In waves 5-7, mental illness was included as one of the disabilities or long-term health conditions participants could select.

For this study, we have used a binary indicator of disability status (yes, no) at each wave to represent the study child's disability status.

Labor force status. The participant reported labor force status at wave 8 (18/19 years of age). We coded their employment status into three categories using Australian Bureau of Statistics definitions (14). Individuals who reported that they worked >1 hours in a job, business, or farm in the last week were classified as employed. Young people who were not working in the last week but had been actively looking for work in the past four weeks and were available to start work were categorized as unemployed. Participants who were neither employed nor unemployed were not considered to be in the labor force. Confounders

The adjusted multinomial logistic regression model of the association between disability trajectory and labor force status included the following confounders: child gender (male, female), child indigenous status (not Aboriginal or

Torres Strait Islander, Aboriginal and/or Torres Strait Islander), child speaks language other than English at home (no, yes), dual or single parent household (dual, single), highest parent year 12 completion (completed year 12, did not complete year 12), housing tenure [owned outright, mortgaged, rented, other (eg, occupied under life tenure scheme, living rent free, or other arrangement)], main household income source (wages, rental property, or dividends; government allowances, pension, or other income source), and mother's age (years).

Analysis

The GBTM analysis was reported following the Guidelines for Reporting on Latent Trajectory Studies checklist, see supplementary table S1 (15). Trajectories of disability were identified based on six waves of child disability data (waves 2-7). Individuals were included in the GBTM if they provided data on disability status in >1 wave from wave 2-7. Trajectories were identified using a logistic model (16) using survey weights to account for the survey design and non-response and to permit interpretation of the resulting trajectories as population prevalence (17). We allowed for possible non-linear shapes of the trajectories using polynomial transformations of time (based on wave) but limited the transformation to a quadratic shape to prevent overfitting the data. Nonsignificant (P>0.05) polynomial terms were excluded from the model (18). We considered models with between two and four trajectory groups. Optimum model selection was guided by the Bayesian Information Criterion (BIC), the mean posterior probabilities, and expert opinion of the authors (18, 19). Following the selection of the optimum trajectory model, individuals were assigned to a trajectory group based on their maximum posterior probability of group membership (18). We calculated the mean posterior probability of group membership and odds of correct classification (OCC) for each trajectory group to further assess model fit (18).

Following the identification of the trajectory groups, we used these groups as predictors of labor force status at wave 8. We used a multinomial logistic regression model to assess the association between trajectory group membership and labor force status at age 18/19 years, with results given as relative risk ratios (RR). The adjusted analysis included the confounders detailed above. Survey weights from wave 1 were included in the regression models (20).

To evaluate the potential impact of missing disability data on our results, we used univariate logistic regression to describe the association between the confounders and wave 2 disability status on missing disability data at follow-up (waves 3-7). Associations between confounders and missing disability data are shown in supplementary table S2. Results suggest that the following factors were associated with increased odds of missing data at follow-up: being Aboriginal or Torres Strait Islander, speaking a language other than English at home, living in a single parent household, having parents who did not complete year 12, living in rented or other kinds of housing, and living in a household where the main income source was from government allowances, pension, or other.

All analysis was performed using Stata version 16 (StataCorp, College Station, TX, USA). The traj plugin was used to perform the GBTM (21).

Results

Descriptive characteristics

Table 1 describes participant wave 1 characteristics (N=4983) and wave 8 labor force status (N=2602). The sample was evenly split amongst males and females, 3.7% of children were Aboriginal or Torres Strait Islander, 89% of children did not speak a language other than English at home, 86% lived in a household with two parents, and 68.3% had one or both parents who completed year 12. Over half of households (58.4%) had a mortgage and 27.8% were renting. Most (84.6%) of the sample's main household income source was from wages, rental property, or dividends. Mother's mean age was 34.6 years. At wave 8, 72.4% of participants were employed, 11.6% were unemployed, and 16% were not in the labor force. Supplementary table S3 shows the prevalence of disability by wave in the sample.

Disability trajectory modeling

The best-fitting model identified four distinct trajectory groups (see supplementary table S4 for fit statistics). This model incorporated disability information from N=4464 participants with disability information reported at least once from waves 2-7. Supplementary table S5 presents coefficients for the estimated trajectories for each group. Figure 1 shows the groups as a function of time from childhood to adolescence. The groups included: low (75.5% of LSAC cohort), low increasing (9.7%), high decreasing (10.9%), and consistently high (3.9%) disability prevalence. For each group, the mean posterior probability and odds of correct classification were: low prob=0.90, odds=1.66; low increasing prob=0.88, odds=168.73; high decreasing prob=0.88, odds=77.2; consistently high prob=0.85, odds=188.77.

Table 2 shows participant characteristics according to trajectory group assignment. A total of N=3760 individuals were assigned to the low trajectory, N=191 to low increasing, N=381 to high decreasing, and N=132 to the consistently high trajectory. Individuals in the low trajectory were more likely than those in the high decreasing and consistently high groups to be female, and they were more likely - than the low increasing, high decreasing, and consistently high groups - to speak a language other than English at home, live in dual parent households, have >1 parent who completed year 12, and live in a household whose main income source was from wages, rental property, or dividends.

Participants in the high decreasing and consistently high trajectories were more likely to be male than individuals in the low and low increasing trajectories. Individuals in the consistently high trajectory were least likely to speak a language other than English at home, and they were most likely to live in a single parent household. A similar proportion of individuals in the high decreasing and consistently high groups had parents who did not complete year 12. Participants in the consistently high trajectory were most likely to live in a household whose main income source was from government allowances or pensions.

Disability trajectories and labor force outcomes

Descriptive information regarding labor force status and disability trajectory can be seen in supplementary table S6. Results of the adjusted multinomial regression analysis assessing the association between disability trajectory and labor force status are shown in table 3. Individuals in the low increasing group were nearly three times as likely to be unemployed at age 18/19 years compared to individuals in the low trajectory (RR 2.96, 95% CI 1.94-4.53). The RR for unemployment at age 18/19 years for the high decreasing (1.09, 95% CI 0.68-1.74) and consistently high (1.36, 95% CI 0.66-2.82) trajectories are less conclusive as suggested by the wide CI that include the null value.

Being in the consistently high trajectory was associated with a greater RR of not being in the labor force at age 18/19 years compared to individuals in the low trajectory (RR 3.65, 95% CI 2.21-6.02). The RR for individuals in the low increasing (1.46, 95% CI 0.872.45) and high decreasing (1.38, 95% CI 0.91-2.09) trajectories may suggest that young people in these groups have a greater probability of being not in the labor force compared to individuals in the low trajectory, although the CI are wide and include the null value.

Discussion

Although the point prevalence of disability across young Australians is estimated to be 7.6% of children aged 0-14 years and 9.3% of young adults aged 15-24 years (2), the disability trajectories presented in this study suggest that about one-quarter of young Australians experience disability across the ages 6/7 to 16/17 years. The estimated population percentages from this study indicate that over 10% of young people experience either a consistently high or increasing prevalence of disability as they age.

The labor force outcomes of young Australians are associated with these disability trajectories. Individuals in the consistently high disability trajectory had increased risk of being not in the labor force at age 18/19 years. Young people in the low increasing trajectory, who may be acquiring new disabilities or experiencing an increase in limitations due to existing health conditions, had increased risk of being unemployed. One explanation for these results may be disability severity, as young people with consistent disabilities may be more likely to have severe disabilities that limit their labor force participation, potentially resulting in being permanently unable to work and receiving government benefits such as disability pensions. We note, however, that only 7% of those in the consistently high group were in receipt of a disability pension at age 18/19 years, suggesting that this is unlikely to account for the associations observed.

Parental expectations and work-related opportunities may also be decreased among young people with consistent disabilities, while young people in the low increasing group may have matured in the context of greater expectations of, and opportunities for, employment and work preparedness. Both expectations and opportunities are predictors of employment after secondary school among young people with disabilities (22), and may explain why young people in the consistently high trajectory have greater risk of being not in the labor force, while individuals in the low increasing group have greater risk of being unemployed.

For young people in the high decreasing group, the impact of disability trajectory on labor force status was less clear. This may arise from heterogeneity with regards to the types of conditions and the limitations young people in this group may experience, as a high decreasing disability prevalence may indicate a young person's responses to medication or treatment, or the benefit of assistive devices and other disability supports in enabling greater labor force participation.

Males were more likely to be in the high decreasing and consistently high disability trajectories, while a greater proportion of females were in the low increasing trajectory. This aligns with evidence showing that disability is more common among males (9.5%) at ages 0-14 years than females (5.7%) (23), with prevalence increasing to 9.5% among females at ages 15-24 years, approximately equal to males (9.2%) (2). In general, individuals in the low trajectory came from more socioeconomically advantaged families, as captured by parent education, household income source and dual-parent family status. This likewise concurs with previous research which has shown that lower childhood socioeconomic status is predictive of onset and severity of mental illness among adults (24) and increases risk of future work disability (25). These results reinforce that disability is associated with socioeconomic status, although further research exploring the intricate relationship between time-varying socioeconomic indicators, disability trajectory, and future labor force outcomes could clarify groups of young people who are most in need of support and intervention throughout childhood and adolescence.

Strengths and limitations

In interpreting the results of this study, there are several important limitations to be aware of. As with most panel studies of its kind, LSAC suffers from attrition. Young people who identified as Aboriginal or Torres Strait Islander, whose parents had lower levels of education, whose parents spoke a language other than English at home, and who lived in single-parent families were more likely to drop out of the study (20). This is consistent with patterns of non-response in the literature (26).

Additionally, there was slight variation in the disability questions included in LSAC over time, such as the inclusion of mental illness as either a restriction to everyday activities or as a disability or long-term health condition. While this study considered disability status as a dynamic phenomenon, we were unable to explore specific types of disability or disability severity due to small numbers of individuals in some groups, and the complex time-varying nature of disability type and severity. This approach may obscure heterogeneity with regards to disability type and severity within the disability trajectories, making it more difficult to identify individuals with the greatest needs for support. Furthermore, there were small numbers of individuals in some of the trajectories, namely the consistently high and low increasing groups, leading to reduced statistical power and wider confidence intervals around estimates. These small numbers also meant we were unable to examine labor force status at a more granular level, such as separating young people who were not in the labor force but studying from their peers who were not in employment, education, or training and who may particularly benefit from tailored interventions.

Finally, GBTM is based on defining 'points of support' for a continuous distribution of trajectories (18). Reality is more complex than the trajectories discussed in this paper suggest, and GBTM likewise does not reflect variation within disability groups. Similarly, the confounders we have included in our logistic regression models are a simplification of the complex interplay between disability status over time, socioeconomic status, and future labor force outcomes.

Strengths of this study include the use of an ongoing longitudinal dataset with rich socioeconomic, health, and labor force information that is representative of Australian young people. Additionally, this analytic approach among young people has not previously been done, and sheds light on the patterns of disability experienced by young people.

Future research

Information on disability type and severity was not used in the construction of disability trajectories in the current study. Assessing variation within disability trajectory groups by type and severity could lead to more specific insights into the experience of disability throughout early life and its associations with labor force status during young adulthood. Methods such as growth mixture modeling could accommodate this information, but require substantial amounts of statistical power.

Additionally, the current study assessed the association between disability trajectory and labor force outcomes, but did not examine the quality of the employment that young people were entering. This is a key area for future analysis as people with disabilities may be more likely to experience poorer quality employment compared to their peers without disabilities (27). As further waves of LSAC become available, researchers will be able to assess how labor force outcomes evolve over time among young people with disabilities. Evaluating how the COVID-19 pandemic impacted the movement into the labor force of young people with and without disabilities will also be a key area of research. Future research could also explore the relationship between disability trajectory, labor force status, and mental health and wellbeing.

Policy and practice implications

The barriers to finding and sustaining employment faced by the general population of young people [eg, lack of jobs, lack of work experience (28)] are being exacerbated by the COVID-19 pandemic (29). This may particularly be the case for young people with disabilities who face additional barriers to work including discrimination (30), lack of employer knowledge about how to accommodate disabilities in the workplace (31), and lack of adequate transition planning, including relevant career guidance and support (32). These barriers are not insurmountable: there is good evidence that work experience and vocational skills development while in secondary school, accompanied by appropriate transitions planning, predicts better post-school employment outcomes for young people with disabilities (33).

However, such programs have been found to be under-resourced and of poor and inconsistent quality, as identified by the Parliament of Victoria's inquiry into career advice activities in schools (34). Young people experiencing disadvantage, including young people with disabilities, are particularly at risk of poor employment transitions due to these policy and programmatic failures. To this end, the Australian Government has launched a National Career Education Strategy to improve the quality of career education provided to young people (35). This strategy, if successful, has the potential to benefit all Australian young people, especially young people with disabilities.

Young people with disabilities who struggle to gain employment may be further disadvantaged by existing employment programs in Australia, which may be unsuitable for jobseekers with limited work experience and with disabilities (36). Given that employment is a human right for all (37), including people with disabilities as explicated in the United Nations Convention on the Rights of Persons with Disabilities (38), it is imperative to enact policies which actively facilitate improved labor force outcomes for young people as a whole, with a particular focus on young people who may experience greater disadvantage, such as young people with disabilities.

The results of this study have made clear that disability is a common experience, with over 10% of young people experiencing either a consistently high or increasing prevalence of disability as they age. The results have also demonstrated that the pattern of disabil- ity a young person experiences is related to their labor force outcomes, with individuals with an increasing or consistently high prevalence of disability having greater risk of being unemployed or out of the labor force alto-gether. This highlights the importance of understanding disability as a dynamic phenomenon among young people which has real impacts on their transition into the labor force. It underscores the urgent need for increased supports to help young people with and without disabilities successfully enter the labor force and gain and maintain employment.

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Data availability statement
LSAC unit record files are held by the Australian Data Archive at the Australian National University. Access to data is free via a formal request and registration with the ADA. Individuals can register and request data at this website: https://dataverse.ada.edu.au/dataverse/ncld.

Sidebar

Shields M, Spittal MJ, Dimov S, Kavanagh A, King TL. Trajectories of disability throughout early life and labor force status as a young adult: Results from the Longitudinal Study of Australian Children. Scand J Work Environ Health. 2022;28(2):118-126. doi:10.5271/sjweh.3994
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DETAILS

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Differential impact of working hours on unmet medical needs by income level: a longitudinal study of Korean workers

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ABSTRACT (ENGLISH)

Objectives Unmet medical need is defined as the perceived need for medical service that is not received. Although the association between unmet medical needs and working hours has been explored before, the combined effect of household income has not been investigated thus far. This study, therefore, aimed to examine the differential association between working hours and the risk of unmet medical needs according to household income. Methods A total of 7047 participants enrolled in the Korea Health Panel data 2011-2014 were considered. The analytical method used in this study was a generalized estimating equation model that accounted for repeated measured participants. By controlling for time-invariant individual-fixed effects, we identified the relationship between long working hours and the risk of unmet medical needs. Results The association between long working hours and the risk of unmet medical needs differed according to household income. In the highest quintile of household income, the risk of unmet medical needs was 1.58-fold higher among those who worked >52 hours per week than among those who worked 30-52 hours per week. However, this association was not significant in the lowest quintile group. Conclusions The current study implies that financial hardship might be a more fundamental health hazard than working longer hours among the low-income group. Future policies should consider not only limiting working hours but also compensating workers' income to adequately protect low-income workers from the health risks associated with long working hours.

FULL TEXT

Headnote

Objectives Unmet medical need is defined as the perceived need for medical service that is not received. Although the association between unmet medical needs and working hours has been explored before, the combined effect of household income has not been investigated thus far. This study, therefore, aimed to examine the differential association between working hours and the risk of unmet medical needs according to household income.

Methods A total of 7047 participants enrolled in the Korea Health Panel data 2011-2014 were considered. The analytical method used in this study was a generalized estimating equation model that accounted for repeated measured participants. By controlling for time-invariant individual-fixed effects, we identified the relationship between long working hours and the risk of unmet medical needs.

Results The association between long working hours and the risk of unmet medical needs differed according to household income. In the highest quintile of household income, the risk of unmet medical needs was 1.58-fold higher among those who worked >52 hours per week than among those who worked 30-52 hours per week. However, this association was not significant in the lowest quintile group.

Conclusions The current study implies that financial hardship might be a more fundamental health hazard than working longer hours among the low-income group. Future policies should consider not only limiting working hours but also compensating workers' income to adequately protect low-income workers from the health risks associated with long working hours.

Key terms health inequity; income level; unmet medical need; working hour.

Unmet medical need is defined as the perceived need for a medical service that is not received (1), suggesting that it is not possible to receive treatment despite the desire for medical services. Studies show that unmet medical needs can lead to a number of adverse consequences, including increased morbidity, more severe disability (2), increased emergency room visits (3) and acute care hospitalization (4), psychological distress (5), poor self-assessment of health and quality of life, and increased mortality (6). Hence, it is considered an important variable to evaluate equal access according to need (7).

The 2016 Korean National Health and Nutrition Examination Survey (KNHANES) reported that approximately 8.8% of the general population in Korea had experienced unmet medical needs at least once a year (8); in contrast, among the 28 countries of the European Union, an average of 2.5% of the total population had experienced unmet medical care in the same year (9). The scope of medical services has expanded to include psychological and social needs of patients to support their emotional and psychological well-being; consequently, rather than focusing on the existing treatment - oriented service provision (10), access to and the use of necessary medical services has become essential to address health problems and secure a good quality of life (11). Therefore, it is important to identify unmet medical needs and understand the reasons for the same, by integrating various perspectives on patients' medical needs (11).

According to prior studies, the factors that drive unmet medical needs can be categorized into availability, accessibility, and acceptability (7). Availability emerges when the required services have not been provided at the desired time or place. Accessibility includes difficulties in accessing medical services owing to financial constraints that hamper the ability to pay, for instance, for medical expenses or transportation. Acceptability occurs because patients lack time to accept services, do not perceive the need for medical services, or have low acceptance of attitudes and knowledge, such as a lack of information about service providers.

Among the various factors that influence unmet medical needs, a lack of time owing to long working hours could cause difficulties in availability and acceptability. The adverse effects of working hours on health have been a major concern for the well-being of workers. Despite the large body of research on the association between long working hours and various health problems (12), few studies have specifically investigated the association between unmet medical needs and long working hours. Seok et al (13) analyzed data from the KNHANES, collected during 2007-2012, which included 8369 participants (4765 males, 3604 females) aged 20-54, who were paid workers (13). The results showed that there was a dose-response relationship between weekly working hours and unmet healthcare needs; however, the cause of unmet healthcare needs and its association with income status were not considered. Consequently, additional research on this topic is required using longitudinal data.

Meanwhile, low-income is a well-known socioeconomic factor leading to an increased risk of unmet medical needs (7). Theoretically, with all other factors being controlled, longer working hours generally accompany higher individual incomes. However, in reality, individuals may want to work fewer hours if their wages are sufficient to afford a decent standard of living for household members, as depicted in a backward-bending labor supply curve (14). In contrast, low-income workers need to work longer hours to secure a sufficient living income. From a labor economics perspective, individuals allocate their time between work and leisure to maximize their utility, given budget and time constraints (15). Accordingly, working hours may have different effects on workers' health depending on their economic background. A study using nationally representative data from South Korea found a significant association between long working hours and estimated cardiovascular disease risk among high-income participants, and no such association in low-income participants (16).

Although the association between unmet medical needs and working hours has been suggested before, to the best of our knowledge, epidemiological evidence with longitudinal data has not been reported. More importantly, the combined effect of household income has not been investigated. Therefore, this study aimed to examine the differential association between working hours and the risk of unmet medical needs according to household income.

Methods

Study population

This study used the Korea Health Panel (KHP) data collected by the Korea Institute for Health and Social Affairs and the National Health Insurance Service. The KHP is a national survey constructed through stratified, multi-stage cluster sampling from the population census data of South Korea, and has been conducted annually since 2008. The primary purpose of the KHP is to provide data on the influence of individual, social, and environmental elements on healthcare expenditure (17). The KHP incorporates a wide range of information, including demographic and socioeconomic characteristics, health status (medical, physical, and psychosocial), working hours, income (pension, income, assets, and housing), and medical expenditure. All the survey items are repeated for each panel wave. Trained interviewers visit the study participants' homes and conduct a computer-assisted personal interview. In the KHP data released from 2008 to 2018, information on the working hours of participants was collected only between 2011 and 2014. Therefore, we used the waves from the 2011 to 2014 KHP data of 23 212 individuals and 66 965 observations. Participants who were paid employees and aged 20-59 years, considering the official retirement age in South Korea, were included. Non-waged workers or non-workers [N=14 795 (63.7%)] and participants aged <20 or >60 [N=1176 (5.0%)] were excluded, as were those who had missing information on unmet medical needs [N=164 (0.7%)] and on working hours, household income, occupation, and shift work [N=30 (0.1%)]. Finally, 7047 participants were included in the current analysis (supplementary material, https://www. sjweh.fi/article/3999, figure S1). The distribution of gender, age, employment status, and household income are presented in supplementary table S1.

Variable measurements

Participants' weekly working hours were recorded using the following questionnaire item: "How many hours do you work per week, including overtime?" Considering South Korea's labor laws, participants' weekly working hours were classified into three groups: <30 (short weekly working hours), 30-52 (standard, and the most frequent weekly working hours) and >52 hours (overtime work allowed in extraordinary situations).

Unmet medical needs were measured by the subjective judgement of the need for medical services. When a participant could not use medical services for various reasons, despite having a medical need, they were judged to have an unmet medical need. Accordingly, participants were asked, "Did you have an experience in the past year in which you were not able to receive the medical service you needed?" The answer "yes" was considered as a case of unmet medical need. If a participant did not receive the necessary medical services, they were asked: "If you could not receive a medical service when you needed it, what was the reason for that?" Respondents could choose between the following options: "For economic reasons", "I did not have time to visit", "Because the medical institution is far away", "Difficult to visit owing to mobility or health reasons", "Because there was no one to take care of the child", "Because the condition is mild", "Do not know where to go", "Because it could not be booked in a short time", and "I did not have a family doctor". Additional analysis was performed on "economic reasons" and "lack of time", which received the highest number of responses.

In this study, age and gender were used as demographic characteristics, and household income as socioeconomic variables. Age was grouped into 20-29, 30-39, 40-49 and 50-59 years. Household income, including labor and financial income, was calculated on an equalized scale by dividing income by the square root of the number of household members (18); further, it was categorized into quintiles from lowest income (Q1) to highest income (Q5) among all survey participants. Job classes were gathered using the Korean Standard Classification of Occupation. We classified managers, professionals and related workers, and office workers into white-collar and service workers, sales workers, skilled agricultural, forestry and fishery workers, craft and related trade workers, equipment, machine operating and assembling workers, and elementary workers as blue-collar workers. Depending on their smoking status, as assessed by questionnaire items, participants were classified into current, former, and non-smokers. Shift work, associated with increased unmet healthcare need (19), was assessed using the following questionnaire item: "Do you usually work during the daytime between 06:00 and 18:00, or in other schedules?"

Statistical analysis

The general characteristics of the study population and the prevalence of unmet medical needs were described. Compared to the reference group, where the weekly working hours were 30-52 hours, odds ratios (OR) and 95% confidence intervals (CI) for unmet medical needs of other weekly working hours groups (<30 and >52 hours) were calculated. We also calculated OR and CI for unmet medical needs of middle and low household income groups, compared with the highest household income group. The analytical method used in this study was a generalized estimating equation model that accounted for repeated measures. This model is suitable for multivariate analysis using time information by repeatedly measuring panel objects through a panel survey. The endogeneity problem, owing to unobservable individual and occupational characteristics, can be overcome using panel data (20). By controlling for time-invariant individual-fixed effects, we identified the relationship between long working hours and the risk of unmet medical needs. The covariates used in the model were age, gender, occupation group (blue- or white-collar), smoking status, shift work, and household income. The occupation group, shift work, and household income were time-varying variables for the repeatedly enrolled participants, according to the 2011 to 2014 waves of the KHP data. Additionally, the association between long working hours and unmet medical needs based on the reason was identified. Consequently, the data were classified into 15 groups according to 3 weekly working hours groups, the quintiles of household income group, and calculated OR, compared to groups with standard working hours (30-52 hours per week) and highest household income (5th quintile). Sensitivity analyses were performed with different weekly working hours grouping (<30, 30-40, 41-52, and >52 hours). We used the PROC GENMOD protocol of the SAS version 9.4 (SAS Institute, Cary, NC, USA). The two-tailed P-values <0.05 were considered statistically significant.

Results

Table 1 summarizes the participants' general characteristics and prevalence of unmet medical needs by the year included in our analysis (2011-2014). The number of surveyed participants was 4071, 3812, 3591, and 4639 in 2011, 2012, 2013, and 2014, respectively. Males accounted for a greater number of participants than females (55.9%, 55.6%, 55.4% and 55.6% in 2011, 2012, 2013 and 2014, respectively). Most participants were in the age group of 40-49 (35.4%, 36.1%, 36.2%, and 35.7% in 2011, 2012, 2013, and 2014, respectively), and worked 30-52 hours per week (67.1%, 68.6%, 72.1%, and 73.6%, respectively). The mean weekly working hours in 2011-2014 were 46.5 [standard deviation (SD) 13.2], 45.5 (SD 12.7), 45.4 (SD 12.4), and 45.0 (SD 11.9), respectively. Supplementary table S2 shows the frequency of unmet medical needs. Throughout the study period, the proportion of participants with unmet medical needs was 16.5%, 14.7%, 16.4%, and 12.1% in 2011, 2012, 2013 and 2014, respectively. Those who worked >52 hours per week most commonly complained of unmet medical needs (21.6%, 17.9%, 18.3%, and 15.1% in 2011, 2012, 2013 and 2014, respectively). The most common reasons included lack of time and economic burden, which accounted for almost 50% and 20%, respectively.

The association between weekly working hours and unmet medical needs is presented in table 2. Unmet medical needs were significantly associated with weekly working hours. Compared with the 30-52 hours per week group, the >52 hours per week group showed a significantly higher OR (1.36, 95% CI 1.22-1.52) for unmet medical needs. Weekly working hours were also significantly associated with unmet medical needs owing to a lack of time and economic burden. Compared with the 30-52 hours per week group, the OR for unmet medical needs owing to lack of time, in the >52 hours per week group was 1.64 (95% CI 1.42-1.90). However, short work time (<30 hours/week) was significantly associated with a lower unmet medical need driven by a lack of time (OR 0.65, 95% CI 0.48-0.88), and a higher unmet medical needs from economic burden (OR 1.61, 95% CI 1.17-2.21). In the gender-stratified analyses, these findings did not differ notably by gender (supplementary table S3).

The association between household income and unmet medical needs is shown in table 3. Compared to the highest household income group, the lowest household income groups showed a significantly higher OR for unmet medical needs at 1.86 (95% CI 1.48-2.34). In the gender-stratified analysis, this association was more prominent among males than females (supplementary table S4). Unmet medical needs due to economic burden were predominantly associated with household income; however, those driven by a lack of time were not significantly associated. The OR for unmet medical needs owing to economic burden in the low household income group was 13.17 (95% CI 8.62-20.12), compared with the highest group.

The same analytical method was used to calculate the OR of long working hours by quintiles of household income level (table 4). The OR of the >52 hours per week group was higher than that of the 30-52 hours per week group as the quintile of household income level increased, suggesting a dose-response relationship according to household income level. The adjusted OR of long working hours from low to high quintiles are as follows: 1.28 (95% CI 0.74-2.23), 1.32 (95% CI 1.02-1.71), 1.36 (95% CI 1.10-1.68), 1.38 (95% CI 1.11-1.72), and 1.58 (95% CI 1.28-1.95). In addition, the association between long working hours and unmet medical needs due to lack of time was strongest among the lowest income group (OR 4.26, 95% CI 1.92-9.46).

Figure 1 shows the combined association between long working hours and quintiles of household income and unmet medical needs. Compared to the reference group (those who worked 30-52 hours per week in the highest household income group), participants with >52 hours per week in the quintiles 5 (highest), 4, 3, 2, and 1 (lowest) had OR for unmet medical needs at 1.51 (95% CI 1.23-1.86), 1.45 (95% CI 1.18-1.80), 1.52 (95% CI 1.24-1.87), 1.73 (95% CI 1.37-2.19), and 2.54 (95% CI 1.59-4.06), respectively. Short-time workers in the lowest income group had significantly high unmet medical needs (OR 2.23, 95% CI 1.42-3.47). However, short-term workers in the highest income group were associated with a lower unmet medical need (OR 0.67, 95% CI 0.40-1.10), although this was not statistically significant.

In the sensitivity analyses with different weekly working hours grouping, the results remained robust (supplementary table S5-7). Long working hours (>52 hours per week) were associated with unmet medical needs, compared with those who worked 30-40 hours a week (OR 1.59, 95% CI 1.40-1.80). The size of the association between long working hours (>52 hours per week) and unmet medical needs was also bigger in high-income groups, as OR (95%

CI) of quintiles 1 (lowest), 2, 3, 4, and 5 (highest) were 1.56 (95% CI 0.85-2.88), 1.31 (95% CI 0.98-1.77), 1.70 (95% CI 1.30-2.21), 1.54 (95% CI 1.20-1.98), and 2.04 (95% CI 1.61-2.59), respectively.

Discussion

The results of our analysis showed that the association between long working hours and the risk of unmet medical needs differed according to household income. In the highest household income, the risk of unmet medical needs was 1.58-fold higher among those who worked >52 hours per week, than those who worked 30-52 hours per week. However, this association was not significant in the lowest income group.

Our finding, of a significant association between long working hours and the risk of unmet medical needs, is in line with those of previous studies. In a study by Ha et al (21), the unmet medical need experience rate of regular workers was found to be 13.3%; it also found that long working hours in Korea create restrictions on the use of medical care by workers because most of them have unmet medical needs owing to a lack of time. Similarly, Seok et al (13) reported that long hours of work might limit healthcare use, thus resulting in unmet medical needs.

Our study found that the effects of long working hours on workers health problems could differ according to their economic status. Specifically, there is a significant association between long working hours and an increased risk of unmet medical needs among the high- but not the low-income group. A previous study supported this finding, where the association between long working hours and 10-year risk of cardiovascular disease was significant only among the highest income group among men, while the association between household income and 10-year risk of cardiovascular disease was significant only among the lowest income group (16).

A possible explanation for these findings is that working hours could affect health differently, depending on the environment and reactions of individuals. Differences in the risk of unmet medical needs due to a lack of time across groups with different income levels may reflect the effect of autonomy on the regulation of working time between the groups. The health effects of long working hours are exacerbated by workers lack of control over working hours, which is more common in lower-income groups (22). Moreover, a lack of autonomy in the use of time restricts access to healthcare. In situations of mandatory overtime, workers further lose the ability to make time for health management. This lack of control over working hours may also be linked to working time mismatch (ie, the difference between actual hours and preferred hours) that negatively affects workers utility (23). According to a study using a periodical survey of Korean workers, poor subjective health status was reported among those whose actual hours did not correspond to their preferred working hours (24). Another study using a nationally representative longitudinal survey in the United Kingdom also showed that a discrepancy between preferred and actual working hours induces psychological stress (25), which is an important aspect while considering the relationship between long working hours and health problems (26). Additionally, there is a possibility that the level of psychological stress from long working hours differs according to preferred working hours, related to the economic status of individuals. From an economic view, for better health, the marginal utility of an increase in leisure time and the marginal utility of an increase in income resulting from the addition of working hours, can vary depending on income level.

Long working hours can reduce recovery and rest time after work, cause work-life imbalance, and disrupt health behaviors, thereby leading to a deterioration in workers' health (27-29). Meanwhile, it has been recognized that the higher the wage, the better the worker's health (30, 31). Nevertheless, the potential difference by income level with regard to the impact of working hours on health has been of limited interest. Workers sometimes change jobs to spend more time with their families, even if it involves a loss of labor income. In contrast, some workers accept jobs with longer working hours if they want higher income at the expense of their own free time (32, 33). While individuals in the highincome group may not want to increase their working hours for more earnings, those in low-income groups may need to increase their income by working longer hours. Considering that workers make choices about working hours based on their income-leisure preferences, the findings of this study could also be interpreted from the perspective of working time preference and mismatch. According to the results of a recent study conducted in Korea, although the negative effects on health generally increase as working hours increase, the health conditions of workers who worked in accordance with their preferred working hours were found to be the best, regardless of working hours (24). Given the backwardbending labor supply curve, unwanted long working hours can adversely

affect health in the group whose income is above a certain level; however, the negative health effects of long working hours may not be apparent on the surface in those who want to receive higher wages by working long hours, owing to low income. Therefore, the results of this study support the complex inter-relationship between income, working hours, and health, by considering the concept of a working hourspreference mismatch.
However, the weaker association between long working hours and the risk of unmet medical needs among lower-income groups does not imply that there are no detrimental effects of long working hours among these groups. The association might be obscured by the negative effects of low income. This was supported by the results that, when compared to the highest household income and standard working hour group, long working hours showed a higher OR for unmet medical needs in the lowest income group, than in the highest income group (figure 1). This implies that financial hardship is a more fundamental health hazard than working longer hours among the low-income group. Our data indicated that the low-income group showed the highest prevalence of unmet medical needs, regardless of working hours. Along with the results of table 3, this finding suggests that only when basic economic needs have been met do the adverse effects of prolonged working hours outweigh the positive income effects and harm the health of people with sufficient resources.
This study has several strengths. Specifically, the use of nationally representative panel data allows for the generalization of results to the broader population of South Korea. Panel data also permit us to focus on within-person changes in the experience of unmet medical needs as working hours change, controlling for unobserved time-invariant characteristics. Failure to control for time-invariant individual characteristics could bias the estimation results if there were correlations between the observed covariates and these unobserved factors. This is in marked contrast to the majority of previous studies based on cross-sectional data in this area. Another notable strength is that this is a unique study investigating how this association between long working hours and unmet medical needs differed by household income level. This could help us understand the mechanisms and identify at-risk populations, potentially contributing to the development of improved public health policies.
Despite these strengths, our study has some limitations. First, the experience of unmet medical needs and working hours was defined using self-reported answers from respondents. However, previous studies have indicated that subjective unmet medical needs are as important as clinically evaluated ones because, in many circumstances, people perceive their healthcare needs better than healthcare professionals (34). Some studies using subjective and objective methods tend to show fairly consistent results (35), and consequently, many studies use subjective measures (7, 13, 21). Second, the participants were restricted to South Korea, limiting the generalizability of our findings to other populations with different medical care systems and cultural contexts, which affect the level of unmet healthcare needs. Therefore, our results should be carefully considered when generalizing them to other countries. Third, the reason for unmet medical care needs should be interpreted with caution, as the respondent could choose only one of the most important reasons. Fourth, because our study sample size in the lowest income status was relatively small, it could have led to biased results, derived from selection bias. It would be possible that workers with extremely low resources, including time and health, could not work, and thus were not included in our analysis or - even if they were included - could not work long hours. Therefore, the results should be interpreted cautiously, owing to the problem of uneven distribution according to income group. Finally, because we used existing data which lacked information on time-varying living and working conditions, job stress, work time control, work-family conflicts, and mental disorders, among others, we could not control for these factors in our analysis. This is an area for further research.
Concluding remarks
This study suggests that the association between long working hours and the risk of unmet medical needs varies based on household income as it was found predominantly among high-income groups, and increases in household income had protective effects on the risk of unmet medical needs. This implies that future policies should consider not only limiting working hours but also compensating workers' income to adequately protect them from the health risks associated with long working hours. We hope our results will contribute to accumulating evidence in supporting the implementation of effective strategies for protecting workers' health.

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Conflict of interest statement
All authors declare no competing interests.

Sidebar

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Working at home and expectations of being available: effects on perceived work environment, turnover intentions, and health

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ABSTRACT (ENGLISH)

Objectives The aim of this study was to determine if (i) working at home and (ii) expectations of being available to the employer in their spare time influences employees' perceptions of their work environment and well-being, health, organizational commitment, or intention to leave. Methods We conducted cross-sectional analyses of survey data from 7861 office workers reporting hours worked at home and 3146 reporting frequency of expectations of being available to the employer in spare time (availability expectations). Prospective analyses (two-year follow up) comprised 5258 and 2082, respectively. Dependent variables were work factors previously associated with health complaints, mental distress, positive affect, work-private life conflict, commitment, and intention to leave. Random intercept linear and logistic regressions controlled for time worked (in addition to regular hours), age, gender, and skill level. Results "Hours working at home" was cross-sectionally associated with higher levels of demands, role ambiguity, role conflicts, decision control, empowering leadership, human resource primacy, commitment, work-private life conflict, and lower support from co-workers. "Availability expectations" was associated with higher levels of demands, role conflicts, neck pain, mental distress, thinking that work was not finished when going to bed, sleep problems, work-private life conflict, intentions to leave and with lower levels of superior support, co-worker support, fair leadership, and commitment. There were no prospective associations. Conclusions Working at home was associated with both positive and negative factors. Specific factors pertaining to role expectations and support from co-workers pose challenges. Availability expectations was associated with potentially negative work factors and health, organizational commitment, and intentions to leave. There were no long-term effects.

FULL TEXT

Headnote

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private life conflict, and lower support from co-workers. "Availability expectations" was associated with higher levels of demands, role conflicts, neck pain, mental distress, thinking that work was not finished when going to bed, sleep problems, work-private life conflict, intentions to leave and with lower levels of superior support, co-worker support, fair leadership, and commitment. There were no prospective associations. Conclusions Working at home was associated with both positive and negative factors. Specific factors pertaining to role expectations and support from co-workers pose challenges. Availability expectations was associated with potentially negative work factors and health, organizational commitment, and intentions to leave. There were no long-term effects.

Key terms control; expectation being available to employer; intention to leave; job demand; mental distress; neck pain; organizational commitment; role conflict; social support; work at home.

Telework was originally proposed in the 1970s as a means to reduce pollution and distress from commuting. Information and communication technology (ICT) with the possibility to access data from remote locations and video conferencing has allowed alternative ways of organizing work (1). The COVID-19 pandemic with restrictions on public commuting and social interactions has been a catalyst of implementation of remote work in employees' homes, and it seems reasonable to expect that working at home will constitute a significant part of working life for a large number of people in the future (2). The overarching aims of the present study were to determine if (i) working at home and (ii) expectations of being available to the employer in their spare time influences (a) employees' appraisal of key psychosocial work factors and (b) organizational commitment, turnover intentions, well-being, or health. We investigated the time period prior to COVID-19 since the imposed remote work due to the pandemic was acute, enforced, and total.

Previous reviews have included all work locations under the concepts of remote work and telecommuting (3, 4). Charalampous and co-workers (3) concluded that "there is still a greater consensus towards a beneficial impact of this working arrangement" (p69). Gajendran &Harrison (4) concluded with "small but favorable effects on perceived autonomy, work-family conflict, job satisfaction, performance, turnover intent, and stress" (p1538). Almost all previous studies of working at home or remote work have addressed work-private life conflict or general outcomes like job satisfaction, engagement, productivity, and 'stress'. A systematic review of studies about working at home from 2010 to February 2021 (5) found only three studies of effects on work-environment characteristics [(control of decisions, co-worker support; 6, 7), perceived fairness; 8)]. Hence, there is scant knowledge of effects on employees' appraisal of specific work factors.

Working at home may potentially influence all aspects of one's job. While working at home may allow more autonomy and control of working hours with possibility for breaks and errands at one's discretion, working hours may expand due to perceptions of what is expected (9). The elimination of travel to work also eliminates the delimitation of work by leaving the workplace [see work-family border theory (10) and boundary theory (11)]. Some organizations expect their employees to attend to and respond to messages in their spare time (9). We have not found studies of consequences of expectations to be available for the employer on appraisal of work environment or health or attitudes.

Working at home can challenge communication between the employee and her/his leader and with co-workers. One consequence is lower levels of social interactions (3, 4, 7), in particular face-to-face meetings. Other hypothetical consequences of interactions and communicating per distance are ambiguous or conflicting definitions of goals and standards, ie, role ambiguity and conflicts. We have previously reported that role conflicts prospectively predict neck pain, headache, mental distress, and disability retirement (12, 13, 14, 15). Furthermore, leaders' capacity to maintain support and fair and empowering leadership and justice may be challenged. Therefore, organizing work in employees' homes may potentially influence task-, group-, and organizational level aspects of the work environment. Hence, there is need for knowledge of a comprehensive set of work environment outcomes to support a sustainable implementation of working at home. Based on a large number of employees from private and public organizations, this study aimed to contribute new comprehensive knowledge of effects of working at home and expectations for being available to the employer in one's spare time on perceptions of task and group level, and leadership factors that can influence health. We also elucidated effects of both factors on organizational commitment, turnover intentions, and health.

There are several reasons for working at home and studies should distinguish between working at home and working extra hours at home. Working at home may be a consequence of high levels of quantitative demands necessitating extra work, but it may also result from high (internal) motivation for the job. The present study sought to delineate working in one's home by taking overtime work into account in the analyses.

The present study was based on data from a comprehensive multifactor full-panel prospective project with the aim to elucidate effects of new ways of working in the 21st century in Norway. The data collection was initiated in 2004 and organizations were recruited de novo until 2019. Those organizations that took part in two survey waves with an approximately 24-month interval were included in prospective analyses.

Methods

Study design and population

The study was part of the project "The new workplace: work factors, sickness absence, and exit from working life" with full-panel prospective design. Organizations were recruited throughout 2004-2019, hence the first measurement survey took place within this extended period. Private and public organizations participated (municipalities, government ministries, federal agency, health care, finance, insurance, education, and non-profit organizations). All current employees of each organization were invited to participate (organizational level convenience sampling method). For those organizations that took part in two survey waves, the interval between survey waves ranged from 17 to 36 months (average 24 months, second survey within 2006-2019). The surveys were primarily web-based (ca 15% responded on a paper version). There was no information of hypotheses or research questions in the information conveyed to participants.

The Norwegian Regional Committee for Medical and Health Research Ethics (REC) and the Norwegian Data Inspectorate approved the study, which was conducted in accordance with the Declaration of Helsinki.

Two samples were defined for the current analyses, a cross-sectional sample for which all employees in companies that participated at least once were eligible and a prospective sample comprising employees from companies that participated at least twice. The cross-sectional sampling frame consisted of 26 841 invited employees of 1482 work units in 101 companies. Of these, 11 604 individuals (43.2%) provided information about whether they worked in an office, and 8086 (69.7% of 11 604) were office workers eligible for inclusion. Of these office workers, 7861 (97.2% of the office workers) provided information about hours spent working at home.

The prospective sampling frame comprised 15 580 invited employees of 986 work units in 69 companies. Of these, 7865 individuals provided information about office work status, 5418 were office workers (68.9% of those providing information), and 5258 provided information about hours working at home (97.0% of office workers).

Expectations of being available to employers in one's spare time (availability expectations) was only asked of subjects who reported working at home (>0 hours). The number of workers who completed this item was 3146 for cross-sectional and 2082 for prospective analyses.

Exposure measures

Working at home was introduced with "Many employees can work at home either by bringing work to their home or by electronic connection with internet (telework)". Time spent working at home (hours worked at home) was assessed by an affect-neutral question: "How many hours per week did you work in your own home during the last week?" with response categories 0, 0-2, 2-5, 5-15, >15 hours.

A specific aspect of role expectations that may be relevant for new ways of working, boundary theory (6), and restitution was assessed by the question "Is it expected that you are available to your employer in your spare time?" (availability expectations) with frequency of occurrence response alternatives (five levels, "very seldom or never" to "very often or always"). Both questions were constructed for the present project.

Baseline-follow-up sample correlations for hours worked at home and availability expectations were 0.66 and 0.67, respectively (Spearman's p, P<0.001).

Outcome measures: work factors

The General Nordic Questionnaire for Psychological and Social Factors at Work (QPSNordic) has been extensively validated, has shown good psychometric properties (16, 17) and provides a comprehensive assessment of key work factors.

The following factors were studied (see supplementary material, www.sjweh.fi/article/3996, appendix): Task level: quantitative demands (time pressure, amount of work; 4 items), decision demands (3 items), decision control (5 items), control over work pacing (4 items), role conflict (3 items), role ambiguity (3 items); Group level: support from co-workers (2 items); Leadership: support from immediate superior (3 items), fair leadership (3 items), empowering leadership (3 items), human resource primacy (3 items). Cronbach's a ranged from 0.61 for decision demands to 0.88 for empowering leadership. The two support-from-co-workers items exhibited Pearson's r correlation 0.67. Since most work factors may vary over time, response categories were frequency of occurrence (five levels, "very seldom or never" to "very often or always") for all scales except human resource primacy (five categories, "very little or not at all" to "very much").

Outcome measures: well-being, health, attitudes to job

Sleep disturbance was recorded with two items "difficulties falling asleep" and "disturbed sleep" in the last four weeks. Response alternatives were "0", "1-3 times per month", "1-2 times per week", "3-5 times per week", and "6-7 times per week". The two items were correlated (p=0.68, P <0.01).

Neck pain and unspecified headache were items of a checklist of 21 health complaints (18). Each complaints were recorded by asking "have you been troubled by .... (ie, neck pain) the last four weeks", with four-level intensity scales. The wording "troubled by" is a common way of expressing the experience of a symptom in Norwegian. If reporting pain ("a little troubled" or stronger), the subject was asked to rate duration of the complaint ("1-5", "6-10", "11-14", or "15-28 days"). Low-intensity chronic pain may be as severe a health problem as more intense pain with short duration. Therefore, intensity and duration were multiplied to form a complaint-severity score (range 0-16, ordinal scale).

Mental distress (symptoms of anxiety and depression) during the previous ("last") week was measured by a 10-item Norwegian version of the Hopkins Symptom Checklist-10 (HSCL-10; 19, 20). Response alternatives were "not at all", "a little", "quite a bit", and "extremely". Cronbach's alpha was 0.86.

Positive affect was measured with three questions from the Work Ability Index (WAI; 21; "have you been able to enjoy your regular daily activities recently?", "have you been active and alert recently?", "have you felt full of hope for the future recently?"). Responses were given on a five-level frequency scale ("never" to "often"). Cronbach's alpha was 0.85.

Working in the home is problematic for family (WaH-problem) was assessed with one item with fivelevel frequency scale.

Work-private life conflict (WPC) was measured with two items from the QPSNordlc "Do you feel that demands from the workplace interfere with your private- and family life?" and "Do you feel that demands from your private- and family life interfere with how you execute your work?" Response alternatives were five-level frequency scales. The Pearson's r correlation between WaH-problem and WPC was 0.39.

Organizational commitment was assessed with three items from the QPSNordic ("I tell my friends this is a good organization to work in", "my values are very similar to those of the organization", "the organization inspires me to do my best") with five response categories ("totally disagree" to " totally agree"). Cranbach's alpha was 0.86.

Intention to leave was measured by two items from the Michigan Organizational Assessment Questionnaire (MOAQ) (22; "I often think about quitting my job" and "It is likely that I will actively look for a new job during the next year"), with five response categories ("Completely disagree" to "Completely agree"). The two items were averaged and treated as a continuous outcome. The Pearson's r correlation between these items was 0.70.

Control variables

Overtime work was included as covariate in analyses since working at home may represent extra or overtime work ("How often have you worked more than the regular working hours during the last four weeks?" with five response alternatives from "Never" to "Very often").

Gender, age, and skill level were included as covariates in all analyses. Skill levels were determined based on occupations, according to a Norwegian adaptation of the International Standard Classification of Occupations (ISCO-88), by Statistics Norway. This classification expresses educational levels or equivalent levels of work experience typically required for different occupations (13). Skill level also serves as proxy for socioeconomic status. Several variables may be influenced by macroeconomic fluctuations that affect labor markets and implementation of technology. Hence, the year of the initial survey measurement was included as covariate in all analyses.

Statistical analyses

Statistical analyses were run with R version 4.0.0 (R Foundation for Statistical Computing, Vienna, Austria). Due to the high number of tests the criterion of statistical significance was P<0.01 and tables' confidence intervals (CI) 99%. Data were analyzed by mixed effects regressions with random intercepts to correct for potential bias due to correlated responses within work units. For outcome variables considered continuous, linear mixed models were used and for outcomes considered ordered categorical (neck pain, headache) cumulative link mixed models (ie, random intercept ordinal logistic regressions) were run. The models were estimated with the packages "lme4" (23) and "ordinal" (24). Including random effects in regression models accounts for possible nonindependence of measurements within clusters, thus correcting for potential bias due to clustering effects that may otherwise deflate standard error estimates and increase the risk of type I error.

Organizations that participated differed considerably in size and scope, with some being one unit organizations and others consisting of many work units distributed over a large geographical area. Work unit membership was considered an appropriate cluster variable, as employees within work units were generally assumed to share context to a larger degree than employees of the overarching organizations.

The prospective analyses included the respective outcome variables at the first measurement occasion as covariates. Attrition analyses showed that hours working at home, availability expectations, gender, working more than regular hours, or leadership responsibilities were not associated with dropout from the study. Age was associated with a statistically significant increased probability of responding at follow-up for all outcomes with odds ratios (OR) ranging from 1.01 to 1.02 and CI for all OR being (1.01-1.03) (analyses not shown). For positive affect and turnover intention, the skill level classified as "managers and unspecified" was associated with increased probability of responding, with OR of 1.58 (95% CI 1.14-2.18) and 1.40 (95% CI 1.00-1.96) (analyses not shown).

The GRADE (Grading of Recommendations, Assessment, Development and Evaluations) system hold that certainty of evidence can be up-graded if there is a dose-response gradient (25). Therefore, we highlighted associations that exhibited monotonic dose-response relationships.

Results

Table 1 shows the number of respondents who work at home (39.2%. Of these, 52.9% reported availability expectations sometimes or more often and 69.7% reported thinking sometimes or more often that work was not finished when going to bed. Hours worked at home was associated (cross-sectionally) with reporting longer than regular working hours (Pearson's r = 0.38, P<0.01).

Work factors

In order to elucidate effects or working at home per se, the following analyses were adjusted for reporting longer working hours, gender, age, and skill level. Hours worked at home was associated (cross-sectionally) with reporting higher quantitative demands, decision demands, expectations of availability, role ambiguity, role conflicts, control of decisions, empowering leadership, and human resource primacy (supplementary material table S6). The association with availability expectations reflected a monotonic dose-response relationship, while those of the two job demands factors seemed to level off at 5-15 hours per week. The other significant associations reflected threshold effects (role ambiguity, empowering leadership, human resource primacy).

Hours working at home was associated (cross-sectionally) with reporting lower support from co-workers, with a monotonic dose-response pattern (table 6).

Availability expectations was positively associated with quantitative demands, decisions demands, and role conflicts with monotonic dose-response relationships, while a significant association with role ambiguity showed no dose-response relation (table 2). Availability expectations was negatively associated with support from both superior and fair leadership with a monotonic dose-response relationships. Availability expectations was also associated with reporting lower support from co-workers.

Well-being, health, attitudes to job

Cross-sectional associations: Hours working at home was associated with higher levels of organizational commitment, with thinking that work was not finished when going to bed, and with WPC (table 3), the latter two showed monotonic dose-response relationships.

Availability expectations was positively associated with neck-pain, mental distress, thinking that work was not finished when going to bed, sleep problems, problems for family situation, and WPC with dose-response relationships (table 4). Availability expectations was negatively associated with commitment and positively associated with turnover intentions.

Prospective associations (two-year follow up): neither hours working at home nor availability expectations showed statistically significant prospective associations with any of the measured indicators of well-being, health or attitudes to the job (see table 5 and supplementary material: table S7).

Discussion

The present study of office workers was undertaken prior to the COVID-19 pandemic and the prevalence of working at home was moderate (39.2%). Reporting that they sometimes or more often were expected to be available for work in leisure time (availability expectations) was common (52.9%). Hours working at home showed associations with both quantitative- and decision demands (table 6). Availability expectations was associated with reporting higher levels of both types of job demands (table 2) with monotonic dose-response relationships. Since the present analyses included overtime work as a covariate, one should expect that the association between hours working at home and the perception of higher job demands reflect aspects of working in one's home rather than having longer working hours. This finding is in accordance with a representative study from the UK that reported "more voluntary effort is expended" among remote workers (26, p205), but contrasts with reports of lower work effort in the 3.4% of US federal agency employees who teleworked (27). There are several possible explanations for associations between working at home and job demands. Working at home may be an inherent part of the job or a coping response to high levels of demands (eg, 28). Working at home may also reflect internal motivation for job tasks (involvement, 29) and there was a positive association between hours working at home and commitment (table 3). Moreover, it is possible that hours working at home and availability expectations increase the perception of job demands by making the employee think about the job for larger parts of the day. Indeed, both factors were associated with thinking that the job was not done when going to bed.

Hours working at home and particularly availability expectations were associated with role ambiguity and role conflicts. Previous studies have reported mixed results. Telework was negatively related to role conflict and positively related to role ambiguity among US teleworking supply chain management employees (30), and US teleworking federal agency employees reported lower role ambiguity (27). The present finding may be a result of lower levels of supervision of employees working at home. Indeed, there was a negative association between availability expectations and reported support from one's superior and with fair and empowering leadership. An alternative explanation is that employees who experience negative work factors cope by doing some of the work in their homes (ie, reverse causality).

Hours working at home and availability expectations were associated with lower coworker support. This is in accordance with a study of homework of employees of a Belgian telecommunications company (7). Promoting optimal levels of social interactions and preventing social isolation are challenges for organizations implementing remote work.

One notable finding was that hours working at home was positively associated with perceived empowering leadership and control of decisions, while availability expectations showed negative associations with these factors. Similarly, hours working at home and availability expectations showed opposite associations with level of organizational commitment: Hours working at home promoted while availability expectations attenuated commitment. The positive effects of working at home on job control and empowerment may promote commitment.

On the other hand, it is conceivable that higher level of commitment motivates working at home (resulting in more hours working at home). Expectations to be available in one's spare time seems perceived as negative and consequently attenuates commitment. A reverse association - that lower commitment causes expectations of being available in one's spare time - seems unlikely. The potentially negative effect of availability expectations was emphasized by its association with intentions to leave the job.

Both hours working at home and availability expectations were associated with thinking that the job was not done when going to bed. Availability expectations was also associated with sleep problems. Both hours working at home and availability expectations were associated with work-private life conflict, but only availability expectations was associated with reporting that working at home was problematic for the family situation. Arlinghaus &Nachreiner (31) analyzed large-scale cross-sectional surveys (Ns >22 000) and found that supplemental work at home (ie, working in one's free time) was associated with self-reported health impairment. They concluded that "in order to minimize negative health effects, availability requirements for employees outside their regular work hours should be minimized" (p1100). An experimental study of being required to be available during nonworking hours showed "significant effects of extended work availability on the daily startof-day mood and cortisol awakening response" (32).

Availability expectations, but not hours working at home, was associated with neck pain and mental distress. We have previously reported that role conflicts predicted risk of neck pain while empowering leadership attenuated the risk (12). We also found that role conflict predicted risk of mental distress while support from one's superior and fair leadership attenuated risk (14). It seems reasonable to conclude that working at home per se implies both positive and negative work factors that often times cancel each other. On the other hand, availability expectations seem associated with potentially negative work factors.

There were no statistically significant prospective effects at two years follow-up. Well-being, mental health, sleep, and attitudes to one's job vary over time and latency from exposure to response may range from hours to months. It seems that hours working at home and availability expectations vary over time or that effects are either transient or moderate. We do not have data pertaining to the duration of periods spent working at home, but correlations between the two survey-wave measurements were 0.66 and 0.67. Previous meta-analyses have suggested an optimal time-lag of 2-3 years for detecting occupational stressor-strain associations (33). Methodological considerations.

Many studies have analyzed working at home as a dichotomous variable. The present study graded hours of working at home and availability expectations and took frequency of overtime work into account in all analyses. Presumably, working at home was not confounded with overtime work. Single-item measures of concrete factors can exhibit high validity and reliability (34). Furthermore, the questionnaire for psychological and social work factors (QPSNordlc) has been thoroughly validated (12-17). The present study comprised a large number of employees reporting that they worked in an office and performed both cross-sectional and prospective analyses.

The data were collected from 2004-2020. The implementation of ICT may have changed the contents of many office jobs in this period. We sought to attenuate this problem by adjusting all analyses for year of data collection. However, one cannot eliminate the possibility that the meaning of work concepts may be transformed with digitalization of tasks. On the other hand, with this long data-collection period, transient effects of business cycles were attenuated.

The number of employees working at home >15 hours per week was low (1.9%), hence the present study cannot generalize to contexts of full-time work at home (eg, during the COVID-19 pandemic). Future arrangements of working >2 days at home (ie, >15 hours) were not adequately represented in these data. However, the findings pertaining to effects of availability expectations should be relevant to work-spare time boundaries in general.

A concern with subjective reports is the risk of method bias, ie, method factors that influence the subject's responding, introducing method variance and/or bias of estimates of the constructs that are measured. Personality characteristics influence perception and appraisal and the reporting of exposures, situations, states, and symptoms. Neuroticism predisposes for reporting mental and somatic symptoms (eg, 35, 36). Social-desirability may produce bias by systematic overor underreporting according to social norms (eg, 37). Response styles and heuristics to minimize cognitive effort may influence responding. Context at the time of reporting may influence affective state, situation models, and cognitive representation. However, Askim &Knardahl (38) found that transient affect has little influence on responding to neutral-valence worded questions, with the possible exception of questions measuring attitudes or social interactions. Perception and appraisal are coping mechanisms that play a role in the causal pathway for factors that contribute to motivation, well-being, health, or function in individuals. Hence, subjective appraisal is a mediator in causal processes rather than an error. The present study sought to elucidate employees' subjective appraisal of their work situation, attitudes, and subjective health indicators.

The assumption that associations based on samesource, self-reported data are inherently invalid due to common method variance (CMV) has received much attention (39). Fuller and coworkers found that "relatively high levels of CMV must be present to bias true relationships among substantive variables at typically reported reliability levels" (40, p3192). The instruments of this study should be rather insensitive to method bias and CMV since the QPSNordic-items are worded for neutral valence, respondents reported frequency of occurrence rather than degree of agreement or satisfaction, and items did not address issues that are inherently negative or positive. However, one cannot eliminate effects of personality traits.

Cross-sectional analyses elucidate short-term effects with the limitation that direction of effects cannot be ascertained, and simultaneity cannot be eliminated. For instance, the association between working at home and job demands may be bidirectional.

Concluding remarks

The present study shows contrasting effects of two aspects of working at home. The results suggest that conducting a moderate part of working hours at home is associated with higher levels of control, empowering leadership, and commitment, ie, aspects that are positive for well-being and health. Higher levels of demands, specific role expectations, and support from co-workers pose challenges. In contrast, expectations to be available to the employer in one's spare time seem to be associated with a series of potentially negative work factors and consequences for health, organizational commitment, and intentions to leave in the short term. The present study identifies specific effects of two aspects of working at home and should be helpful in advancing knowledge of specific factors that can be modified or prevented.

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The authors report no conflicts of interest.

Protection of research participants

Questionnaire responses were collected with a two-stage identity-code system to ensure that participants' responses were protected from access from other persons both during administration of questionnaires in organizations and during data storage and analysis. All participants allowed the use of the data for the present set of analyses.

Sidebar

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DETAILS

Subject:	Working conditions; Work environment; Leadership; Long-term effects; Telecommuting; Organizational aspects; Availability; Employers; Human resources; Influence; Dependent variables; COVID-19; Workers; Job satisfaction; Working hours; Perceptions; Social interaction; Sleep disorders; Employees; Pandemics; Empowerment; Neck pain; Coronaviruses
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Estimating population burdens of occupational disease

Anonymous

ABSTRACT (ENGLISH)

[...]asbestos makes development of lung cancer more likely, while coal mine dust causes chronic obstructive pulmonary disease (COPD) through incremental loss of lung function. Estimates of relative risk for paired combinations of occupational risk factor and disease were collated with data on the population prevalence of exposure to calculate population attributable fractions (PAF) (3), which then were multiplied by estimates of the total population impact of the disease (in terms of deaths and disability-adjusted life-years) to derive burdens attributable to occupation (2). The burden of back and neck pain was assessed in relation to "occupational exposure to ergonomic factors" (2), defined as "proportion of the population who are exposed to ergonomic risk factors for low back pain at work or through their occupation" (3). [...]the uncertainty in thousands of deaths globally in 2017 from occupational exposure to formaldehyde is reported as 1 to 1, and that for lung cancer from occupational exposure to diesel exhaust as 16 to 20 (3).

FULL TEXT

Knowing the public health impact of occupational hazards is important for prioritization of preventive and mitigating measures and in monitoring how well they succeed. Information is needed on attributable morbidity and mortality, both globally and by national/regional jurisdiction. The best method of estimating population burdens will vary according to the nature of the hazard.

One important consideration is whether health effects can be ascribed to work with confidence in the individual. Such attribution is straightforward where a disease occurs only as a consequence of occupational exposure (eg, coal workers' pneumoconiosis, byssinosis). Alternatively, a link to occupation can sometimes be established through clinical investigation. For example, allergic contact dermatitis may confidently be attributed to work where it is associated with demonstrable sensitization to an agent encountered only in the workplace; and the role of work in an acute injury or poisoning may be clear from its circumstances and timing. Even where a disorder is not occupational in origin, it may be made worse by exposures in the workplace to an extent that can be determined in the individual case. For example, exacerbation of pre-existing asthma by occupational inhalation of irritants may be apparent from serial measurements of lung function when an employee is at, and away from, work.

In such circumstances, public health burden can be estimated by aggregating data on individual cases, either across the population as a whole, or in a representative subsample. Possible sources of information include routine surveillance schemes such as the Health and Occupation Research (THOR) Network (1), data on claims for industrial injuries compensation (provided they are sufficiently accurate and complete), and ad hoc surveys in representative samples of the population. Where a disease has material fatality (eg, silicosis), counts of deaths may provide a good measure of attributable mortality.

More commonly, occupational disorders are not specific to work, and there is no reliable way of determining occupational contribution in the individual case. The hazard may increase the probability and/or the average severity of a disease. For example, asbestos makes development of lung cancer more likely, while coal mine dust causes chronic obstructive pulmonary disease (COPD) through incremental loss of lung function. Either way, the need is to determine how much morbidity or mortality would be eliminated across the population, if the relevant occupational exposure were removed. To this end, epidemiological data comparing health outcomes in people according to their exposure must be combined with information on the prevalence and distribution of exposure in the population for which an estimate is sought.

This is the approach underpinning the WHO/ILO analysis that is reported in Pega et al's paper (2). Estimates of relative risk for paired combinations of occupational risk factor and disease were collated with data on the population prevalence of exposure to calculate population attributable fractions (PAF) (3), which then were multiplied by estimates of the total population impact of the disease (in terms of deaths and disability-adjusted life-years) to derive burdens attributable to occupation (2).

The analysis was necessarily restricted to combinations of risk factor and disease for which there was judged to be adequate evidence, but it also has other important limitations, not all of which are acknowledged and discussed. Some of the assumed hazards are questionable. For example, occupational exposure to formaldehyde is estimated to account for some 350-400 deaths per year from leukemia. Although the International Agency for Research on Cancer has classified formaldehyde as a human carcinogen (4), that decision was controversial, and the systematic review and meta-analysis from which the relative risk was derived concluded that "on balance, these data do not provide consistent support for a relationship between formaldehyde exposure and leukemia risk" (5). Similarly, doubts have been cast on the assumed hazard of ischemic heart disease from long working hours, at least among people of higher socioeconomic status (6).

A second problem lies in the ambiguous specification of some risk factors. The analysis attributes large numbers of deaths from COPD to occupational exposure to "particulate matter, gases and fumes" (2). It is unclear, however, what exactly is implied by that term. The many and varied particulates, gases and fumes that people encounter through their work differ widely in their toxicity. If the mix of such pollutants differed between the studies that were used to estimate the prevalence of exposure, and those used to estimate relative risk, then major bias is possible. Even where risk factors are specified more precisely (eg, sulfuric acid), there are challenging complexities in the characterization and classification of exposure. Impacts at an individual level, whether on risk of disease or its severity, can vary enormously according to the timing, duration and intensity of exposures. An earlier report suggests that for many occupational carcinogens, exposures were classed to three levels (background/low/ high) (7). However, within such broad categories, there may be substantial heterogeneity of risk. In the WHO/ILO analysis, many of the risk estimates for occupational carcinogens come from industrial cohort studies, which have tended to focus on working populations known or expected to have relatively high intensity and duration of exposure (making any risks more readily detectable). In contrast, data on the prevalence of exposure derive from studies that aimed to ascertain the full extent of exposure in the population, even if only at a modest level. Within a broad exposure category, a meta-estimate of risk from published cohort studies may not be applicable to the distribution of exposures within that category in the general population, and such incompatibility could in some cases cause population burden to be seriously overestimated.

Another challenge when extrapolating risk estimates from samples to populations is the potential for effect modification. The burden of back and neck pain was assessed in relation to "occupational exposure to ergonomic factors" (2), defined as "proportion of the population who are exposed to ergonomic risk factors for low back pain at work or through their occupation" (3). However, it is unclear how well the calculation allowed for major variation between countries in the individual risk of musculoskeletal pain and disability from specified occupational activities (8, 9).

One way round these problems is to estimate population burden more directly, using the same study to provide information both on the distribution of exposure in the population and the effects of that exposure. For example, a national analysis of mortality by occupation has been used to estimate excess deaths from COPD among coal miners in England and Wales (10). While such analyses have other important limitations (for example, mortality as recorded on death certificates is an imperfect marker for disease, and full account cannot be taken of changes in occupation over a lifetime), the risk estimates that they generate are an average for exposure as it occurs in the population as a whole. In this respect, provided the ascertainment of exposure is reasonably sensitive (specificity is less critical), estimates of population burden will be less prone to bias.

Given the many sources of uncertainty in the WHO/ILO analysis, only some of which have been highlighted here, it is surprising that such tight 95% uncertainty ranges are reported. For example, the uncertainty in thousands of deaths globally in 2017 from occupational exposure to formaldehyde is reported as 1 to 1, and that for lung cancer from occupational exposure to diesel exhaust as 16 to 20 (3). This is a concern because findings published under the auspices of authoritative international bodies such as WHO and ILO are liable to be accepted by many without question.

As occupational health researchers and practitioners, we are naturally disposed to champion the importance of health protection in the workplace, but that enthusiasm should not compromise scientific rigor. Findings that appear to support our case must be scrutinized with the same care as those that call it into question. When estimating population burdens of disease from occupational hazards, we should aim if possible to triangulate between different analytical approaches and sources of data, carefully considering and acknowledging sources of uncertainty. The potential for error will often be greatest for exposures that are relatively prevalent in the working population (eg, long working hours), for which small differences in excess relative risk can translate into substantial differences in estimated burdens of disease at population level.

Sidebar

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DETAILS

Subject:	Obstructive lung disease; Asbestos; Population; Leukemia; Epidemiology; Estimates; Mortality; Lung cancer; Risk factors; Population statistics; Low back pain; Occupational diseases; Chronic obstructive pulmonary disease; Pain; Exposure; Risk analysis; Occupational hazards; Occupations; Fatalities; Working hours; Respiratory function; Lung diseases; Occupational health; Public health; Diesel engines; Coal mines; Health risks; Occupational exposure; Health surveillance
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How does accelerometry-measured arm elevation at work influence prospective risk of long-term sickness absence?

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ABSTRACT (ENGLISH)

Objective Elevated arm work is prevalent in many jobs. Feasible device-based methods are available to measure elevated arm work. However, we lack knowledge on the association between device-measured elevated arm work and prospective risk of long-term sickness absence (LTSA). We aimed to investigate this association. Methods At baseline, 937 workers wore accelerometers on the right arm and thigh over 1-5 workdays to measure work time spent with elevated arms in an upright position. Between baseline and 4-year prospective follow-up in the national registers, we obtained information on the individuals' first event of LTSA (>6 consecutive weeks). We performed compositional Cox proportional hazard analyses to model the association between work time with arm elevation >30°, >60°, or >90° and the probability of LTSA. Results Workers spent 21% of their work time with >30° arm elevation, 4% with >60° arm elevation, and 1% with >90° arm elevation; in the upright body position. We found a positive dose-response association between work time spent with elevated arm work and the risk of LTSA. Specifically, we found that increasing two minutes of work time spent with arm elevation at (i) >90° increased the risk of LTSA by 14% [hazard ratio (HR) 1.14, 95% confidence intervals (95% CI 1.04-1.25)] (ii) >60° increased the LTSA risk by 3% (HR 1.03, 95% CI 1.03-1.06), and (iii) >30° increased the LTSA risk by 1% (HR 1.01, 95% CI 1.00-1.02). Conclusion Device-measured elevated arm work is associated with increased prospective LTSA. This information ought to be brought into preventive workplace practice by accessible and feasible device-based methods of elevated arm work.

FULL TEXT

Headnote

Objective Elevated arm work is prevalent in many jobs. Feasible device-based methods are available to measure elevated arm work. However, we lack knowledge on the association between device-measured elevated arm work and prospective risk of long-term sickness absence (LTSA). We aimed to investigate this association.

Methods At baseline, 937 workers wore accelerometers on the right arm and thigh over 1-5 workdays to measure work time spent with elevated arms in an upright position. Between baseline and 4-year prospective follow-up in the national registers, we obtained information on the individuals' first event of LTSA (>6 consecutive weeks). We performed compositional Cox proportional hazard analyses to model the association between work time with arm elevation >30°, >60°, or >90° and the probability of LTSA.

Results Workers spent 21% of their work time with >30° arm elevation, 4% with >60° arm elevation, and 1% with >90° arm elevation; in the upright body position. We found a positive dose-response association between work time spent with elevated arm work and the risk of LTSA. Specifically, we found that increasing two minutes of work time spent with arm elevation at (i) >90° increased the risk of LTSA by 14% [hazard ratio (HR) 1.14, 95% confidence intervals (95% CI 1.04-1.25)] (ii) >60° increased the LTSA risk by 3% (HR 1.03, 95% CI 1.03-1.06), and (iii) >30° increased the LTSA risk by 1% (HR 1.01, 95% CI 1.00-1.02).

Conclusion Device-measured elevated arm work is associated with increased prospective LTSA. This information ought to be brought into preventive workplace practice by accessible and feasible device-based methods of elevated arm work.

Key terms compositional data analysis; dose-response; elevated arm work; prevention.

Sickness absence puts a large burden on employees, workplaces, and our society. In Denmark alone, 16 million sick days were reported in 2019, with a societal cost of almost 6 billion DKK (1).

A considerable fraction of the long-term sickness absence (LTSA) is associated with high physical work demands (2, 3). Work with elevated arms is prevalent in many jobs (4, 5). Elevated arm work puts a biomechanical load and restricted blood supply to shoulder and arm tissues (6). Thus, elevated arm work can lead to excessive fatigue, musculoskeletal pain, and LTSA (7-9).

Elevated arm work above shoulder level (or >90°) is associated with a higher risk of musculoskeletal pain (8, 10) while few studies have investigated the association with sickness absence (3, 7, 11). Additionally, a number of laboratory studies have shown the influence of time spent on arm elevation of various degrees (30°, 60° or 90°) on muscle fatigue and pain (12, 13). However, we lack such knowledge from studies on the arm elevation of various degrees during normal daily work and risk of sickness absence. Moreover, most knowledge on this topic is based on self-reported work time spent with elevated arms. Because it is very difficult to remember and estimate the amount of work time spent with elevated arms over the day, such information using self-reports is shown to be imprecise and potentially biased (14, 15). One study used an expert-rated job-exposure matrix and found that jobs with high mechanical exposures at work (including arm elevation >90° for >45 minutes per workday) were associated with increased sickness absence risk (16). However, the job-exposure matrices provide very gross estimate of exposure measures (17). This is because it is based on subjective rating provided by expert and that all workers within one job group get one rating of exposure that can vary substantially within a job group. These limitations can obscure the true relation between elevated arm work and risk of LTSA. Another option for measuring elevated arm work is via workplace visual observations (18). However, workplace observations are both costly and shown to be of rather low reliability (19). Thus, better methods to measured elevated arm work are needed to understand its true relation with risk of LTSA.

Freely available, accessible, and feasible devicebased methods have recently been developed for accurate measurements of elevated arm work (20). However, because no study has investigated the association between device-measured elevated arm work and prospective register-based LTSA, we lack the required knowledge to interpret, evaluate and take workplace actions on preventing prevalent elevated arm work (21). This lack of knowledge hinders the use of feasible device-measured elevated arm work in workplace risk assessments and

prevention of LTSA due to prevalent elevated arm work.
Thus, the study aimed to investigate the association between device-measured elevated arm work and prospective register-based LTSA.

Methods

Study design, population, and data

This is a prospective study with 4-years of follow-up time (212 weeks). Specifically, the study used baseline measurements on device-measured, elevated-arm work that were collected from workers enrolled in the cohort between 2011 to 2013. From the date of baseline measurement of each worker, the worker was followed for 212 weeks (approximately four years) in the national Danish registers to obtain information on the first event of an eventual long-term sickness absence (LTSA). This meant that workers (i) had an equal time of follow-up, exactly 212 weeks and (ii) ended the four-year follow-up on different dates between 2015 to 2017.

Baseline data comes from the 'technically measured compositional Physical wOrk DEmands and Prospective register-based Sickness Absence study (PODESA) cohort' (2, 22). The PODESA cohort contains harmonized data from the NOMAD (23) and DPHACTO (24) cohorts. These two cohorts were easily harmonized due to similar procedures used to perform accelerometry for 1-5 working days and to collect additional information. Additionally, for participants in both of these cohorts, it was possible to access sickness absence data from national registers. More details on how we harmonized these cohorts and their background information are provided in our previously published protocol article (22).

The Ethics Committee for the Capital Region of Denmark approved the DPhacto and NOMAD cohorts (file number H-2-2012-011 and H-2-2011-047) (22). All eligible workers received written and oral information about (i) the practicalities of participation, (ii) potential risks of participating, and (iii) freedom of withdrawing from the project. Individuals gave a written consent to participate in the study and use their data for research studies. According to Danish law, questionnaire- and register-based studies do not need approval by ethical and scientific committees or informed consent (25).

With assistance from trade unions, we recruited a convenience sample of workers from 22 Danish workplaces in manufacturing, cleaning, transport, healthcare, garbage collection, construction, assembling, and mobile plant operations sectors in Denmark.

Accelerometry

The workers wore two ActiGraph accelerometers (GT3X+, Florida, USA); one on the right thigh and one on the right upper arm for 1-5 consecutive working days (26). During these measurement days, the workers were also asked to complete a short diary indicating the time of starting and ending work, and the time of going to and getting out of bed each day.

After the measurement period, the workers returned the accelerometers to the research team. The accelerometer data were downloaded using Actilife Software version 5.5 and further processed using the MATLAB program Acti4 (27, 28). Acti4 uses a posture- (including arm elevation) and movement-identification algorithm that has previously been shown to have high sensitivity and specificity (27, 29). Using Acti4, thigh-based accelerometer and the self-reported diary information, we determined work time spent in upright position (ie, time spent standing, walking, running and stair climbing) and non-upright position (ie, seated). Additionally, combining the data from thigh-based accelerometer with data from arm accelerometer, we determined work time spent with arm elevation at <30°, >30°, <60°, >60°, <90° and >90° in upright position (26).

Based on the information in the self-reported diary, data were classified as work periods with hours spent in the primary occupation.

For the analysis, data for each participant on all postures and movements and total measured work time were averaged across all valid measured work periods (average/day). A work period was considered valid if it consisted of four hours or 75% of the average measured work time across days for a worker. In the analyses, we included all workers with at least one valid work period.

Prospective register-based long-term sickness absence

The information on the first event of LTSA during the four years follow-up was retrieved from the Registerbased Evaluation of Marginalization (DREAM) (30) using the workers' unique civil registration number. The DREAM register contains information on granted subsidized sickness absence per week for each individual in Denmark. The sickness absence benefit is given by the state to the sick worker after 30 continuous days of sickness absence. LTSA event was defined as the first LTSA event that lasted for >6 consecutive weeks during the 4-year follow-up period from the last day of baseline measurements (31).

Potential confounders

The potential confounders were chosen a priori based on the previous studies on the association between arm elevation at work and musculoskeletal pain and sickness absence (7-9; and supplementary material www.sjweh.fi/article/4000: Directed Acyclic Graph in Appendix G to justify the inclusion of selected confounders in the study). Information on the chosen confounders was collected at baseline via a questionnaire, a health check, or via the DREAM register. Age of the workers was determined using their unique civil registration number. Sex of the workers was determined using a single item 'are you male or female?' Body mass index (BMI) of the workers was determined using objective measurements of weight (kg) and height (cm). Work time spent with lifting and carrying was determined using a single item with six responses ranging from 'almost all the time' to 'never' (32). Information on 'type of work' was determined using a single item 'are you a worker engaged in administrative work tasks (white-collar) or production (blue-collar)? Information on the event of LTSA within 12 months before baseline was determined using DREAM register. Information on the influence at work was determined using two items from the Copenhagen Psychosocial Questionnaire (33). The responses were summarized and translated into a scale of 0-100% where 0 meant no influence at work.

Statistical analysis

All analyses were performed using a compositional data analysis (CoDA) approach. For a more detailed description of the implementation of CoDA in occupational research, please read reference (34). Our exposure was work time spent with arm elevation which is compositional data because of two properties: (i) if work time spent with arm elevation is increased or decreased, it will modify work time spent on at least one other exposure and (ii) data on work time spent with elevated arm are constrained in nature as it can only range between 0-100% work time. Traditional statistical methods are not suitable to handle compositional data. Instead, we are recommended to use CoDA-based methods. In CoDA, the first step is to transform the data from the constrained data space (ie, compositional data space) to a space where data can range freely between -æ to +(». The most popular transformation method has been the isometric log-ratios (ilrs) that results in D-1 logratios where D is number of parts within a composition. Thereafter, any standard statistical methods can be used to analyze the transformed data. However, the interpretation of the resulting estimates based on the transformed data can be difficult. Thus, the analyses are usually coupled with predictions methods helping to interpret the resulting estimates.

We performed three sets of CoDA-based analyses on exposures of interest of the study: three compositions of work time (figure 1). Each composition contained three parts: (i) "Composition A": arm elevation >30° in upright body position, arm elevation <30° in upright body position, and total non-upright body position or seated position (figure 1A); (ii) "Composition B": Arm elevation >60° in upright body position, arm elevation <60° in upright body position, and total non-upright body position (figure 1B), and (iii) "Composition C": Arm elevation >90° in upright body position, arm elevation <90° in upright body position, and total non-upright body position (figure 1C).

In all compositions, we focused on arm elevation during upright position only and not during non-upright position. Although we did not have contextual information on when arms were supported at work, we believe the arms are more supported in non-upright position (seated position) compared to upright position. When arms are supported, the elevated arm work does not increase the load or strain on the shoulders (5, 26), thus elevated arm work with arm support does not pose a health risk to the workers. Please refer to sensitivity analysis 1 if considering the arm elevation while in only upright position as in the main analyses instead of considering the arm elevation during both upright and non-upright position could give different results.

Main analyses

The main CoDA analyses consisted of three steps.

Step 1. We transformed each work time composition to ilrs [see (35) to understand how ilrs are calculated]. For each composition, this transformation resulted in two ilrs (ilrj and ilr2). Ihy indicates the ratio of time spent with arm elevation of a higher degree in upright position relative to time spent with arm elevation of a lower degree in upright position and total time spent in a non-upright position. Ilr2 indicates the ratio of time spent with arm elevation of a lower degree in upright position and total time spent in non-upright position. The equations for calculating these ilrs are given in the Appendix A.

Step 2. We performed three separate Cox proportional hazards regression analyses (respectively for each composition), modeling both ilrs (as continuous variables) against the first event of LTSA. The models were first adjusted for age and sex only (crude model). In the fully adjusted models, we also adjusted for BMI, work time spent with lifting/carrying, and type of work (blue- or white-collar). The resulting estimates from for the Cox models (both crude and fully-adjusted) on each composition are given in supplementary appendix B.

In the Cox models, each worker contributed with risk time until the first event of LTSA occurred or until the end of a 4-year follow-up in case of no event. A total of 45 workers were censored - ie, dropped out during the 4-year follow-up due to one of the following reasons: emigrated, died, entered early retirement, entered ordinary retirement, or became pregnant (ie, going on maternity leave 8 months following baseline). These censored workers contributed to the risk time in the analyses until the week of dropping out.

The assumption of the proportional hazards was tested via visual inspection and via the GrambschTherneau test (36). The statistical significance of the association between work time compositions and LTSA risk was assessed using the Type-II likelihood-ratio tests. The results were considered significant at $P<0.05$.

Step 3. To interpret the resulting ilr-based estimates (reported in supplementary appendix B) obtained from each Cox analysis, we implemented a previously used analysis (32, 37) that is described in supplementary appendix A with one detailed example. First, the reference was determined that is the "average composition" A, B, or C as shown in figure 1. Second, from this reference composition, new theoretical compositions of work time were determined by reallocating a fixed amount of time from one part to another part, so that the total average composition time is kept constant. We performed these reallocations with increments of ±2 minutes from the average composition, resulting into nine new theoretical compositions that we transformed into ilrs. Third, using the Cox-estimates from step 2, we predicted hazard ratios (HR) and their 95% confidence intervals (CI) indicating the predicted difference in LTSA risk corresponding to the difference in new theoretical composition and the "reference composition". The formula for calculating these predicted HR and their 95% CI are given in supplementary appendix A. Finally, we plotted these predicted HR and their 95% CI against corresponding reallocations (±2 minutes) as shown in figure 2.

We chose such small reallocations of ±2 minutes because we wanted to compare the results of all three compositions A, B and C (figure 1), which required the increments to be of similar duration for all three compositions. We chose ±2 minutes reallocations because of a small average (3 minutes) and a narrow range (5-95th percentile: 0.5-13 minutes) for time spent with arm elevation >90° (composition C). This also meant that we performed the reallocations that produced theoretical compositions covering a wide range of composition C but only a 'partial' range for composition A and B.

We repeated step 3 on a new set of theoretical com- positions (called second-set compositions shown in supplementary appendix C). For these second-set compositions, instead of the average composition, the reference composition contained the minimum exposure to arm elevation of higher degrees in each composition. The reallocation increments were large enough to cover the whole range (5-95th percentile) of work time spent with arm elevation of higher degrees. The range of these reallocations was for Composition A: 24-169 minutes, Composition B: 3-46 minutes and Composition C: 0.5-13 minutes. The predicted HR indicated how the risk of LTSA developed over the whole range of work time spent with arm elevation. We plotted the predicted HR against the measured 5-95th percentile range (in minutes) of arm elevation of higher degrees for each composition as shown in supplementary appendix E.

Sensitivity analyses

To test the sensitivity of the results obtained from the main analyses, we also performed three sensitivity analyses: (i) For the primary analyses, we split the arm elevation information in upright position but not during the non-upright position. However, we wanted to see if the findings remained robust when not splitting the arm elevation time in upright and non-upright body position. Thus, we investigated the association between the arm elevation during the whole work time - not differentiating between upright and non-upright position - and risk of LTSA; (ii) Due to technical errors, we did not obtain answers from 204 workers for the questions on influence at work. Thus, the main analyses were performed without and with additional adjustment for influence at work on the remaining 733 workers; (iii) We also performed a separate analysis where we excluded the workers who had pre-events of LTSA, ie, events within 12 months before baseline (N=57).

All analyses were performed in the R software [version (3.5.1)] using the software packages 'robCompositions' (38) and 'survival' (39).

Results

Participants flow and descriptive

Of the invited 2498 eligible workers, in the main analyses, we included 937 workers with valid data on at least one working period (measured work time/day = 457 minutes) and with information on potential first event of LTSA from the national register. More details on the flow of the participants are given in supplementary appendix D.

These 937 workers were on average 45 years old and had a BMI of 27 kg/m2. Additionally, 44% of them were women, and 93% of them were engaged in blue-collar occupations (table 1). In total, 201 workers (21%) had their first event of LTSA at on average (median) 76th week within the 4-year (ie, 212 weeks) follow-up time.

Of the measured work time/day of 457 minutes, 155 minutes were spent in non-upright body position (sitting or lying) and remaining 302 minutes in the upright body position. Of the working time spent in the upright body position, workers spent; 94 minutes with >30° and remaining 208 minutes with arm elevation <30° (composition A); 17 minutes with >60° and remaining 285 min with arm elevation <60° (composition B); and 3 minutes with >90° and remaining 299 minutes with arm elevation <90° (composition C), respectively (table 2). Comparing workers with (N=201) and without (N=736) LTSA event, no major differences in descriptive characteristics were found, except that the group of workers with LTSA event had relatively more women, had slightly less influence at work and had more preevents of LTSA (ie, LTSA event during 12 months before baseline) (see table 1).

Main analysis

Results of the compositional Cox proportional hazard models indicated that, based on the fully-adjusted models, there was a significant respective association between work time spent on composition A (P=0.04), composition B (P=0.05), and composition C (P=0.001) and risk of LTSA (composition A, B, and C shown in figure 1). Results were similar when models were adjusted for only age and sex and when further adjusting for age, sex, BMI, work time spent with lifting/carrying, and type of work (results shown in supplementary appendix B).

Results on the first-set compositions

In composition A, reallocating two more minutes to arm elevation >30° from arm elevation <30°, keeping the remaining work time, ie, non-upright, constant, was associated with 1 % (HR 1.01, 95% CI 1.00-1.02) higher risk of LTSA. In composition B, reallocating two more minutes to arm elevation >60° from <60° was associated with 3% (HR 1.03, 95% CI 1.01-1.06) higher LTSA risk. In composition C, two more minutes to arm elevation >90°from <90° was associated with 14% (>90° HR 1.14, 95% CI 1.04-1.25) higher LTSA risk (figure 2).

Results on the second-set compositions

In a separate analysis on the second set of work time compositions (supplementary appendix C), we determined how the LTSA risk develops over the entire range of elevated arm work at various degrees. We found that compared to null exposure, increasing 124 minutes time spent with arm elevation >30° (thus reducing 124 minutes from <30° and keeping 155 minutes with non-upright position constant) was associated with a two-fold higher risk of LTSA (supplementary appendices C and E). Such twofold risk of LTSA were observed at increasing 37 minutes of work time with arm elevation >60° and increasing only 8 minutes of work time with arm elevation >90°.

Sensitivity analyses

We performed three sensitivity analyses to test the robustness of the main results as shown in supplementary appendix F. Overall, we found that the results of the main analyses and these sensitivity analyses were similar.

Discussion

We investigated the association between device-measured elevated arm work and prospective register-based LTSA risk. We found a clear positive dose-response association between work time spent with arm elevation and LTSA risk. Specifically, we found that this dose-response association was steeper at higher degrees of arm elevation.

To the best of our knowledge, this is the first study investigating the association between device-measured work time spent with arm elevation and LTSA risk. The results of a positive association between arm elevation at work and LTSA risk are in line with previous studies using self-reports or job exposure matrix to determine elevated arm work (7, 16, 40). However, the levels of work time spent with arm elevation in these previous studies were very high. For example, in a national survey in Denmark, 20% of the workers reported that on average they spent >25% of the work time with arm elevation >90° (4). However, in our study, none of the workers were exposed to such high levels of work time spent with arm elevation >90°. Thus, the findings of these previous studies based on self-reports- or job exposure matrix-based arm elevation are not comparable to our study. The previous studies using device-measured elevated arm work did not investigate the association with sickness absence risk (8, 41). Thus, there is a need for more studies on device-measured elevated arm work and prospective LTSA risk to test the validity and generalizability of our findings.

We also found that the positive dose-response association between time spent with elevated arm work and risk of LTSA was steeper at higher degrees of arm elevation (figure 1). This meant that increasing similar amount of work time of arm elevation, the LTSA risk was much higher at higher degrees of arm elevation than lower degrees of arm elevation. However, please note that workers generally spent higher work time with lower degrees arm elevation (eg, on average, 94 minutes with arm elevation >30°) than higher degrees arm elevation (eg, on average 17 minutes with arm elevation >60° and 3 minutes with arm elevation >90°; table 2). Thus, workers had to spend higher time with arm elevation of lower degrees to observe similar LTSA risk compared to time spent with arm elevation of higher degrees. These results are in line with the experimental studies that have shown that with increasing arm elevation degree, the intra-muscular pressure in the infra- and supraspinatus muscles increases (12). This accentuates hypovascularity and blood flow impairment in these muscles resulting into reduced recovery, higher fatigue and in the long-run musculoskeletal pain and sickness absence (13). However, due to lack of similar epidemiological studies, we could not compare our results with previous research. Thus, we require similar epidemiological studies using device-based measurements of elevated arm work to facilitate confirmation of our results.

The practical implication of the results

First, we believe that our study is the first to provide knowledge to practitioners, workplaces, and policymakers on precise, device-measured, elevated arm work and LTSA risks. This is because the exposure levels of elevated arm work from self-reported studies have been much higher, and unreliable in comparison to the actual workplace exposures to elevated arm work. Thus, the results of this study provide precise knowledge on an association between elevated arm work and LTSA risk.

Second, the observed effect sizes in our study were significant and of practical relevance. Two minutes of reallocation between arm elevation <30° and >30° was associated with 1% change in LTSA risk (figure 2). This effect size seems small because it corresponds to only 2% difference from the average exposure of arm elevation >30° (ie, 2 minutes reallocation is 2% of the average 94 minutes time spent on arm elevation >30°). If we choose a higher reallocation of time spent on arm elevation >30°, the effect sizes will look much larger as shown in appendices E and H. For example, appendix H shows that reallocating 20 minutes (being about 20% of the total work time spent on arm elevation>30°) between arm elevation <30° and >30° is associated with 11% change in LTSA risk. Thus, if it is feasible to change >20 minutes exposure of arm elevation >30° at work, the observed effect would indeed be of practical relevance for the prevention of LTSA.

Third, feasible and accessible device-based methods to measure elevated arm work are already developed and available for researchers and practitioners where this precise knowledge can be integrated (42). One example of such method is ErgoArmMeter (42) which uses an app on a phone attached on the arm to measure accurate time spent with the arm in various degrees of elevation. Direct postural feedback via smartphone apps and socalled smart textiles have also been positively tested, in short-term interventions (43). Very recently researchers have proposed thresholds for when upper arm work becomes a risk for musculoskeletal pain (44). However, these thresholds are not based on evidence from prospective studies and we still lack knowledge on the precise dose of work time spent with elevated arm work and the risk of LTSA. Currently, the available feasible and accessible methods cannot provide such knowledge to researchers and practitioners. Our results can provide relevant knowledge as to when specific minutes of exposure to elevated arm work increases LTSA risk. For instance, our results indicate that when exposure to arm elevation >60° increases from null to almost ten minutes, the risk of LTSA increases by approximately 50% (Appendix E). The integration of such knowledge into the feasible and accessible device-based method may help workplaces to determine the existing exposure to elevated arm work of various degrees and determine the current risk of LTSA due to time spent on elevated arm work among workers. Such accurate risk assessment may help workplaces to design realistic, data-driven, and evidence-based interventions to prevent harmful elevated arm work. Thus, the knowledge from the study will help to establish an accurate and easy risk assessment for better workplace prevention.

Strengths, limitations, and methodological considerations

One limitation of the study is that only 37% of the total sample was included in the main analyses. This is because not all workers were offered to participate in arm accelerometry. Previous studies on these data have also shown no relevant differences in their demographics (eg, age, gender distribution) between participants and non-participants (24). Another limitation is a lack of information on the "load" (eg, if the arms were supported and if the workers were lifting any weight) while elevating arms, which limited us to elaborate on our findings. Another limitation is lack of contextual information on work tasks including elevated arm work. Future studies should strive to collect such supplementary information on load and contextual factors. Another limitation is that we lack cause-specific information on LTSA. As shown in table 1, the workers with LTSA had a higher prevalence of musculoskeletal pain compared to those without LTSA events. Thus, there is a high probability that the observed detrimental association between elevated arm work and LTSA may be related to LTSA specific to musculoskeletal pain. Cause-specific information on LTSA might have indicated if the observed LTSA risk was mainly due to musculoskeletal pain or due to some other diseases. On the other hand, because of the high co-morbidity between musculoskeletal disorders and other causes of LTSA, such as depression and anxiety (45), the validity of musculoskeletal painspecific LTSA can be questioned. Thus, the absence of cause-specific LTSA may not be considered a major limitation of our study. Another limitation is the availability of information on only a few job groups that limit the generalizability of our results to other job groups. The limitation of the study is also the potential presence of residual confounding that can always occur in observational non-randomized studies.

One strength of the study is the device-measured information work time spent with arm elevation of various degrees. Another strength is the usage of CoDA that is a recommended analytic method to handle compositional data like work time spent with arm elevation as in our study. Yet another strength is the prospective register-based LTSA.

In our main analyses, we chose to investigate the LTSA risk associated with arm elevation during upright position only, and not during non-upright position. To investigate this further, we performed a separate analysis investigating the association between arm elevation during the entire work time and LTSA. We observed similar trends as in the main results (Appendix F), but as expected, the associations between elevated arm work of various degrees during the entire work time and LTSA were weaker. For the results based on two minutes reallocations, the CI of the resulting HR look narrow. Had it been that the corresponding reallocation was larger (say 20 minutes reallocations), the 95% CI of the HR would have been wider. The reason for this is that the farther you move from the average value of a distribution (2 minutes reallocation to 20 minutes reallocation), the less confident we are about the estimated effect, thus producing wider CI (seen in appendix H).

Concluding remarks

For the first time, a dose-response association between precise device-based measurements of elevated arm work and prospective risk of LTSA risk was observed. The dose-response association between elevated arm work and LTSA was steeper at higher degrees of arm elevation. Such knowledge can be brought into preventive workplace practice by accessible and feasible device-based methods of measuring elevated arm work.

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Sidebar

Gupta N, Lund Rasmussen CL, Forsman M, Søgaard K, Holtermann A. How does accelerometry-measured arm elevation at work influence prospective risk of long-term sickness absence? Scand J Work Environ Health. 2022;48(2):137-147. doi:10.5271/sjweh.4000

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Professional cleaning and risk of asthma - a Danish nationwide register-based study

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ABSTRACT (ENGLISH)

Conclusions Asthma risk was increased in the inception cohort for cumulative years of cleaning but decreased in the full cohort. We could not confirm that recent work within cleaning was associated with increased risk of asthma. This may be due to healthy worker bias. Thus, we cannot rule out that long-term professional cleaning may be associated with increased risk of asthma.

ABSTRACT (ENGLISH)

Objective This study aimed to investigate the risk of asthma among professional cleaners in a nationwide population-based study. Methods Professional cleaners, aged 16-50 years, were identified according to the yearly assigned administrative job and industrial codes in a register-based, matched cohort study with other manual workers as references (1995-2016). Asthma was defined from national registers based on hospitalization and medication. Associations between recent and cumulative cleaning years and risk of asthma were estimated using Poisson regression, first in a full cohort and then in an inception cohort, among workers aged 16-20 years at the start of follow-up. Results The risk of asthma was not increased for recent cleaning compared to references [adjusted incidence rate ratio (IRRadj) 1.02 [95% confidence interval (CI) 0.99-1.04]. Similar results were seen for the inception cohort, where cumulative years of cleaning were associated with increased risk of asthma, more prominent for the group with the maximum of six years of cleaning IRR^ 2.53 (95% CI 1.38-4.64). Cumulative years of cleaning were associated with decreased risk of asthma, more pronounced for the maximum of ten compared to one year of cleaning [IRRadj 0.74 (95% CI 0.63-0.88)].

FULL TEXT

Headnote

Objective This study aimed to investigate the risk of asthma among professional cleaners in a nationwide population-based study.

Methods Professional cleaners, aged 16-50 years, were identified according to the yearly assigned administrative job and industrial codes in a register-based, matched cohort study with other manual workers as references (1995-2016). Asthma was defined from national registers based on hospitalization and medication. Associations between recent and cumulative cleaning years and risk of asthma were estimated using Poisson regression, first in a full cohort and then in an inception cohort, among workers aged 16-20 years at the start of follow-up.

Results The risk of asthma was not increased for recent cleaning compared to references [adjusted incidence rate ratio (IRRadj) 1.02 [95% confidence interval (CI) 0.99-1.04]. Similar results were seen for the inception cohort, where cumulative years of cleaning were associated with increased risk of asthma, more prominent for the group with the maximum of six years of cleaning IRR^ 2.53 (95% CI 1.38-4.64). Cumulative years of cleaning were associated with decreased risk of asthma, more pronounced for the maximum of ten compared to one year of cleaning [IRRadj 0.74 (95% CI 0.63-0.88)].

Conclusions Asthma risk was increased in the inception cohort for cumulative years of cleaning but decreased in the full cohort. We could not confirm that recent work within cleaning was associated with increased risk of asthma. This may be due to healthy worker bias. Thus, we cannot rule out that long-term professional cleaning may be associated with increased risk of asthma.

Key terms cleaner; cumulative exposure; Denmark; epidemiology; new-onset asthma; occupational asthma; occupational exposure.

More than 20 years ago, cleaning work was identified as a risk factor for prevalent asthma in a large population-based study (1) and some years later also for incident asthma in the same cohort (2). Within the last decades, several other studies have contributed evidence on the association between cleaning and the risk of asthma (3-9). The reviews mainly include cross-sectional studies on professional and household cleaning and the use of cleaning products from different sources and include human observational studies, exposure studies, and experimental mechanistic studies (3-7).

Being a professional cleaner has been associated with work-related asthma, especially chronic irritant induced asthma (10) and exacerbation of asthma (5). Specifically, agents like bleach (hypochlorite), ammonia, disinfectants, and mixing of products (eg, hypochlorite and hydrochloric acid) may cause asthma or worsen an existing asthma (5, 10). For professional cleaners, the risk for asthma, asthma symptoms, and impaired respiration seems to be dose-dependently associated to the use of cleaning spray and duration of cleaning (11-13). The increased risk of asthma is seen both for professional cleaners at workplaces and in private homes (3).

Ghost and colleagues (14) showed that adult onset asthma was associated with ever working in one of 18 occupations, among others cleaning jobs and jobs where exposure to cleaning agents are likely. In Denmark, only one population-based study has investigated asthma among professional cleaners. It showed that female cleaners had an increased risk of current asthma compared to women in administrative jobs [prevalence ratio 2.17 (95% confidence interval (CI) 1.47-3.21)] compared to administrators (15).

In the present study, we investigated for the first time whether professional cleaning was associated with the risk of asthma in a nationwide register-based, matched cohort study. We hypothesized that professional cleaners would have a higher risk of developing asthma compared to other manual workers and that the risk would increase with years of working in cleaning.

Methods

Study population

The study was conducted in the Danish Occupational Cohort, DOC·X, a national register-based workforce database (16). The database combines a number of health and administrative registers for all individuals in Denmark, who have been active at the Danish Labour market between 1976 and 2015 for at least one year (17). On a yearly basis, individuals are categorized according to the job held for the longest time period of that year. We included individuals aged 16-50 years who worked at least one year with professional cleaning activities (hereafter called cleaners) starting 1 January 1998, until 31 December 2015. For each included cleaner, we selected three workers in other manual or low skilled jobs as references (figure 1).

Outcome

We retrieved information on asthma from two nationwide registers and categorized asthma according to the definitions given by Liu and colleagues (18): (i) The Danish National Patient Register (1994-2018) provides information on inpatient, outpatient, and emergency visits. An individual was considered diagnosed with asthma by having a hospital contact with International Classification of Diseases 10 (ICD-10) codes J45 (Asthma) or J46 (Status asthmaticus); (ii) From the Danish National Prescription Registry (1997-2018), we included information about asthma medication. An individual was considered diagnosed with asthma if the person redeemed a prescription at least twice within 12 months. The following medication codes of the Anatomical Therapeutic Chemical Classification System (ATC) were included: ß2-agonists (R03AC02-04, R03AC12, and R03AC13), corticosteroids/inhaled glucocorticoids (R03BA01, R03BA02, and R03BA05), combination-products/fixed-dose combination of inhaled ß2-agonists and glucocorticoids (R03AK06 and R03AK07), leukotriene receptor antagonists (R03DC03), and anti-IgE treatment (R03DX05).

Asthma was defined as at least one hospital contact due to asthma within the last 12 months and/or redemption of a prescription of one of the asthma medications at least twice within the past 12 months. The information from both registers was used to form a dichotomous outcome for asthma (yes/no).

Exposure to cleaning

Cleaners were identified from their individual job titles based on the Danish International Standard Classification of Occupation (DISCO-88) or the Danish Industrial Classification of All Economic Activities 2007 [Dansk Branchekode (Danish Industrial Code) 2007 (DB07)].

We utilized the following four-digit DISCO-88 codes to define cleaners: 9131 (domestic helpers and cleaners) and 9142 (vehicle, window, and related cleaners). Individuals working in the mixed group 9132 (helpers and cleaners in offices, hotels and other establishments) were only included if they were also registered under the DB07 codes 8121 (general cleaning of buildings) or 8129 (other cleaning activities), to increase specificity. Finally, we included individuals that lacked a DISCO-88 code but had the industrial code 8121 (general cleaning of buildings) in order to include individuals working in companies with <10 employees for which reporting of DISCO-88 code is not mandatory in Denmark.

Exposure to cleaning was assessed in two ways (figure 2). Recent cleaning was assessed annually from 1998 to 2015. Participants were excluded if they had asthma or were diagnosed with chronic obstructive pulmonary disease (COPD) in any of the two years prior to or in the calendar year of exposure to cleaning (figure 1). Cumulative exposure to cleaning was assessed in a cohort with start of follow-up in year 2007 by summarizing the years of cleaning during the preceding 10 years (1998-2007 to 2006-2015). The participants were excluded if they were diagnosed with asthma or COPD in the ten years preceding the start of follow-up.

References group

For recent exposure, each cleaner was annually matched on sex, age, and socio-economic position to three reference individuals. Matching on socio-economic position was conducted at the first-digit DISCO-88 code level and included the following job groups: five service workers and shop and market sales workers; seven craft and related trades workers; eight plant and machine operators and assemblers; and nine elementary occupations except the cleaners defined previously (figure 1). The references were solely included in the analyses investigating recent exposure (figure 2A). Due to the annual selection of references, each participant could contribute both with years as cleaner and years as reference, albeit not in the same year.

Covariables

Information on COPD was retrieved from the Danish National Patient Register based on the following ICD10 codes: J43, J43.0, J43.1, J43.2, J43.8, J43.9, J44, J44.0, J44.1, J44.8, or J44.9 (19). Highest obtained education level was obtained from the Education Register and grouped into five categories: primary school, upper secondary school, vocational training, bachelor's programme, and master's programme or higher. Furthermore, we included sex and age in the year of exposure (16-20, 21-30, 31-40, and 41-50 years).

Analyses

We excluded participants with incomplete information on age, sex, highest obtained educational level, and workers residing outside Denmark during the period of interest (figure 1).

In the analysis of recent exposure, all matched references to the excluded cleaners were also excluded. Additionally, references, who independently had plete were excluded on an individual basis, meaning that a cleaner could have less than three references (figure 1). Cleaners were compared to their references by estimating the incidence rate ratios (IRR) of asthma (with a 95% CI) the year after exposure using Poisson regression models (figure 2A). Individuals were followed until the date of asthma or censored at the date of emigration, diagnosis of COPD, death, or the end of follow-up on 31 December each year. The crude analysis was adjusted for the year of cleaning, and the adjusted analysis were further adjusted for the highest obtained educational level, sex and age. The follow-up

period was 1 January 1999 until 31 December 2016.
No external references were used in the analyses of cumulative cleaning; hence, all participants worked at least one year in cleaning (figure 1). Prior exposure to cleaning work was cumulated for the preceding ten years, starting in 2007. This procedure was repeated annually until 2015. Each year, the cohort was expanded with new individuals who had worked in cleaning for at least one year (figure 2B). The references consisted of individuals with one year of cleaning work. We used Poisson Regression models for estimating the IRR (95% CI) for asthma with start of follow-up on 1 January 2008. The individuals were followed until the date of asthma or censored at the date of emigration, diagnosis of COPD, death, or after ten years of follow-up, whichever came first. Follow-up was finalized on 31 December 2016. Crude and adjusted analyses were conducted as described for the analyses of recent exposure, including also the same co-variables.
Sensitivity and subgroup analyses
To deal with potential healthy worker bias by ensuring complete exposure history and outcome information for the study participants, we defined an inception cohort of 16-20-year-old participants who had their first cleaning employment between 1998 and 2015. The analyses were similar to the analyses described above, for recent and cumulative exposure to cleaning, respectively (figures 2A and 2B). However, for cumulative exposure, a maximum of six years of cleaning could be accumulated over the course of ten years for this young cohort (20).
To investigate the impact of cleaning work among individuals without previous professional cleaning activities, we repeated the analysis of recent exposure in the subgroup of workers without employment in cleaning during the ten years prior to entrance into the cohort (2007-2015). Cleaners were compared with their matched references, also without cleaning in the past ten years.
Results
In the analyses of recent exposure to cleaning, we included 360 479 cleaners and 1 218 692 references, contributing 1 014 893 and 2 777 052 person-years, respectively (table 1). The prevalence of asthma was similar (0.7%) for cleaner and reference years. About 2/3 were females. The oldest age group, 41-50 years, contributed the most person-years (33%), whereas the youngest age group (16-20 years) contributed the least (15%). Due to matching, the distribution of age was similar for cleaners and references. More than half of the cleaners had obtained primary education as their highest educational level, and 39% had obtained secondary education, whereas among the references 38% had obtained primary education, while more than half had a secondary education. The earlier years of the follow-up period contributed the most person-years ranging from 7.4% in 1998 to 3.4% in 2015.
The population of cleaners included in the analysis of cumulative cleaning contributed 984 766 person-years. The distribution of asthma and sex was similar to the recent exposure cohort, apart from a larger proportion of workers aged 21-30 years. Due to the design of the study, the study population gradually increased in size until 2015. Among cleaners in the cumulative exposure population, 34% had worked only one year in cleaning, whereas 3% had ten consecutive years of cleaning.
In the crude analyses, recent exposure to cleaning was associated with a slightly increased risk of asthma compared to the references. This attenuated in the adjusted analysis [adjusted IRR (IRRadj) 1.02 (95% CI 0.99-1.04), figure 3]. This was confirmed in the inception cohort [IRRadj 1.02 (95% CI 0.99-1.04), figure 4]. The risk of asthma was also similar in the subgroup with no cleaning in the past ten years, IRRadj 1.01 (95% CI 0.91-1.12; data not shown). This subgroup comprised 108 732 person-years among cleaners and 281 760 person-years among references.
The analysis of cumulative years of cleaning during the preceding ten years indicated an increased risk of asthma in the crude analysis with the highest risks for seven and nine years of cleaning, IRR 1.25 (95% CI 1.08-1.46) and IRR 1.25 (95% CI 1.06-1.46), respectively. However, in the adjusted analysis, the risk of asthma decreased with increasing number of years in cleaning, most pronounced for eight or ten years [IRRadj 0.78 (95% CI 0.65-0.94) and IRRadj 0.74 (95% CI 0.630.88), respectively, figure 3].
In the inception cohort, the results for cumulative exposure is only presented up to six years of work in cleaning due to small numbers of asthma events (N=270 115 person-years, asthma events=1104). Both unadjusted and adjusted analyses showed higher risks of asthma with increasing number of cleaning years. IRRadj for five and six years of

cleaning were 1.52 (95% CI 0.99-2.33) and 2.53 (95% CI 1.38-4.64), respectively (figure 4).

Discussion

The overall aim of the study was to investigate whether professional cleaning increases the risk of asthma. The risk of asthma was increased in a dose-dependent manner in the inception cohort, where the cleaners were 16-20 years of age at inclusion but not in the full cohort with many prevalent hires, where we observed a decreased asthma risk with increased cleaning years. This indicates that a healthy worker bias may occur among cleaning professionals. We could not confirm that recent professional cleaning, ie, cleaning within the previous year, was associated with an increased risk of asthma.

To account for the selection processes related to duration of exposure before inclusion in the present study, we used an inception cohort where we assume prior exposure would be negligible. The findings of higher risks of asthma with increasing number of cleaning years from the inception cohort are partly supported by previous findings conducted in populations of cleaners in general [summarized in Folletti et al (3)], based on two studies. The study by de Fatima Macaira et al (21) showed association between duration of exposure to cleaning and work-related asthma, while Obadia et al (22) did not confirm these results.

Most published epidemiological studies indicate an effect of cleaning activities and cleaning/disinfecting agents on prevalence or incidence of asthma (23). This was, however, not confirmed by our analyses of recent cleaning. Job title constitutes a crude measure of clean- ing without details on type or level of exposure to cleaning agents. We can therefore not conclude that recent cleaning is not related to incident asthma, but in light of our results, working in cleaning does not seem to have a large impact on incident asthma at the population level.

We interpret the inverse association between cumulative years with cleaning and asthma to be primarily an effect of healthy worker bias, which is a selection process. It can be described by (i) workers who are less fit for exposure during their employment are more likely to leave this work early and thereby accumulate less exposure; and (ii) a confounding effect, which relates to differences in health-related risk factors in workers with frequent job change and workers, who are established at the labor marked (19, 24, 25). This is supported by the findings in a follow-up study by Dumas and colleagues (26). They did not find associations in standard analyses of airborne exposure and asthma (including industrial cleaning agents) but observed clear indications of positive associations between exposure to allergens/irritants and asthma using a marginal structural model as a way to take the healthy workers bias into account.

In the review by Vincent et al (7), most studies reported increased risk of self-reported, physician-diagnosed asthma following work in cleaning. The present study also used physician-diagnosed asthma but based on either a physician's diagnosis upon hospital contact or redeemed prescriptions prescribed by a physician. The discrepancy between our finding on recent exposure and some previous findings could be due to differences in the information on exposure and outcome, as most previous studies relied on self-reported questionnaire data on exposure and outcome (26).

Furthermore, the composition of reference groups can be of significance to the results of our study. Asthma occurs more frequently among individuals with low socioeconomic position (27). According to a review by Jaakkola &Jaakkola (28) cleaners have increased risk of developing asthma compared to reference groups of administrative and professional employees. As socioeconomic position and related lifestyle factors are associated with the risk of developing asthma (12), it can be difficult to select an ideal comparison group in studies investigating occupational exposures in cleaners (27). We matched our cleaners to references with similar socio-economic position via job titles but still found the references to be somewhat higher educated (table 1). Our results showed that the highest obtained education was the most influencing factor on the results for of recent cleaning references (data not shown). On the other hand, job titles at a similar socio-economic position as cleaners might carry their own asthma inducing exposures (eg, unskilled work in the food and industry and construction), leading to underestimation of the true risk attributable to cleaning work.

One main reason for studying work in cleaning and onset of asthma is the inherent potential for cleaning agents to cause respiratory disorders (29). For example, Weinmann and colleagues (30) reported a three-fold higher odds of a doctor-diagnosed asthma for individuals aged 20-24 years exposed to disinfectants. Most of the epidemiological studies included in the review by Clausen and colleagues (9) indicated an increased risk of asthma due to use of cleaning agents in spray form both among professional and non-professional cleaners. Unfortunately, it is not possible to retrieve information on the type and use of cleaning agents in this cohort due to the register-based design of the study. Furthermore, very little is known on the asthma inducing potential of substances in spray cleaning products (31).

In the analysis of recent exposure in the full cohort, we did a post hoc analysis of individuals with asthma. The data showed that the risk of asthma increased over time. Furthermore, the data also showed that asthma events consisted of both new-onset and re-occurring asthma (data not shown). For earlier asthmatics to be included in our analyses, their prior asthma had to have occurred more than two years prior to the year of exposure to cleaning due to the exclusion criteria. The risk of re-occurring with asthma increased over time from 6% of the cohort in 1999 to 40% in 2014 (data not shown). However, the subgroup analyses of recent exposure in cleaners without asthma in the past ten years showed similar findings as for the original analyses indicating that inclusion of re-occurring asthma probably did not affect our results in a large degree.

In a post hoc analysis, we showed that 7964 cleaners (corresponding to 3.4% of the excluded cleaners; data not shown) were left out of the analysis due to onset of asthma within the year of exposure in cohort used in the analysis of recent exposure (full cohort). This could indicate that some cleaners will be at risk of early onset asthma within the year of exposure; however, the magnitude of this problem is not possible to estimate in our study, because of the register-based design. The total proportion of excluded cleaners left out of the analysis due to asthma two years prior to and in the year of exposure was 21.9%.

The marked change from excess risk to protective effect in the crude and adjusted analyses of cumulative cleaning, respectively, occur due to adjustment for age, whereas sex and education had no or small influence on the associations. As age and cumulated years of cleaning are somewhat correlated, the adjustment for age might over-adjust, and thus, attenuate excess risk. As we do not, however, find the same degree of change due to adjustment for age for the associations in the inception cohort, we anticipate over-adjustment to be a minor problem.

Strengths and limitations

Due to the nationwide, register-based design, it was possible to include a large population of cleaners over an extensive time period; hence, we included more than one million person-years of cleaning. The references were chosen based on similarity to the cleaners' socioeconomic position. Group 6 "skilled agricultural and fishery workers", the one-digit DISCO-88 code level, was, however, omitted from the references since these job groups carry an increased risk of asthma (32). All data was collected prospectively in nationwide registers and analyzed as such. Due to the register-based design, the information on exposure and outcome was collected independently of each other. Exposure status was, furthermore, assessed based on job titles supplied by the employer. This minimizes the risk of reporting bias for exposure, albeit at the expense of exposure accuracy. Our data enabled us to investigate both the recent and the long-term effects of cleaning.

Both full- or part-time work, sickness absence, and maternity leave may have influenced the findings, but this information was, unfortunately, not available. We only included individuals if their main occupation was cleaning, but - by disregarding part-time work and absence from work - we overestimated the exposure, and thereby potentially underestimated the association between cleaning exposure and asthma.

Work in cleaning is associated with a poorer health status due to competing risks (eg, musculoskeletal disorders) and low socioeconomic status. By using other manual workers as the reference group, we believe, we partly overcame the difference in competing risks between cleaners and references in the analyses of recent exposure. In the analyses on cumulated exposure, we compare cleaners to cleaners, and we do not believe differences in competing risks within the cleaning group is a substantial problem.

We did not have information on lifestyle factors, most importantly smoking, a recognized risk factor for asthma. We cannot rule out smoking confounded our results, and we cannot foresee the direction of a possible bias, despite our reference group is assumed to have similar smoking habits as the cleaners. In the DOC·X cohort, exposure matrices for six different lifestyle factors was developed, including smoking (33). These matrices provide information based on the DISCO-88 codes; hence, everyone working in cleaning will be assigned the same level of, eg, smoking, and the matrices were therefore not useful in the current analysis.

Asthma was based on information from two nationwide registers, on hospital diagnoses and redemption of prescriptions of asthma medication. Therefore, we investigated asthma in general and not asthma registered as work-related asthma. Work-related asthma implies per se a causal association between work and asthma, and would therefore not have been useful in the current analyses.

The analyses were conducted as complete case analysis, as cleaners and references without information on highest obtained educational level were excluded from the cohort. The cleaning profession primarily consists of unskilled workers, and furthermore, an unknown proportion of the cleaners are immigrants for whom we do not have information about their educational level. Thus, the lack of information on educational level might lead to an underestimation of asthma risk.

Concluding remarks

In conclusion, an increased asthma risk was found in the inception cohort for cumulative cleaning years but not in the full cohort with many prevalent hires, indicating that healthy worker bias was at play. In our study, recent work within cleaning was not associated with an increased risk of asthma compared to references of similar socio-economic status.

Even though the association between cleaning and asthma has previously been investigated in several studies, we could address under-investigated issues including age at exposure and the impact of cumulative years of exposure to cleaning. Future studies should make an effort to understand differences between newly hired and experienced cleaners. An important next step would be to combine the advantages of a prospective nationwide study with more detailed information about cleaning exposures, eg, specific agents or modes of application.

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The authors declare no conflicts of interest.

Sidebar

Sejbaek CS, Flachs EM, Carøe TK, Meyer HW, Frederiksen M, Frydendall KB, Wolkoff P, Clausen PA, Haugaard KS, Schlünssen V. Professional cleaning and risk of asthma - a Danish nationwide register-based study. Scand J Work Environ Health - online first. doi:10.5271/sjweh.3997

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DETAILS

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Global, regional and national burden of disease attributable to 19 selected occupational risk factors for 183 countries, 2000–2016: A systematic analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury

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ABSTRACT (ENGLISH)

Objectives We provide a brief introduction to the objectives, data, methods and results of the World Health Organization (WHO)/International Labor Organization (ILO) Joint Estimates of the Work-related Burden of Disease and Injury (WHO/ILO Joint Estimates), which estimated the burden attributable to 19 selected occupational risk factors. Methods The WHO/ILO Joint Estimates were produced within the global Comparative Risk Assessment framework, which attributes the burden of one specific health outcome (ie, disease/injury) to a specific occupational risk factor. For 39 established occupational risk factor-health outcome pairs, estimates are produced using population attributable fractions (PAF) from recent burden of disease estimates. For two additional pairs, PAF are calculated from new databases of exposure and risk ratios produced in WHO/ILO systematic reviews. Attributable disease burdens were estimated by applying the PAF to total disease burdens. Results Globally in 2016, it is estimated that 1.88 [95% uncertainty range (UR) 1.84-1.92] million deaths and 89.72 (95% UR 88.61-90.83) million disability-adjusted life years were attributable to the 19 selected occupational risk factors and their health outcomes. A disproportionately large work-related burden of disease is observed in the WHO African Region (for disability-adjusted life years), South-East Asia Region, and Western Pacific Region (for deaths), males and older age groups. Conclusions The WHO/ILO Joint Estimates can be used for global monitoring of exposure to occupational risk factors and work-related burden of disease and to identify, plan, cost, implement and evaluate policies, programs and actions to prevent exposure to occupational risk factors and their associated burden.

FULL TEXT

Headnote

Objectives We provide a brief introduction to the objectives, data, methods and results of the World Health Organization (WHO)/International Labor Organization (ILO) Joint Estimates of the Work-related Burden of Disease and Injury (WHO/ILO Joint Estimates), which estimated the burden attributable to 19 selected occupational risk factors.

Methods The WHO/ILO Joint Estimates were produced within the global Comparative Risk Assessment framework, which attributes the burden of one specific health outcome (ie, disease/injury) to a specific occupational risk factor. For 39 established occupational risk factor-health outcome pairs, estimates are produced using population attributable fractions (PAF) from recent burden of disease estimates. For two additional pairs, PAF are calculated from new databases of exposure and risk ratios produced in WHO/ILO systematic reviews. Attributable disease burdens were estimated by applying the PAF to total disease burdens.

Results Globally in 2016, it is estimated that 1.88 [95% uncertainty range (UR) 1.84-1.92] million deaths and 89.72 (95% UR 88.61-90.83) million disability-adjusted life years were attributable to the 19 selected occupational risk factors and their health outcomes. A disproportionately large work-related burden of disease is observed in the WHO African Region (for disability-adjusted life years), South-East Asia Region, and Western Pacific Region (for deaths), males and older age groups.

Conclusions The WHO/ILO Joint Estimates can be used for global monitoring of exposure to occupational risk factors and work-related burden of disease and to identify, plan, cost, implement and evaluate policies, programs and actions to prevent exposure to occupational risk factors and their associated burden.

Key terms occupational epidemiology; work-related disease; work-related injury; working hour.

Despite a long history of productive interagency collaboration, the World Health Organization (WHO) and the International Labor Organization (ILO) have, until recently, produced separate estimates on work-related burden of disease. Their different methodologies have yielded different results. The two United Nations (UN) specialized agencies have been asked by Member States to harmonize their estimates. Additionally, the Sustainable Development Goals (SDGs) and the UN 2030 Agenda (1) call for partnerships for development and improved policy coherence. In response, an agreement was made in 2016 between WHO and ILO to develop a joint estimation methodology and produce the most comprehensive set of official estimates of work-related burden of disease produced to date: the first WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury (WHO/ILO Joint Estimates).

While it was possible to apply WHO and ILO's existing methodologies for many established pairs of occupational risk factors and health outcomes, several other pairs were considered in need of a new evidence review. Additionally, some were identified that had not been included in past estimates but were likely to contribute appreciably to the burden of disease. For these potential new pairs, WHO and ILO conducted a series of systematic reviews and meta-analyses of the evidence base, for which protocols were developed, peer-reviewed and pre-published (2-19). These were carried out with support of experts from government departments in 11 countries (often ministries of health and labor) and over 220 individual experts from 35 countries, covering all six WHO regions.

Here we present a brief summary of the methodology and results of the WHO/ILO Joint Estimates. More detail on the burden of disease attributable to 19 selected occupational risk factors (41 pairs of occupational risk factor and health outcome) included in the WHO/ILO Joint Estimates can be found in the WHO/ILO Global Monitoring Report and Technical Report (21). In this article, as in the broader burden of disease framework, the term "burden of disease" refers to the combined burdens of three types of health outcomes, namely communicable diseases, non-communicable diseases and injuries (22, 23).

Methods

All WHO/ILO Joint Estimates are produced according to the strict statistical rules and established regulations of WHO and the ILO. The data sources and methods used in obtaining these estimates are reported according to the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) (24). The technical report and previous publication can be referred to for more details (21, 25).

Established pairs

Thirty-nine established pairs of occupational risk factors and health outcomes, considered to have a sufficient evidence base, were selected for inclusion (table 1). The burden of disease attributable to established occupational risk factors was estimated using the Comparative Risk Assessment (CRA) framework, a systematic evaluation of the changes in population health that result from modifying the population distribution of exposure to a risk factor or a group of risk factors (22, 23). Recent burden of disease estimates from the Global Burden of Disease Study (26), openly available at http://ghdx.healthdata.org, were used to derive population attributable fractions (PAF). PAF quantify the proportion of deaths or disability-adjusted life years (DALY) lost from a particular health outcome that is attributable to a specific risk factor.

Estimation methods

For each pair, the total number of deaths and DALY for each health outcome in the WHO Global Health Estimates total disease envelopes for 2000, 2010 and 2016 (27) were multiplied by the pair's PAF. This resulted in the estimates of the numbers of deaths and DALY from the health outcome that are attributable to its respective occupational risk factor. For pairs for which there are larger PAF, a larger fraction of the total burden of disease from the health outcome will be estimated.

Recently added pairs

Following scoping reviews, 16 additional pairs of occupational risk factors and health outcomes were selected, which may contribute substantially to the work-related burden of disease. Systematic reviews and meta-analyses were conducted for these pairs to gather evidence for the WHO/ILO Joint Estimates on the prevalence of exposure to occupational risk factors and on the effect of exposure to these risk factors on health outcomes (2-19). The new methods used (28) have been published in an international academic journal (29). WHO and ILO determined that there were two pairs for which there was sufficient quality and strength of evidence to proceed to burden of disease estimation: exposure to long working hours (defined as working >55 hours per week) and the health outcomes of ischemic heart disease and stroke. It should be noted that evaluation of the evidence for some of these pairs is ongoing.

To provide exposure data for these two new pairs, new WHO/ILO databases on exposure to long working hours were developed from data shared by Member States with one or more of WHO, ILO and Eurostat. The databases provided data on the number of workers exposed to long working hours. They used results from 2324 surveys (mostly labor force surveys) from 154 countries, as well as 1742 quarterly datasets of labor force surveys conducted in 46 countries (25).

Estimation methods

Prevalence of exposure. We used an established multilevel model and data from direct exposure measurements provided by the two new WHO/ILO databases to predict the geographical and temporal prevalence of exposure to long working hours (30). As is essential in modelling studies, several modelling assumptions needed to be made. Based on advice from a WHO/ILO technical advisory group and available evidence, an exposure window of ten years, evenly spaced around a lag time of ten years, was agreed upon (ie, to estimate burden of disease in 2016 for example, exposure was modelled for the time window of 2001-2010). The annual prevalence of exposure to long working hours for each year within this window was used in exposure modelling (25). Sensitivity analyses (eg, altering the lag time and the length of the time window) were conducted to test our assumptions.

Burden of disease. As for the established risk factors, the burden of disease attributable to exposure to long working hours was estimated within the CRA framework (22, 23). From the systematic reviews, a pooled risk ratio (RR) of 1.17 [95% confidence interval (CI) 1.05-1.31] was found for risk of ischemic heart disease following exposure to long working hours (>55 hours/week) (9); for stroke, a pooled RR of 1.35 (95% CI 1.13-1.61) was found (3). These pooled RR, along with the prevalence estimates produced by WHO and ILO, were used to calculate the PAF for these two new pairs. These PAF were then applied to the health outcomes' total disease burden envelopes from the WHO Global Health Estimates for the years 2000, 2010 and 2016 (27), as described above for the established pairs, yielding the number of deaths and DALY from each health outcome attributable to exposure to long working hours (25).

Inequalities. To improve workers' health equity between and within countries, health inequalities in the workrelated burden of disease must be monitored. For describing inequalities between regions, sexes and age groups, we used the global number of deaths or DALY per 100 000 working-age (>15 years) population as the reference. For specific regions, sexes or age groups, we calculated (i) the rate difference: the rate for the specific group minus the reference rate (an absolute inequality measure); and (ii) the rate ratio: the rate for the specific group divided by the reference rate (a relative inequality measure) (31).

Uncertainty. All estimates of exposure to occupational risk factors and of burden of disease were produced with their 95% UR (25), using bootstrapping (32). Consistent with previous global health estimates (33-36), the 2.5% and 97.5% quantiles of the random deviates of the exposures were calculated and assigned as the lower and upper limits of the UR, respectively. Here, we present 95% UR for key estimates in the text; however, they are available for all estimates in the online estimates repository (www. who.int/teams/environment-climate-change-and-health/ monitoring/who-ilo-joint-estimates).

Results

Main findings

Globally in 2016, exposure to the 19 selected occupational risk factors was attributable for an estimated 1 879 890 (95% UR 1 835 140-1 924 640) deaths and 89.72 (95% UR 88.61-90.83) million DALY due to the respective health outcomes.

Table 1 shows the numbers of deaths and DALY corresponding to each occupational risk factor - health outcome pair, with rates per 100 000 working-age population [rates per 100 000 total population are available in the Global Monitoring Report (20)]. The pair with the highest number of deaths was chronic obstructive pulmonary disease attributable to occupational exposure to particulate matter, gases and fumes (450 381 deaths, 95% UR 430 248-470 514). The pair with the highest number of DALY was stroke attributable to exposure to long working hours (12.60 million DALY, 95% CI 11.82-13.39 million). Figure 1 displays deaths and DALY by occupational risk factor and figure 2 displays deaths and DALY by health outcome. Figures 3 and 4 show the rates of deaths and DALY per 100 000 of working-age population by country (numbers provided in the supplementary material, www.sjweh.fi/ article/4001,

table S1).
The two new pairs of risk factor and health outcome contributed substantially to the burden of work-related disease. Exposure to long working hours and ischemic heart disease, and exposure to long working hours and stroke combined were responsible for 39.6% of deaths (744 924, 95% UR 744 924-784 328) and 25.9% of DALY (23.26 million, 95% UR 22.15-24.37 million), making this previously unquantified occupational risk factor the one with the largest attributable burden of disease. Detailed breakdowns and interpretations of these findings can be found elsewhere (20, 25). Additionally, the WHO/ILO Joint Estimates are available for each pair, disaggregated by sex and age group, and at global, region and country levels, from dedicated websites hosted by WHO (www.who.int/teams/ environment-climate-change-and-health/monitoring/ who-ilo-joint-estimates) and the ILO (www.ilo.org/ global/topics/safety-and-health-at-work/programmesprojects/WCMS_674797/lang-en/index.htm).
Trends over time
In absolute terms, the global number of occupational risk factor-related deaths from 2000 to 2016 increased by 177 914 between 2000 and 2016. Global work-related DALY increased by 9.67 million from 2000 to 2016.
In terms of rates, globally between 2000 and 2016 rates of total deaths attributable to exposure to occupational risk factors decreased from 39.9 to 34.3 deaths per 100 000 working-age population; this corresponds to a 14.2% decrease in the rate. Similarly, global DALY rates decreased from 1878.4 to 1635.9 DALY per 100 000 working-age population.
Inequalities in work-related burden of disease
By geographic region. The absolute differences in death rates by WHO region, compared with the global rate, ranged from 10.7 (in the South-East Asia Region) to -12.0 deaths per 100 000 working-age population (in the Region of the Americas). For DALY, in absolute terms, rate differences by WHO region ranged from 463.3 DALY per 100 000 working-age population in South-East Asia to -564.1 DALY per 100 000 workingage population in the Americas. For both deaths and DALY, the rate ratios varied from 1.3 for South-East Asia to 0.7 for the Americas.
By sex. The death rate per 100 000 working-age males is 51.4, 17.1 per 100 000 higher and 1.5 times the rate for both sexes. The death rate of 17.2 per 100 000 workingage females is lower compared with the rate for both sexes, this is 17.1 per 100 000 lower and 0.5 times this rate. For DALY, a similar pattern was seen.
By age group, Older age groups carried disproportionally greater disease burden, with the age group 85-89 years having the highest rate difference (higher than the global rate by 212.6 deaths per 100 000 working-age population) and highest risk ratio (7.2). Conversely, the rate for the age group 15-19 years was 4.3 deaths per 100 000 working-age population, yielding a rate difference of -30.0 and a rate ratio of 0.1 compared to the global rate. Similarly for DALY, the older age groups were more burdened.
Discussion
WHO and ILO have produced the first set of the WHO/ ILO Joint Estimates of the Work-related Burden of Disease and Injury (20). Multiple data sources across all WHO regions have been used to quantify the burden of specific health outcomes attributable to some key occupational risk factors. The WHO/ILO Joint Estimates are available to users disaggregated by sex and age group, at the global, regional and national levels.
Target 8.8 of the SDGs aims to "Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment". Although indicator 8.8.1 refers to the "frequency rates of fatal and non-fatal occupational injuries", injuries accounted for only 19.3% of deaths and 29.5% of DALY attributable to occupational risk factors in 2016. An additional, complementary indicator for Target 8.8, quantifying the burden of deaths from diseases attributable to exposure to occupational risk factors, would more accurately capture the extent of the burden of the work-related disease. The WHO/ILO Joint Estimates can support Member States reporting on indicator 8.8.1 and the proposed indicator, especially where dedicated reporting systems for such deaths may not yet exist.
Preventive actions
Actions required vary by occupational risk factor, to reduce the burden related to many of the established risk factors and their health impacts (as here quantified), governments should develop interventions to reduce risk factors with

the active involvement of employers and workers or their representatives, as part of a hierarchy of controls (39). Where it is not possible to eliminate risk factors or use less hazardous substitutions, engineering controls can be introduced, followed by administrative controls. As a last and least-preferred option, workers can be protected with personal protective equipment.

The burden of stroke and ischemic heart disease attributable to exposure to long working hours was previously unquantified. The generation of the first estimates for this burden may motivate actors to address this risk factor. ILO Conventions define the maximum limits of working hours in industrial and services sectors (40, 41) as 48 hours per week (with some specific exceptions). Human resources management and work organization management can be used to prevent exposure to long working hours, in particular for some specific working modalities (eg, teleworking, self-employment and freelancing) (42). Additionally, occupational health services can play an important role. All workers should be covered (43), and occupational health risk assessments should consider numbers of working hours and other cardiovascular risk factors (eg, obesity, physical activity, smoking and diet) that exposure to long working hours could influence. The introduction of social protection floors would enable people to stop working unhealthy long hours, by guaranteeing access to essential health care and basic income security. This would particularly benefit disadvantaged workers (eg, those in the informal economy, and vulnerable groups such as pregnant women, older people and migrant workers) (44).

Strengths and limitations

The WHO/ILO Joint Estimates have used established methods to quantify the work-related burden of disease attributable to 19 occupational risk factors (22, 23). A pair was only proceeded for estimation if WHO and ILO judged there to be sufficient quality and strength of evidence for the pair, providing confidence that the burden of disease estimates reported are attributable to the occupational risk factor. As a result, the organizations have estimated that 1.9 million deaths and 89.7 million DALY are attributable to the selected 41 pairs of occupational risk factor and health outcome.

There are some limitations that should be considered when interpreting the estimates. First, these estimates are affected by the source and quality of input data, and the type and complexity of the models of exposure and health estimates. A wide range of approaches have been used to collect and synthesize data. Although estimates have been included only if the underlying body of dence was to be of sufficient quality and strength, some are based on exposure data from limited sources and from areas of limited country and regional coverage. To improve future estimates, more large-scale global official datasets of exposure to occupational risk factors are needed, ideally from direct measurement or through strong proxies such as occupation and industrial sector. Similarly, more primary studies need to be conducted on the effect of exposure to occupational risk factors on health outcomes (29). In particular, more evidence is needed from low- and middle-income countries.

Second, while estimates have been included only if WHO and ILO, supported by a large number of individual experts, judged the underlying body of evidence to be of sufficient quality and strength, this is based on judgement. As this is subjective it may be that other organizations or individuals reach a different judgement. This was demonstrated by a commentary indicating disagreement with the rating of "sufficient evidence for harmfulness" that there is of long working hours with regard to ischemic heart disease (45). The WHO/ ILO Working Group, composed of a large number of individual experts, acknowledged and responded to the commentary, elaborating on why the assigned rating is supported by the evidence (46). WHO and the ILO are collaborating on the WHO/ILO Joint Estimates with over 200 individual experts based around the world, to ensure that judgements made represent the views of a diverse and representative expert group.

Third, it must be noted that not all occupational risk factors and attributable burdens of disease have yet been quantified. The production of estimates for some pairs was not possible in this estimation cycle, such as: occupational exposure to biological risk factors and infectious diseases; occupational exposure to psycho-social risk factors and mental health outcomes; and occupational exposure to ambient air pollution and its various health outcomes. Further, while there are established methods for estimating the burdens of silicosis, asbestosis, coal worker's pneumoconiosis and unspecified pneumoconiosis attributable to occupational exposure to dusts and fibers, WHO and the ILO are currently reviewing these methods and the available bodies of evidence (10); these pairs were therefore not included in this estimation cycle. While this means that the work-related burden of disease is almost certainly higher than the current estimate of selected pairs, the addition of such pairs in future will broaden the scope of these estimates and capture the work-related burden of disease more comprehensively.

Fourth, estimates by their nature are modelled based on certain assumptions (like the appropriate time window of exposure). While the assumptions made draw from the latest evidence base and are transparently reported, as evidence develops, it is possible that new evidence may emerge in the future which could lead us to alter these assumptions. Sensitivity analyses were performed and reported to assess the impact of alternative assumptions related to exposure to long working hours (25).

Concluding remarks

The WHO/ILO Joint Estimates report that globally in 2016 1.88 million deaths and 89.72 million DALY from health outcomes were estimated to be attributable to the 19 occupational risk factors covered. A disproportionately large work-related burden of disease is observed in the WHO African Region (for DALY), South-East Asia Region and the Western Pacific Region (for deaths), males and older age groups. Future steps should include estimation of disease burden for more occupational risk factor and health outcome pairs, as more high-quality data and evidence become available, to ensure more of the workrelated burden of disease is captured.

The WHO/ILO Joint Estimates have widened the scope of the global CRA and strengthened the global capacity for modelling disease burden in occupational health. They allow the global monitoring of exposure to occupational risk factors and the work-related burden of disease, to detect inequalities and trends over time. This will enable policy-makers and institutions to plan, cost, implement and evaluate actions to prevent exposure to occupational risk factors and their attributable burden of disease.

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Declaration of interests

Authors declare no conflicts of interest.

Sidebar

Pega F, Hamzaoui H, Náfrádi B, Momen NC. Global, regional and national burden of disease attributable to 19 selected occupational risk factors for 183 countries, 2000-2016: A systematic analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury. Scand J Work Environ Health. 2022;48(2):158-168.

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Cillekens, B., M.Sc, Huysmans, M. A., PhD., Holtermann, A., PhD., Van mechelen, W., PhD, Straker, L., PhD., Krause, N., PhD., . . . Coenen, P., PhD. (2022). Physical activity at work may not be health enhancing. A systematic review with metaanalysis on the association between occupational physical activity and cardiovascular disease mortality covering 23 studies with 655 892 participants. Scandinavian Journal of Work, Environment & Health, 48(2), 86-98. doi:https://doi.org/10.5271/sjweh.3993

Objectives Emerging evidence suggests contrasting health effects for leisure-time and occupational physical activity. In this systematic review, we synthesized and described the epidemiological evidence regarding the association between occupational physical activity and cardiovascular disease (CVD) mortality. Methods A literature search was performed in PubMed, Embase, CINAHL, PsycINFO and Evidence-Based Medicine Reviews, from database inception to 17 April 2020. Articles were included if they described original observational prospective research, assessing the association between occupational physical activity and CVD mortality among adult workers. Reviews were included if they controlled for age and gender and at least one other relevant variable. We performed meta-analyses on the associations between occupational physical activity and CVD mortality. Results We screened 3345 unique articles, and 31 articles (from 23 studies) were described in this review. In the meta-analysis, occupational physical activity showed no significant association with overall CVD mortality for both males hazard ratio (HR) 1.00, 95% confidence interval (CI) 0.87-1.15] and females (HR 0.95, 95% CI 0.82-1.09). Additional analysis showed that higher levels of occupational physical activity were non-significantly associated with a 15% increase in studies reporting on the outcome ischemic heart disease mortality (HR 1.15, 95% CI 0.88-1.49). Conclusions While the beneficial association between leisure-time physical activity and CVD mortality has been widely documented, occupational physical activity was not found to have a beneficial association with CVD mortality. This observation may have implications for our appreciation of the association between physical activity and health for workers in physically demanding jobs, as occupational physical activity may not be health enhancing.

Hartikainen, E., M.Sc, Solovieva, S., PhD., Viikari-Juntura, E., & Leinonen, T., PhD. (2022). Associations of employment sector and occupational exposures with full and part-time sickness absence: Random and fixed effects analyses on panel data. Scandinavian Journal of Work, Environment & Health, 48(2), 148-157. doi:https://doi.org/10.5271/sjweh.4003

Objective We aimed to investigate the influence of unobserved individual characteristics in explaining the effects of work-related factors on full (fSA) and part-time sickness absence (pSA). Methods We used register-based panel data for the period 2005-2016 on a 70% random sample of the Finnish working-age population. The relationships between employment sector and occupational exposures (% exposed to physically heavy work and job control score based on job exposure matrices) and the annual onset of fSA and pSA were investigated among men and women. First, random effects (RE) models were applied controlling for observed sociodemographic factors and then fixed effects (FE) models that examine within-individual changes over time and thereby further account for unobserved time-invariant individual characteristics. Results In the RE analyses, public employment sector, physically heavy work and lower job control each increased the use of fSA and pSA among both genders. When unobserved individual characteristics were controlled for with the FE models, the effects on fSA attenuated. For pSA, the effects of employment sector and physical heaviness of work among women even reversed. The effect of lower job control on pSA remained especially among women. Conclusions The role of individuals' unobserved characteristics in explaining the effects of work-related factors on SA should not be neglected. The effects of work-related factors are likely to be overestimated when using traditional approaches that do not account for unobserved confounding, ie, selection of individuals with a high likelihood of SA into particular work environments.

Shields, M., M.P.H., Spitta, M. J., PhD., Dimov, S., B.P.S.Y.C.H.S.C.(H.O.N.S.), Kavanagh, A., PhD., & King, T. L., PhD. (2022). Trajectories of disability throughout early life and labor force status as a young adult: Results from the longitudinal study of australian children. Scandinavian Journal of Work, Environment & Health, 48(2), 118-126. doi:https://doi.org/10.5271/sjweh.3994

Objectives Young people with disabilities have poorer labor force outcomes than their peers without disabilities. These understandings, however, are largely based on research assessing disability at one time point only, an approach that potentially obscures variation in disability over time. We aimed to identify trajectories of disability during childhood/adolescence and assess associations between trajectory membership and labor force status in young adulthood. Methods We conducted group-based trajectory modeling of disability status information from six waves waves 2-7 (age 4/5 to 16/17 years)] of the Longitudinal Study of Australian Children. The trajectories were used to predict labor force participation (employed, unemployed, not in the labor force) at wave 8 (18/19 years), adjusted for confounders. Results We identified four trajectory groups of the prevalence of disability: low (75.5% of cohort), low increasing (9.7%), high decreasing (10.9%), and consistently high (3.9%). Individuals in the low increasing trajectory were nearly three times as likely to be unemployed at age 18/19 years compared to individuals in the low trajectory risk ratio (RR) 2.96, 95% confidence interval (CI) 1.94-4.53]. Individuals in the consistently high trajectory had a greater RR of not being in the labor force at age 18/19 years compared to individuals in the low group (reference) (RR 3.65, 95% CI 2.21-6.02). Conclusions Results suggest that prolonged and increasing experiences of disability among young Australians may be differentially associated with future labor force outcomes. Additional support to prepare young people for the labor force should focus on individuals who consistently or increasingly report a disability.

Lee, D., PhD., Choi, J., PhD., Kim, H., PhD., Myong, J., PhD., & Kang, M., PhD. (2022). Differential impact of working hours on unmet medical needs by income level: A longitudinal study of korean workers. Scandinavian Journal of Work, Environment & Health, 48(2), 109-117. doi:https://doi.org/10.5271/sjweh.3999

Objectives Unmet medical need is defined as the perceived need for medical service that is not received. Although the association between unmet medical needs and working hours has been explored before, the combined effect of household income has not been investigated thus far. This study, therefore, aimed to examine the differential association between working hours and the risk of unmet medical needs according to household income. Methods A total of 7047 participants enrolled in the Korea Health Panel data 2011-2014 were considered. The analytical method used in this study was a generalized estimating equation model that accounted for repeated measured participants. By controlling for time-invariant individual-fixed effects, we identified the relationship between long working hours and the risk of unmet medical needs. Results The association between long working hours and the risk of unmet medical needs differed according to household income. In the highest quintile of household income, the risk of unmet medical needs was 1.58-fold higher among those who worked >52 hours per week than among those who worked 30-52 hours per week. However, this association was not significant in the lowest quintile group. Conclusions The current study implies that financial hardship might be a more fundamental health hazard than working longer hours among the low-income group. Future policies should consider not only limiting working hours but also compensating workers' income to adequately protect low-income workers from the health risks associated with long working hours.

Knardahl, S.,PhD.M.D., & Christensen, J. O., PhD. (2022). Working at home and expectations of being available: Effects on perceived work environment, turnover intentions, and health. Scandinavian Journal of Work, Environment & Health, 48(2), 99-108. doi:https://doi.org/10.5271/sjweh.3996