Report Information from ProQuest

26 October 2023 01:59

TABLE OF CONTENTS

1. Does occupational forward bending of the back increase long-term sickness absence risk? A 4-year prospective register-based study using device-measured compositional data analysis..... 1

2. Overqualification at work and risk of hospitalization for psychiatric and somatic diseases among immigrants in Sweden - a prospective register-based study..... 13

3. Occupational risk of COVID-19 across pandemic waves: a two-year national follow-up study of hospital admissions..... 23

4. Does a change to an occupation with a lower physical workload reduce the risk of disability pension? A cohort study of employed men and women in Sweden..... 29

5. Longitudinal changes in proportionate mortality due to COVID-19 by occupation in England and Wales... 39

6. Workplace psychosocial resources and risk of cardiovascular disease among employees: a multi-cohort study of 135 669 participants..... 50

7. What is next for occupational cancer epidemiology?..... 61

8. Physical work demands and expected labor market affiliation (ELMA): Prospective cohort with register-follow-up among 46 169 employees..... 70

9. Suicide among transport industry workers: A systematic review and meta-analysis..... 79

Bibliography..... 94

Does occupational forward bending of the back increase long-term sickness absence risk? A 4-year prospective register-based study using device-measured compositional data analysis

Gupta, Nidhi [1] ; Bjerregaard, Søren Skotte [2] ; Yang, Liyun [3] ; Forsman, Mikael [4] ; Rasmussen, Charlotte Lund [5] ; Rasmussen, Charlotte Diana Nørregaard; Clays, Els; Holtermann, Andreas [1] of musculoskeletal disorders and physical workload, National Research Centre for the Working Environment, Copenhagen, Denmark. [2] Department of analysis and data, National Research Centre for the Working Environment, Copenhagen, Denmark. [3] School of Engineering Sciences in Chemistry, Biotechnology and Health, KTH Royal Institute of Technology, Huddinge, Sweden. [4] IMM Institute of Environmental Medicine, Karolínska Institutet, Stockholm, Sweden. [5] Department of Public Health and Nursing, Norwegian University of Science and Technology, Trondheim, Norway

ABSTRACT (ENGLISH)

Objective Forward bending of the back is common in many jobs and a risk factor for sickness absence. However, this knowledge is based on self-reported forward bending that is generally imprecise. Thus, we aimed to investigate the dose-response relation between device-measured forward bending at work and prospective register-based risk of long-term sickness absence (LTSA). Methods At baseline, 944 workers (93% from blue-collar jobs) wore accelerometers on their upper back and thigh over 1-6 workdays to measure worktime with forward bending (>30° and >60°) and body positions. The first event of LTSA (>6 consecutive weeks) over a 4-year follow-up were retrieved from a national register. Compositional Cox proportional hazard analyses were used to model the association between worktime with forward bending of the back in an upright body position and LTSA adjusted for age, sex, body mass index (BMI), occupational lifting/ carrying, type of work, and, in an additional step, for leisure time physical activity (PA) on workdays. Results During a mean worktime of 457 minutes/day, the workers on average spent 40 and 10 minutes on forward bending >30° and >60° in the upright position, respectively. Five more minutes forward bending >30° and >60° at work were associated with a 4% [95% confidence interval (CI) 1.01-1.07] and 8% (95% CI 1.01-1.16) higher LTSA risk, respectively. Adjustment for leisure-time PA did not influence the results. Conclusion We found a dose-response association between device-measured forward bending of the back and prospective LTSA risk. This knowledge can be integrated into available feasible methods to measure forward bending of the back for improved workplace risk assessment and prevention.

FULL TEXT

Headnote

Objective Forward bending of the back is common in many jobs and a risk factor for sickness absence. However, this knowledge is based on self-reported forward bending that is generally imprecise. Thus, we aimed to investigate the dose-response relation between device-measured forward bending at work and prospective register-based risk of long-term sickness absence (LTSA). Methods At baseline, 944 workers (93% from blue-collar jobs) wore accelerometers on their upper back and thigh over 1-6 workdays to measure worktime with forward bending (>30° and >60°) and body positions. The first event of LTSA (>6 consecutive weeks) over a 4-year follow-up were retrieved from a national register. Compositional Cox proportional hazard analyses were used to model the

association between worktime with forward bending of the back in an upright body position and LTSA adjusted for age, sex, body mass index (BMI), occupational lifting/ carrying, type of work, and, in an additional step, for leisure time physical activity (PA) on workdays. Results During a mean worktime of 457 minutes/day, the workers on average spent 40 and 10 minutes on forward bending >30° and >60° in the upright position, respectively. Five more minutes forward bending >30° and >60° at work were associated with a 4% [95% confidence interval (CI) 1.01-1.07] and 8% (95% CI 1.01-1.16) higher LTSA risk, respectively. Adjustment for leisure-time PA did not influence the results. Conclusion We found a dose-response association between device-measured forward bending of the back and prospective LTSA risk. This knowledge can be integrated into available feasible methods to measure forward bending of the back for improved workplace risk assessment and prevention.
Key terms occupational activity; occupational health; sick leave; trunk flexion.
High ergonomic work demands are established risk factors for long-term sickness absence (LTSA) (1), and LTSA puts a large burden on the workplaces and society (2). Thus, many workplaces aim to prevent LTSA by assessing and intervening on the ergonomic work demands (3-7).
Forward bending of the back while in an upright position (when workers are on their feet) is a prevalent ergonomic exposure (8) and associated with an increased risk of sickness absence (9, 10). However, this knowledge is either based on self-reports, workplace observations, or expert opinions, all with major limitaDepartment tions. Self-reported forward bending at work is shown to correspond poorly with device-based measurements (11). Moreover, both workplace observations and expert opinions of body movements such as forward bending are known to be of low precision, or only based on a short period of the worktime (12). Thus, existing knowledge about the dose-response relation of forward bending at work with sickness absence risk can at best be imprecise and, at worst, biased.
To obtain valid measurements of forward bending at work, feasible device-based (eg, accelerometers) measurement systems are now available. These systems can accurately measure forward bending at work over several days (13). Recent research has focused on investigating the dose-response relation between devicemeasured worktime spent forward bending of the back at various degrees (eg, >30° and >60°) and musculoskeletal pain (14). However, work environment researchers, practitioners, and stakeholders lack knowledge on the dose-response relation between device-measured forward bending at work and sickness absence risk. Such knowledge is warranted for better risk assessment and preventive initiatives.
We aimed to investigate the dose-response relation between worktime with forward bending of the back in an upright position and the prospective risk of LTSA.
Methods
Study design and population
This was a four-year prospective study where individuals were invited to participate in baseline measurements. Baseline measurements included accelerometry measurements, a questionnaire, and a health check. Individuals were then followed up in the national register to obtain information on the first event of LTSA within four years following the date of baseline (ie, from the last day of accelerometry measurement). This meant that each worker had an equal follow-up period of four years (ie, 212 weeks).
This study used baseline data from the 'Physical wOrk DEmands and Prospective register-based Sickness Absence' (PODESA) study (15, 16) and prospective data on sickness absence from the national register. PODESA consists of harmonized data from the 'New method for Objective Measurements of physical Activity in Daily living' (NOMAD) (17) and the 'Danish PHysical ACTivity cohort with Objective measurements' (DPhacto) (18) cohorts. In both cohorts, labor unions assisted in recruiting participants from 22 workplaces within the manufacturing, cleaning, transport, healthcare, garbage collection, construction, assembling, and mobile plant operations sectors in Denmark. All workers from these workplaces were invited to local information meetings where study details were provided and were offered participation. Of the 2107 workers in DPhacto and 391 workers in NOMAD who were offered participation, 1390 (55.6%) workers either participated in the questionnaire and/or health check at the baseline. The baseline data in the NOMAD and DPhacto cohorts was collected from 2011-2012 and 2012-2013, respectively.

Previous studies on DPhacto found no relevant differences between participants and non-participants at baseline for the demographics and lifestyle-related factors (18). Similarly we found no relevant differences in NOMAD cohorts between those who wanted and did not want to participate [non-participants (N=88) age: 43.4 years, females: 34%, job seniority: 151 months, daily smokers: 37%; participants (N=262) age: 44.6 years, females: 40%, job seniority: 165 months, daily smokers: 34%). More details on how we recruited these workplaces and harmonized these cohorts and their background information are provided in our previously published articles (15, 18) and more details on the flow of the participants are given in the supplementary material (www.sjweh.fi/article/4047), appendix A.

Ethical approval

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) (15). 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 provided written consent to participate in the study and to use their data for research purposes.

Accelerometry

In the PODESA cohorts, participants were offered to wear Actigraph (GTX3+, Florida, USA.) accelerometers on the right arm, right thigh, upper back, and hip for 4-7 consecutive workdays including at least two workdays (19, 20). This study used data from the right thigh and upper back to measure forward bending of the back while in the upright position. For a sensitivity analysis (refer to statistical analyses section), we also used data from the arm accelerometer to get information on elevated arm above shoulder height (used as a confounder). During the measurement period, workers were also asked to fill out a short daily diary indicating the time of starting and ending their primary work and time of getting in and out of the bed on each measured day.

The accelerometer data were downloaded using the ActiLife Software version 5.5 and further processed using the valid MATLAB program Acti4 (13, 20, 21). First, using the thigh-based accelerometer data and the self-reported diary information, we determined work-time spent in the upright position (ie, time with standing, walking, running, and stair climbing) and non-upright position (ie, sedentary as sitting or lying). Second, data from the upper back accelerometer were used together with data from the thigh-based accelerometer to determine how much of the worktime in the upright position was spent with forward bending of the back at <30°, >30°, <60°, and >60°. We chose these cut points because of their previously shown relevance for musculoskeletal pain (14, 22, 23).

A workday was defined as a 24-hour day when the participant is working. A work period was defined as a continuous period/work shift when the participant spends time on their occupation. A participant could have several work periods within one workday (for example, an industrial manufacturing worker is working 00.00-07.00 and then 19.00-00.00 hours). Hours spent in all work periods within one workday were summed together to calculate total working hours per day.

Data for each participant on all postures and movements were averaged across all valid measured work periods. A work period for a worker was considered valid if consisted of >4 work hours or >75% of the average measured work time/day for that worker. In the analyses, we included all workers with at least one valid work period (average measured work period range: 5-95th percentile 5.2-10.5 hours or 312-630 minutes).

Register-based long-term sickness absence (LTSA)

We retrieved information on the first event of LTSA during the four-year follow-up from baseline via the Register-based Evaluation of Marginalization (DREAM) register (24) using the workers' unique civil registration number. The DREAM register contains information on granted subsidized sickness absence benefits per week given by the state to the workplace of each sick worker in Denmark. DREAM register contains around 100 codes for various social transfers. The study by Madsen &Larsen (25) describes which of these codes to be used when determining sickness absence based on the DREAM register. These sickness absence benefits are provided after 30 continuous days of sickness absence. Thus, we chose >6 continuous weeks as the cut point to be certain that we captured all sickness absence events lasting >30 continuous days of sickness absence. This is also the reason why other studies from Denmark using the DREAM register to define LTSA have used the cut point of >6 continuous weeks (1, 26).

Potential confounders

We chose the potential confounders a priori based on previous evidence on the association of ergonomic exposures, including forward bending at work, with musculoskeletal pain and sickness absence (9, 27, 28). We determined the age of the workers using their unique civil registration number while we identified the sex of the workers using a single item 'Are you male or female'? We measured the body mass index (BMI) of the workers by objectively measuring their weight (kg) and height (cm). We determined how much time the workers spent on lifting and carrying at work via a single item with 6 responses ranging from 'almost all the time' to 'never' (29). We retrieved information on the type of work using a single item "Are you a worker engaged in administrative work tasks (white-collar) or production (blue-collar)?" as a proxy of socioeconomic status (30). We identified the event of LTSA within 12 months before baseline using the DREAM register. We determined how much influence workers had at work using two items from the Copenhagen Psychosocial Questionnaire (31, 32). The two items for influence at work were "Do you have a large degree of influence concerning your work?"; "Can you influence the amount of work assigned to you?". Scores on these items were summarized separately into a scale of 0 to 100% where 0 meant no influence at work. We measured leisure time physical activity (time spent on sedentary behavior and upright position) using thigh accelerometry (16).

Statistical analysis

Measured data on worktime with forward bending of the back is compositional (33). Composition of various exposures in worktime, ie, time with forward bending of various degrees while in the upright position and total time with non-upright position, for each participant sums up to 100% of worktime. Additionally, these exposures in the worktime composition are inherently co-dependent. The traditional analytical approach is not designed to handle such compositional data. Accordingly, we followed a compositional data analysis (CoDA) approach to perform all statistical analyses. For a thorough understanding of the implementation of CoDA in occupational research, please read the explanation here (33, 34).

For the analyses, we first defined two types of compositional exposures (figure 1):

* "Composition A" consisted of three exposures: (i) worktime with forward bending of the back >30° in the upright body position, (ii) worktime with forward bending of the back <30° in the upright body position, and (iii) worktime in the non-upright body position (figure 1A).
* "Composition B" consisted of three exposures: (i) worktime with forward bending of the back >60° in the upright body position, (ii) worktime with forward bending of the back <60° in the upright body position, and (iii) worktime in the non-upright body position (figure IB).

Main analyses

The main analyses consisted of three steps: Step 1) we transformed each composition (ie, worktime composition A or B) to isometric log-ratios [ilrs, see these articles (34, 35) to understand how ilrs are calculated and interpreted]. For each composition, this transformation resulted in two ilrs (ilr1 and ilr2). These are the following equations for calculating ilr1 and ilr2 for Composition B.

Where i is one worker.

Step 2) we performed two separate Cox proportional hazards regressions (one for each composition), modeling both ilrs against the onset of LTSA event (34). The models were adjusted for age, sex, BMI, worktime with lifting/carrying, and type of work (blue-collar or whitecollar). Ilrl, ilr2, age, BMI, and lift/carry duration at work were modeled as continuous variables while the remaining were modeled as categorical variables. The resulting cox model and its interpretation is given in the supplementary material of Gupta &Rasmussen (34) article.

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. During the 4-year follow-up, 45 workers dropped out for one of the following reasons: emigrated, died, entered early retirement, entered ordinary retirement, or became pregnant. These workers contributed to the risk time in the analyses until the week of dropping out.

We verified the assumption of the proportional hazards via visual inspection and the Grambsch-Therneau test (36). We assessed the statistical significance of the association between worktime compositions and LTSA risk using the Type-II likelihood-ratio tests. We considered the results to be significant at $P<0.05$.

Step 3) the regression coefficients of the ilrs (the effect sizes) obtained from the Cox models were in logarithmic scale, which were difficult to interpret (see these coefficients in supplementary appendix C). Thus, we used compositional isotemporal substitution analysis to interpret these logarithmic coefficients (29, 34).
Briefly, we first calculated a 'reference composition' ie, the sample mean worktime with forward bending while in the upright position and non-upright position. For example, for composition A, this was 40 minutes >30°, 261 minutes <30°, and 156 non-upright minutes (table 2). Based on the reference composition, we calculated new theoretical compositions by incrementally reallocating a fixed amount of time from one exposure to another exposure of the composition while keeping the time in the non-upright position and total worktime constant. For example, for composition A, we reallocated 5 minutes of forward bending >30° to forward bending <30° keeping constant the non-upright time (156 minutes) and the total worktime (457 minutes or 7.6 hours). This resulted in the following new theoretical composition: 35 minutes >30°, 266 minutes <30°, and 156 non-upright minutes. We performed similar reallocations for both compositions (A and B). The size of the reallocations was chosen to keep the resulting theoretical compositions within the range of the measured exposures.
The new theoretical compositions were then transformed to ilrs using the formulas given above. Using the regression coefficients obtained from the Cox models (shown in supplementary appendix C), we predicted hazards ratios (HR) and their 95% confidence intervals (CI) for these theoretical ilrs indicating the predicted difference in the LTSA risk corresponding to the difference between the new theoretical composition and the reference composition. Hence, the predicted HR indicated the relative risk of LTSA attributed to a higher/lower duration of forward bending. The formula for predicting the HR and their 95% CI is given in the supplementary file of the Gupta &Rasmussen (34) article.
Finally, we plotted these predicted HR together with their 95% CI on the y-axis against measured worktime spent on forward bending >30° or >60° (in minutes) on the x-axis.
To interpret the results in terms of absolute risk of LTSA, we rewrote the Cox model as P(t|i) n p(t)exp (XP') , where p(t|i) is the probability of survival (no LTSA-event) past time t given the values of the predictors X (ilrs and confounders in our case), and ßis the regression coefficients. Based on the Cox model estimates, we estimated Kalbfleisch-PrenticeCox survival function P(t |i), which is adju sted for the predictors (ilrs and confounders). The effect of the predictors is to raise the survival function to power of exp (Xß) (37). We then plotted the predicted cumulative risk of LTSA F (t|A) = 1 - Š(t)exp 1 for varying time reallocations of forward bending to make the results interpretable. F is a cumulative risk at a certain time point 't'.
Sensitivity analyses
To test the sensitivity of the results obtained from the main analyses, we also performed these additional analyses: (i) Due to technical errors, some workers could not answer questions on influence at work. Thus, the main analyses were performed without and with additional adjustment for influence at work for the remaining 739 workers; (ii) 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); (iii) We performed the main analyses with and without adjustment for leisure time physical activity on workdays (N=828, average leisure time=476 minutes, 5-95th percentile=302-697 minutes or 5.04-11.6 hours); (iv) The observed association in the main analysis could be confounded by other "co-occurring" ergonomic exposures, such as work with elevated arm above shoulder height. Thus, we performed a sensitivity analysis where we also adjusted the statistical model for minutes of worktime spent with elevated arm above shoulder height in the upright position (N=924), measured using arm-based and thigh-based accelerometry as described previously (34).
All analyses were performed in the R software (version [3.5.1]) using the software packages 'Compositions' (38), 'robCompositions' (39) and 'survival' (40). Results
Participant flow and descriptives
Of the 2498 eligible and invited workers, 944 were included in the main analysis as they had valid data on at least one working period and provided their unique civil registration number to obtain information on LTSA from the DREAM register. More details on the participant flow are given in supplementary appendix A.

These 944 workers were, on average, 45 [standard deviation (SD) 9.7] years old and had an average BMI of 27.2 kg/m2 (SD 4.9). Additionally, 43.9% of them were women, 93.2% of them were engaged in bluecollar occupations, and 58.9% were working in the manufacturing sector. In total, 204 workers (21.6%) had their first event of LTSA at 78th week (median) within the 4-year (ie, 212 weeks) follow-up time. The analyses included a total of 167,184 person-years during the follow-up time.

Workers were, on average, measured for 3 days with a range of 1-6 workdays. The variation in the measured number of days between workers was due to differences in measured non-workdays, sick days, vacation days, and non-valid work periods (A work period for a worker was considered valid if consisted of >4 work hours or >75% of the average measured work time/day for that worker). On average, the whole analytical sample was measured for 457 minutes (7.6 hours) of worktime/day, of which 156 minutes were spent in a non-upright body position (sitting or lying) and 301 minutes were spent in the upright body position. Of these 301 minutes spent in the upright body position; in Composition A, 40 minutes were spent on forward bending >30° and 261 minutes on forward bending <30°. In composition B, 10 minutes were spent on forward bending >60° and the remaining 291 minutes on forward bending <60°. We have added a ternary plot to visualize the distribution of the forward bending of the back at >30 and <30 , and at >60 and <60° (supplementary appendix B).

Comparing workers without (N=740) and with (N=204) LTSA event, no major differences in baseline descriptive characteristics were found, except that the group with LTSA event had relatively more women, had slightly less influence at work and had more pre-events of LTSA (ie, LTSA event during 12 months before base-line) (see table 1).

Main analysis

Results of the Compositional Cox Proportional Hazard models on the 944 workers showed a statistically significant association (using the likelihood ratio test) between worktime compositions of forward bending of the back <30° and >30° while in the upright position (composition A; x2=7.0, P=0.03) and LTSA risk. Similar but borderline non-significant results were observed for worktime composition of forward bending of the back <60° and >60° (Composition B; x2=5.8, P=0.06). The resulting estimates obtained from the models are presented in Appendix C.

For composition A (ie, forward bending above and below 30°), from the average, reallocating five more minutes to forward bending of the back >30° in the upright position per day was associated with a 4% (HR 1.04, 95% CI 1.01-1.07) higher risk of LTSA at any given time point in the 4-year follow-up period (figure 2). Please note that these extra minutes of forward bending of the back >30° were obtained by subtracting five minutes from forward bending <30°, and keeping the remaining worktime (ie, non-upright) constant. Similarly, reallocating five more minutes to forward bending of the back >60° in the upright position was associated with an 8% (HR 1.08, 95% CI 1.01-1.16) higher LTSA risk (figure 2).

Figure 3 displays the predicted absolute LTSA risk over time up to 4 years for worktime spent forward bending >30° (Composition A) and >60° (Composition B). The assumption was that the exposure, ie, time spent on forward bending, remained the same throughout the follow-up period. At the end of the fourth year, the risk of LTSA for 10 minutes forward bending >30° was 9%. This risk increased to 12.2% at 40 minutes forward bending >30° (representing the average of this population), and 14.5% at 70 minutes of forward bending >30°. Similarly, 1, 10, and 30 minutes of forward bending >60° were associated with 8%, 12.3%, and 15% absolute risk of LTSA, respectively. The relative risk (HR) and absolute risk are related. For example, five minutes higher forward bending >30° and >60° from its average was associated with 0.4 and 1.0%-point increase in LTSA absolute risk and 4% and 8% relative risk at the grand mean of all remaining variables in the model (variables indicated in step 2 of the Statistical Analysis section), respectively.

Sensitivity analyses

Overall, the results of the main analyses and the four sensitivity analyses were similar (results not shown). For example, when not adjusting for worktime with elevated arm above shoulder height in the upright position, we found that reallocating five more minutes to forward bending of the back >60° in an upright position was associated with an 8% (HR 1.08, 95% CI 1.00-1.16) higher LTSA risk. When we adjusted for worktime with elevated arm above

shoulder height in the upright position in the statistical model, the corresponding results remain similar (HR 1.07, 95% CI 1.00-1.15).

Discussion

As far as we know, our study is the first to investigate the dose-response relation between device-measured forward bending of the back at work and prospective register-based risk of LTSA.

Our finding that device-measured forward bending of the back at work increases the prospective risk of LTSA corroborates findings in previous studies using self-reported measures (41, 42). However, the main novelty of our study is that we can quantify the relationship with a resolution down to minutes spent on forward bending of the back and LTSA risk. We found that five more minutes forward bending >30° and >60° were associated with 4% and 8% higher risk, respectively. We consider this to be a big step forward compared to previous studies based on very gross exposure information on forward bending at work using self-reports, workplace observations, or expert ratings. For example, previous studies (10, 11) used questionnaires where workers reported their worktime spent on forward bending in the following categories; "never", "sometimes", "25%", "50%", "75%", and "more than 75%" of the worktime. Based on the knowledge from device-measured forward bending at work, it is obvious that these gross exposure categories do not provide realistic information of the true exposure of forward bending, and not being precise enough to give a sufficient resolution of the exposure down to minutes (10, 11). Additionally, self-reported ergonomic exposures are shown to be systematically misclassified depending on factors such as musculoskeletal complaints and sex (43, 44). These limitations restrict the use of self-reports in risk assessment and designing effective workplace initiatives to prevent sickness absence. Our study uses accurate forward bending measurements (13) and provides quantifiable LTSA risk estimates for as little as 5 minutes of forward bending of the back. These specific estimates on the true work exposure are valuable for risk assessments and workplace interventions and thus important for occupational health professionals and practitioners. In our previous study (34), we published results on the association between worktime spent with elevated arms and LTSA risk using the similar measurement method used in this study. This means that practitioners can use the same method for risk assessment of both elevated arm work and work with forward bending of the back.

Our study also shows that the dose-response association between forward bending of the back and LTSA risk is steeper for >60° than >30° of forward bending. This finding can be explained by the higher load on the structures of the back with forward bending at >60° compared with >30° (45, 46), and suggests that particularly much worktime spent with forward bending of the back >60° should be reduced for preventing LTSA.

We believe that our study, providing more specific and valid estimates of the dose-response association between forward bending of the back and LTSA, generates valuable knowledge for practitioners, employers, and policymakers aiming to improve the prevention of LTSA due to high ergonomic exposures. For example, figure 3 shows the absolute LTSA risk of workers with different exposures of forward bending at work at 1, 2, and 4 years. We believe this knowledge can encourage practitioners and workplaces to use feasible measurement tools to perform an accurate risk assessment of forward bending of the back. If practitioners and workplaces are provided with such specific measures of the true exposure of forward bending at work, and its associated risk of LTSA, we believe that it can improve workplace interventions targeting forward bending of the back and prevention of LTSA. To perform such accurate risk assessment and design specific workplace preventive interventions, workplaces can tap upon accessible and user-friendly device-based tools to measure ergonomic exposures. Examples of such tools that are available for researchers and practitioners can be found here (47-49). The prices of the ergonomic measurement devices are becoming lower and the device-based systems' usability and feasibility is increasing. Thus, the integration of knowledge produced in this study into the feasible device-based tools will be the way forward for collecting large-scale data, performing accurate risk assessment, and performing better workplace prevention.

Strength and limitations

One limitation was the inclusion of only 37% of the total sample in the main analyses. This was both due to workers not willing to participate or it was not feasible to perform measurements on workers due to vacation, travelling, sick

leave, odd working periods or shortage of accelerometers etc. However, previous studies on the DPhacto cohort did not indicate any differences between those who participated and those who did not (17, 18). Similarly, we found no significant differences for the NOMAD cohort between non-participants and participants (see results presented in the section "Study design and population"). Another limitation was the lack of information on the "load" (eg, if the forward bending was performed while lifting heavy weights) when performing forward bending of the back. The potential occurrence of residual confounding and bias in observational non-randomized studies is a general limitation. The lack of information on the cause of sickness absence was another limitation of the study.

An obvious strength was the use of accelerometry to measure worktime with forward bending of the back in combination with body position. Another strength was the use of recommended CoDA-based analyses in handling compositional data like worktime with forward bending of the back. The application of a prospectivestudy design and the use of register-based LTSA were additional strengths of the study. An additional strength was also that we investigated if adjustment for a potential "co-occurring ergonomic work exposure" arm elevation above shoulder height would influence our results on the association between forward bending of the back and LTSA risk. We did not adjust for the worktime composition of arm elevation (that also includes time spent with arm elevation below shoulder level) in the analysis. This is because of the statistical challenges of modeling two potential overlapping compositions (of ergonomic work exposures such as forward bending of back and arm elevation) in the same model. In the future, we should develop analytical methods that can model the effect of two overlapping compositions of ergonomic exposures and their effect on sickness absence.

Concluding remarks

We found a clear dose-response association between device-measured forward bending of the back and register-based prospective LTSA risk. Five more minutes worktime spent on forward bending of the back >30° and >60° were associated with 4% and 8% higher risk of LTSA, respectively. We consider this new knowledge of specific and realistic dose-response association between forward bending of the back at work and LTSA risk to be useful and valuable for workplace prevention practices by using new practical and feasible device-based tools.

Acknowledgement

We would like to thank the participants and the entire research group involved in the DPHACTO and NOMAD cohorts. We would also like to thank the Danish Working Environment Research Fund (01-2015-09) for providing the financial assistance to the study.

Sidebar

Gupta N, Bjerregaard S S, Yang L, Forsman M, Rasmussen CL, Rasmussen CDN, Clays E, Holtermann A. Does occupational forward bending of the back increase long-term sickness absence risk? A 4-year prospective register-based study using device-measured compositional data analysis. Scand J Work Environ Health. 2022;48(8):651-661. doi:10.5271/sjweh.4047

6 Faculty of Physical Culture, Palacký University, Olomouc, Czech Republic.

7 Department of Public Health and Primary Care, Ghent University, Ghent, Belgium.

8 Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark.

Correspondence to: Nidhi Gupta, National Research Centre for the Working Environment, Lerso Parkalle 105, DK-2100 Copenhagen, Denmark. [E-mail. ngu@nfa.dk]

Received for publication: 1 April 2022

References

References

1. Andersen LL, Thorsen SV, Flyvholm MA, Holtermann A. Long-term sickness absence from combined factors related to physical work demands: prospective cohort study. Eur J Public Health 2018 Oct;28(5):824-9. https://doi.org/10.1093/eurpub/cky073.

2. Høeg MB, Jakobsen KN, Nielsen N. Sygefravær - flere hurtigere tilbage i job [Sickness absenceEnglish translation]. June 2019. A report by Dansk Arbejdsgiverforening. https://www.da.dk/globalassets/besk%C3%A6ftigelse/rapport_rammefort%C3%A6lling_ sygefrav%C3%A6r-flere-hurtigere-tilbage-i-job-20192.pdf

[accessed on 01 December 2021].
3. Rasmussen CD, Sørensen OH, van der Beek AJ, Holtermann A. The effect of training for a participatory ergonomic intervention on physical exertion and musculoskeletal pain among childcare workers (the TOY project) - a wait-list cluster-randomized controlled trial. Scand J Work Environ Health 2020 Jul;46(4):429-36. https://doi.org/10.5271/ sjweh.3884.
4. Rasmussen CD, Holtermann A, Jørgensen MB, Ørberg A, Mortensen OS, Søgaard K. A multi-faceted workplace intervention targeting low back pain was effective for physical work demands and maladaptive pain behaviours, but not for work ability and sickness absence: stepped wedge cluster randomised trial. Scand J Public Health 2016 Aug;44(6):560-70. https://doi. org/10.1177/1403494816653668.
5. Rivilis I, Van Eerd D, Cullen K, Cole DC, Irvin E, Tyson J et al. Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. Appl Ergon 2008 May;39(3):342-58. https://doi.org/10.1016/j. apergo.2007.08.006.
6. Sundstrup E, Seeberg KGV, Bengtsen E, Andersen LL. A Systematic Review of Workplace Interventions to Rehabilitate Musculoskeletal Disorders Among Employees with Physical Demanding Work. J Occup Rehabil. 2020 Dec;30(4):588-612. https://doi.org/10.1007/s10926-020-09879-x.
7. Burgess-Limerick R. Participatory ergonomics: Evidence and implementation lessons. Appl Ergon. 2018 Apr;68:289-293. https://doi.org/10.1016/j.apergo.2017.12.009.
8. Det National Forskningscenter for Arbejdsmiljø. Arbejdsmiljø og Helbred i Danmark, AH. Copenhagen2018 [cited 2021]; Available from: https://nfa.dk/da/Arbejdsmiljoedata/ Arbejdsmiljo-i-Danmark/Arbejdsmiljo-og-helbred-i-Danmark.
9. Andersen LL, Fallentin N, Thorsen SV, Holtermann A. Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. Occup Environ Med 2016 Apr;73(4):246-53. https://doi. org/10.1136/oemed-2015-103314.
10. Wai EK, Roffey DM, Bishop P, Kwon BK, Dagenais S. Causal assessment of occupational bending or twisting and low back pain: results of a systematic review. Spine J 2010 Jan;10(1):76-88. https://doi.org/10.1016/j. spinee.2009.06.005.
11. Koch M, Lunde LK, Gjulem T, Knardahl S, Veiersted KB. Validity of questionnaire and representativeness of objective methods for measurements of mechanical exposures in construction and health care work. PLoS One 2016 Sep;11(9):e0162881. https://doi.org/10.1371/journal. pone.0162881.
12. Takala EP, Pehkonen I, Forsman M, Hansson GÅ, Mathiassen SE, Neumann WP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. Scand J Work Environ Health 2010 Jan;36(1):3-24. https://doi.org/10.5271/sjweh.2876.
13. Korshøj M, Skotte JH, Christiansen CS, Mortensen P, Kristiansen J, Hanisch C et al. Validity of the Acti4 software using ActiGraph GT3X+accelerometer for recording of arm and upper body inclination in simulated work tasks. Ergonomics 2014;57(2):247-53. https://doi.org/10.1080/00 140139.2013.869358.
14. Lunde LK, Koch M, Merkus SL, Knardahl S, Wærsted M, Veiersted KB. Associations of objectively measured forward bending at work with low-back pain intensity: a 2-year follow-up of construction and healthcare workers. Occup Environ Med 2019 Sep;76(9):660-7. https://doi. org/10.1136/oemed-2019-105861.
15. Dencker-Larsen S, Rasmussen CL, Thorsen SV, Clays E, Lund T, Labriola M et al. Technically measured compositional physical work demands and prospective register-based sickness absence (PODESA): a study protocol. BMC Public Health 2019 Mar;19(1):257. https:// doi.org/10.1186/s12889-019-6581-z.
16. Gupta N, Dencker-Larsen S, Lund Rasmussen C, McGregor D, Rasmussen CDN, Thorsen SV, et al. The physical activity paradox revisited: a prospective study on compositional accelerometer data and long-term sickness absence. Int J Behav Nutr Phys Act. 2020 Jul 20;17(1):93. https://doi. org/10.1186/s12966-020-00988-7.
17. Gupta N, Christiansen CS, Hallman DM, Korshøj M, Carneiro IG, Holtermann A. Is objectively measured sitting time associated with low back pain? A cross-sectional investigation in the NOMAD study. PLoS One 2015 Mar;10(3):e0121159. https://doi.org/10.1371/journal. pone.0121159.

18. Jørgensen MB, Gupta N, Korshøj M, Lagersted-Olsen J, Villumsen M, Mortensen OS, et al. The DPhacto cohort: An overview of technically measured physical activity at work and leisure in blue-collar sectors for practitioners and researchers. Appl Ergon. 2019 May;77:29-39. https://doi.org/10.1016/j. apergo.2019.01.003.
19. Villumsen M, Samani A, Jørgensen MB, Gupta N, Madeleine P, Holtermann A. Are forward bending of the trunk and low back pain associated among Danish blue-collar workers? A cross-sectional field study based on objective measures. Ergonomics 2015;58(2):246-58. https://doi.org/10.1080/00 140139.2014.969783.
20. Skotte J, Korshøj M, Kristiansen J, Hanisch C, Holtermann A. Detection of physical activity types using triaxial accelerometers. J Phys Act Health 2014 Jan;11(1):76-84. https://doi.org/10.1123/jpah.2011-0347.
21. Ingebrigtsen JS. Ingunn; Christiansen, Caroline; Skotte, Jørgen; Hanisch, Christiana; Krustrup, Peter; Holtermann, Andreas. Validation of a Commercial and Custom Made Accelerometer-Based Software for Step Count and Frequency during Walking and Running. J Ergonomics. 2013;3(2). https://doi.org/10.4172/2165-7556.1000119.
22. Esola MA, McClure PW, Fitzgerald GK, Siegler S. Analysis of lumbar spine and hip motion during forward bending in subjects with and without a history of low back pain. Spine 1996 Jan;21(1):71-8. https://doi.org/10.1097/00007632199601010-00017.
23. Lagersted-Olsen J, Thomsen BL, Holtermann A, Søgaard K, Jørgensen MB. Does objectively measured daily duration of forward bending predict development and aggravation of low-back pain? A prospective study. Scand J Work Environ Health 2016 Jun;42(6):528-37. https://doi.org/10.5271/ sjweh.3591.
24. Lund T, Kivimäki M, Labriola M, Villadsen E, Christensen KB. Using administrative sickness absence data as a marker of future disability pension: the prospective DREAM study of Danish private sector employees. Occup Environ Med 2008 Jan;65(1):28-31. https://doi.org/10.1136/ oem.2006.031393.
25. Madsen IE, Larsen AD, Thorsen SV, Pejtersen JH, Rugulies R, Sivertsen B. Joint association of sleep problems and psychosocial working conditions with registered longterm sickness absence. A Danish cohort study. Scand J Work Environ Health 2016 Jul;42(4):299-308. https://doi. org/10.5271/sjweh.3571.
26. Sundstrup E, Hansen ÅM, Mortensen EL, Poulsen OM, Clausen T, Rugulies R et al. Retrospectively assessed physical work environment during working life and risk of sickness absence and labour market exit among older workers. Occup Environ Med 2018 Feb;75(2):114-23. https://doi.org/10.1136/oemed-2016-104279.
27. Merkus SL, Mathiassen SE, Lunde LK, Koch M, Wærsted M, Forsman M et al. Can a metric combining arm elevation and trapezius muscle activity predict neck/shoulder pain? A prospective cohort study in construction and healthcare. Int Arch Occup Environ Health 2021 May;94(4):647-58.
28. Wærsted M, Koch M, Veiersted KB. Work above shoulder level and shoulder complaints: a systematic review. Int Arch Occup Environ Health. 2020 Nov;93(8):925-954. https://doi. org/10.1007/s00420-020-01551-4.
29. Gupta N, Korshøj M, Dumuid D, Coenen P, Allesøe K, Holtermann A. Daily domain-specific time-use composition of physical behaviors and blood pressure. Int J Behav Nutr Phys Act. 2019 Jan 10;16(1):4. https://doi.org/10.n86/ s12966-018-0766-1.
30. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 2). J Epidemiol Community Health 2006 Feb;60(2):95-101. https://doi.org/10.1136/jech.2004.028092.
31. Pejtersen JH, Kristensen TS, Borg V, Bjorner JB. The second version of the Copenhagen Psychosocial Questionnaire. Scand J Public Health 2010 Feb;38(3 Suppl):8-24. https:// doi.org/10.1177/1403494809349858.
32. Burr H, Berthelsen H, Moncada S, Nübling M, Dupret E, Demiral Y et al.; international COPSOQ Network. The Third Version of the Copenhagen Psychosocial Questionnaire. Saf Health Work 2019 Dec;10(4):482-503. https://doi.org/10.1016/j.shaw.2019.10.002.
33. Gupta N, Rasmussen CL, Holtermann A, Mathiassen SE. Time-Based Data in Occupational Studies: The Whys, the Hows, and Some Remaining Challenges in Compositional Data Analysis (CoDA). Ann Work Expo Health 2020 Oct;64(8):778-85. https://doi.org/10.1093/ annweh/wxaa056.
34. Gupta N, 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 Mar;48(2): 137-47. https://doi.org/10.5271/sjweh.4000.

35. Egozcue JJ, Pawlowsky-Glahn V, Mateu-Figueras G, Barceló-Vidal C. Isometric Logratio Transformations for Compositional Data Analysis. Math Geol 2003;35(3):279300. https://doi.org/10.1023/A:1023818214614.
36. Grambsch P, Therneau T. Proportional hazards tests and diagnostics based on weighted residuals. Biometrika 1994;81:515-26. https://doi.org/10.1093/biomet/81.3.515.
37. Harrell F. Regression Modeling Strategies. 2nd ed. Heidelberg: Springer; 2015.
38. Gerald van den Boogaart K. Raimon Tolosana, Bren M. Compositional data analysis: Compositions. 1.40-1 ed2013.
39. Templ M, Hron K, Filzmoser P. robCompositions: an R-package for robust statistical analysis of compositional data. In: Pawlowsky-Glahn V, Buccianti A, editors. Compositional Data Analysis Theory and Applications. Chichester (UK) John Wiley &Sons; 2011. p. 341-55.
40. Therneau T. A Package for Survival Analysis in S. 2.38 ed2015.
41. Hoogendoorn WE, Bongers PM, de Vet HC, Ariëns GA, van Mechelen W, Bouter LM. High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. Occup Environ Med 2002 May;59(5):323-8. https://doi. org/10.1136/oem.59.5.323.
42. Murtezani A, Hundozi H, Orovcanec N, Berisha M, Meka V. Low back pain predict sickness absence among power plant workers. Indian J Occup Environ Med 2010 Aug;14(2):4953. https://doi.org/10.4103/0019-5278.72241.
43. Hansson GA, Balogh I, Byström JU, Ohlsson K, Nordander C, Asterland P et al.; Malmö Shoulder-Neck Study Group. Questionnaire versus direct technical measurements in assessing postures and movements of the head, upper back, arms and hands. Scand J Work Environ Health 2001 Feb;27(1):30-40. https://doi.org/10.5271/sjweh.584.
44. Gupta N, Heiden M, Mathiassen SE, Holtermann A. Is self-reported time spent sedentary and in physical activity differentially biased by age, gender, body mass index, and low-back pain? Scand J Work Environ Health. 2018 Mar 1;44(2):163-170. https://doi.org/10.5271/sjweh.3693.
45. Takahashi I, Kikuchi Si, Sato K, Sato N. Mechanical Load of the Lumbar Spine During Forward Bending Motion of the Trunk-A Biomechanical Study. Spine (Phila Pa 1976).2006 Jan 1;31(1):18-23. https://doi.org/10.1097/01. brs.0000192636.69129.fb.
46. Nachemson AL. Disc pressure measurements. Spine 1981 Jan-Feb;6(1):93-7. https://doi.org/10.1097/00007632198101000-00020.
47. Yang L, Forsman M. A user guide for ErgoArmMeter Stockholm, Sweden: Karolínska Institute, 2015 Contract No.: Version 2016-02-23.
48. Yang L, Grooten WJ, Forsman M. An iPhone application for upper arm posture and movement measurements. Appl Ergon 2017 Nov;65:492-500. https://doi.org/10.1016/j. apergo.2017.02.012.
49. Lind CM, Yang L, Abtahi F, Hanson L, Lindecrantz K, Lu K, et al. Reducing postural load in order picking through a smart workwear system using real-time vibrotactile feedback. Appl Ergon. 2020 Nov;89:103188. https://doi.org/10.1016/j. apergo.2020.103188
50. Dumuid D, Pedišić Ž, Palarea-Albaladejo J, MartínFernández JA, Hron K, Olds T. Compositional data analysis in time-use epidemiology: What, why, how. Int J Environ Res Public Health 2020 Mar;17(7):E2220. https://doi. org/10.3390/ijerph17072220.

DETAILS

Subject:	Physical activity; Accelerometers; Self report; Employment; Questionnaires; Risk assessment; Body mass index; Risk analysis; Data analysis; Workers; Participation; Knowledge; Illnesses; Body mass; Bending machines; Body size; Bend tests; Risk factors; Thigh; Sick leave

Business indexing term:	Subject: Employment Risk assessment Workers Sick leave
Location:	Denmark
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	651-661
Publication year:	2022
Publication date:	2022
Section:	Original article
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4047
ProQuest document ID:	2738247350
Document URL:	https://www.proquest.com/scholarly-journals/does-occupational-forward-bending-back-increase/docview/2738247350/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022
Last updated:	2023-08-22
Database:	Public Health Database

Overqualification at work and risk of hospitalization for psychiatric and somatic diseases among immigrants in Sweden - a prospective register-based study

Brendler-Lindqvist, Maria [1] ; Tondel, Martin [2] ; Helgesson, Magnus [3] ; Nordqvist, Tobias; Svartengren, Magnus [1] Department of Medical Sciences, Occupational and Environmental Medicine, Uppsala University, Uppsala, Sweden. [2] Occupational and Environmental Medicine, Uppsala University Hospital, Uppsala, Sweden. [3] Department of Clinical Neuroscience, Division of Insurance Medicine, Karolínska Institutet, Stockholm, Sweden.

ABSTRACT (ENGLISH)

Objectives This study aimed to (i) describe the prevalence of overqualification at work among immigrants in Sweden and (ii) analyze any association between overqualification and the risk of hospitalization for somatic and psychiatric disease among refugees and labor immigrants. Methods We performed a prospective register study in a cohort of 120 339 adults who immigrated to Sweden in 1991-2005 and were employed in 2006. Education-occupation status was defined as the combination of an individual's highest level of education and their occupation skill level. Individuals were followed from 2007 to 2016 with regard to hospitalization for a psychiatric, cardiovascular, respiratory or musculoskeletal disease or diabetes. Hazard ratios (HR) with 95% confidence intervals (CI) were calculated in a multivariate Cox regression analysis adjusted for age, gender, reason for residence and duration of residence. Results The overall prevalence of overqualification among immigrants with an academic education was 39%. Overqualified individuals had an increased risk of hospitalization for any disease (HR 1.33, 95% CI 1.21-1.46) compared to "job-matched with an academic education". However, the risk estimates were lower than that of "job-matched with no academic education" (HR 1.56, 1.46-1.68). The increased risk of hospitalization for a psychiatric disease of overqualified individuals did not differ from that of job-matched with no academic education. Conclusion Our study showed that being overqualified was associated with poorer health outcomes than jobmatched individuals with an academic education. Considering the high prevalence of overqualification in immigrants, this constitutes a concern, for both society and individuals.

FULL TEXT

Headnote

Objectives This study aimed to (i) describe the prevalence of overqualification at work among immigrants in Sweden and (ii) analyze any association between overqualification and the risk of hospitalization for somatic and psychiatric disease among refugees and labor immigrants. Methods We performed a prospective register study in a cohort of 120 339 adults who immigrated to Sweden in 1991-2005 and were employed in 2006. Education-occupation status was defined as the combination of an individual's highest level of education and their occupation skill level. Individuals were followed from 2007 to 2016 with regard to hospitalization for a psychiatric, cardiovascular, respiratory or musculoskeletal disease or diabetes. Hazard ratios (HR) with 95% confidence intervals (CI) were calculated in a multivariate Cox regression analysis adjusted for age, gender, reason for residence and duration of residence. Results The overall prevalence of overqualification among immigrants with an academic education was 39%. Overqualified individuals had an increased risk of hospitalization for any disease (HR 1.33, 95% CI 1.21-1.46)

compared to "job-matched with an academic education". However, the risk estimates were lower than that of "job-matched with no academic education" (HR 1.56, 1.46-1.68). The increased risk of hospitalization for a psychiatric disease of overqualified individuals did not differ from that of job-matched with no academic education. Conclusion Our study showed that being overqualified was associated with poorer health outcomes than jobmatched individuals with an academic education. Considering the high prevalence of overqualification in immigrants, this constitutes a concern, for both society and individuals.

Key terms discrimination; emigration; employment; immigration; labor migrant; migrant worker; mismatch; occupational exposure; occupational health; refugee; status incongruence; status incongruency; status inconsistency; occupation; working condition; work exposure; work-related health.

Migration is a growing phenomenon, and in 2019 the number of international immigrants reached almost 272 million globally (1). In Sweden, immigrants made up about 25% of the working age population in 2020, a proportion that is expected to increase (2). In recent years, about half of newly arrived immigrants had a post-secondary education, a figure higher than among the Swedish-born population (3). Immigrants make important contributions to the Swedish labor force, but labor market integration of immigrants also brings challenges. Studies have shown that immigrants have higher rates of un- or underemployment, overqualification, and allocation to more physically demanding and lower paid occupations than the non-immigrant population (4, 5).

One adverse working condition that affects immigrant populations to a high extent is overqualification, ie, a situation where the educational or skill attainment exceeds the qualifications required for the occupation. The rate of overqualification among immigrants with post-secondary education was 10% points higher than among the nonimmigrant population in the OECD countries in 2017 (6). In Sweden, recent numbers have shown that 74% of immigrants with an academic education were employed in an occupation that matched their qualifications, compared with 90% among the Swedish-born (7). The health consequences of overqualification are not fully understood. While some studies found negative effects of overqualification on self-rated health (8, 9), mental health (10, 11), work injuries (12), incidence of cardiovascular disease (13) and mortality (14), there have also been studies not finding any such associations (15-17). One possible explanation for the observed negative health effects is that overqualification leads to psychological stress due to a sense of inferiority and lost social status (14). Over time, such stress may increase the risk of cardiovascular disease and diabetes through biological stress response mechanisms and maladaptive coping behaviors, such as alcohol consumption and smoking (14, 18). Negative health effects may also be due to social and organizational factors at the workplace, for example overqualified individuals may suffer from lack of relevant vocational training for the job and less solidarity from colleagues increasing the risk of exposure to work hazards (12).

Despite the magnitude of the problem with overqualification among immigrant workers, only four studies were identified that focused specifically on immigrant populations (8, 10, 11, 19). These studies were small, surveybased, and focused on selected groups, such as newly arrived immigrants. Moreover, most of the studies made use of cross-sectional analysis, which limits the possibility of drawing conclusions regarding causal directions. Thus, there is a need to better understand the long-term health consequences for this particular group. To the best of our knowledge, there is no former study on the health consequences of overqualification among immigrant populations with a prospective study design using objective measurements of health status, such as hospitalization for somatic and psychiatric diseases. Most immigrants to Sweden are refugees, who make up a more vulnerable group when it comes to both health and the risk of overqualification. By studying a large, economically active population of immigrants to Sweden - including refugees and labor immigrants - we were able to increase knowledge on how overqualification affects the health.

The aims of this study were to describe the prevalence of overqualification among immigrants in Sweden and to analyse any association between overqualification and the risk of hospitalization for somatic and psychiatric disease among refugees and labor immigrants.

Methods

Study design

This was a prospective cohort study based on register data. The index population was defined on 31 December 2006 and included all individuals born in 1942-1987 who immigrated to Sweden from selected geographical regions in 1991-2005 and who were aged 18-59 years at the time of immigration (N=287 635). The selected regions were: (i) Eastern Europe, Russia and the post-Soviet republics, (ii) the West (including Western Europe, USA, Canada, Australia and New Zealand), (iii) the Middle East, (iv) the Horn of Africa and Sudan, (v) South and Central America, (vi) East Asia and (vii) other. These regions are the origin of the vast majority of non-Nordic immigrants to Sweden and were defined in order to create somewhat homogenous units in terms of national income level, language, culture and religion. As 65 years was the regular retirement age in Sweden in 2006, individuals aged >64 years at baseline were excluded. Only individuals with a registered income from employment in November 2006 were included. In the index population, 48% (N=137 947) did not fulfil this criterion. Moreover, immigrants were excluded from the study if there was information on neither reason for residence (N=1307) nor education and/or occupation (N=27 213). We also excluded individuals hospitalized in 2006 for a psychiatric, cardiovascular, respiratory or musculoskeletal disease or for diabetes, as these are diseases of a persistent nature or with a high risk of relapse, which can be assumed to affect work ability (N=829). The final study population consisted of 120 339 individuals, who were followed from 1 January 2007 to 31 December 2016. The study population differed from the index population mainly regarding time since residence as 25% of the included individuals had been in Sweden less than six years, compared to 52% among those who did not meet the inclusion criteria.

All data were retrieved from national registers at Statistics Sweden and the Swedish National Board of Health and Welfare and linked at an individual level through the unique personal identification number assigned to each individual when obtaining a residence permit in Sweden. These numbers were replaced by a serial number by Statistics Sweden before data were made available to the researchers in order to guarantee anonymity. Information on demographic characteristics and reason for residence were retrieved from Statistics Sweden's longitudinal database for integration studies (STATIV). Immigrants were defined as individuals born outside Sweden with two parents born outside Sweden. Immigrants from the Nordic countries were not included in the study as information on reason for residence is largely lacking in the registers due to an agreement on free movement between the Nordic countries.

The Regional Ethics Review Board in Uppsala, Sweden, approved the study (file number 2021-01893).

Variables

Exposure. In this study, education-occupation status was defined in an objective way by combining information on an individual's education and occupation from the longitudinal integrated database for health insurance and labor market studies (LISA). Information on individuals' occupation titles is provided by employers on a yearly basis and classified based on the Swedish Standard Classifications of Occupations (SSYK96). SSYK is a national adaptation to the International Standard Classification of Occupations (ISCO-88) and is a hierarchical classification with four levels, based on the type of work performed and the skill level required. The baseline year of 2006 was chosen as this was the first year when information on occupation was available for all sectors. Information on education obtained in Sweden was retrieved from education registers. Information on foreign education was retrieved from multiple sources. From 1999 and onward, each immigrant receives a survey from Statistics Sweden in the year after obtaining residency with questions regarding education level. Supplementary surveys to immigrants for whom there is no information on education in the register were sent out in 1995, 1999 and 2005/2006. Survey information is updated later, when immigrants register their qualifications in contacts with the Swedish authorities. For the purpose of this study, academic education was defined with a cut-off of post-secondary education of three years or more. Managerial work, occupations requiring an advanced level of higher education and occupations requiring higher education qualifications or the equivalent were defined as qualified occupations for an individual with an academic education. All other occupations were defined as non-qualified. Thus, overqualification was defined as having a postsecondary education of >3 years and an occupation not requiring higher education qualification according to SSYK96. Conversely, an individual with <3 years of post-secondary education and an occupation requiring higher education was defined as underqualified. Individuals with post-secondary education of >3 years and an occupation

requiring higher education were defined as "job-matched with an academic education", while individuals without post-secondary education and an occupation not requiring higher education were defined as "job-matched with no academic education".

Outcome

Data on main discharge diagnoses from in-patient care at Swedish hospitals coded with the International Classification of Diseases, version 10 (ICD-10) (20) were retrieved from the National Patient Register (NPR). NPR is held by the Swedish National Board of Health and Welfare, and the reporting of data is mandatory for the County Councils. The outcome was defined as being hospitalized at least once for selected diagnoses from the ICD-10 chapters mental and behavioral disorders, diseases of the circulatory system, diseases of the respiratory system or diseases of the musculoskeletal system and connective tissue, or having a diagnosis of diabetes, hereafter referred to as psychiatric, cardiovascular, respiratory and musculoskeletal diseases (table 1). The selected diagnoses represented 81% of all hospitalizations in 2006 and are diseases of a persistent nature or with a high risk of relapse.

Covariates

Demographic characteristics considered in the statistical model were sex, age at baseline, duration of residence and reason for residence. Age at baseline was derived as the difference between 2006 and year of birth and presented in four age groups: 19-29, 30-39, 40-49 and 50-64 years. Duration of residence was calculated as the difference between 2006 and year of residency registered by the Swedish Migration Agency, and was categorized as 11-15, 6-10 or 1-5 years. Individuals were classified as (i) refugees, (ii) family reunification immigrants, (iii) labor immigrants, and (iv) others, based on reason for residence as registered by the Swedish Migration Agency. For individuals who were granted residence more than once, information on the last reason for residence was used. The group 'others' consisted of 80% of students.

Statistical analyses

Hazard ratios (HR) with 95% confidence intervals (CI) were calculated with multivariate Cox regression analysis in SPSS version 27 (IBM Corp, Armonk, NY, USA), for hospitalization for any psychiatric, cardiovascular, respiratory or musculoskeletal disease, or diabetes, depending on which occurred first. HR were also calculated for each of the psychiatric, cardiovascular, respiratory, and musculoskeletal disease groups separately. No separate analysis was carried out regarding hospitalization for diabetes due to too few cases. "Job-matched with academic education" was chosen as the reference. Person-years under risk for disease were calculated from 1 January 2007 to the first event of emigration, death or hospitalization for any of the diseases studied, or to the end of study on 31 December 2016. Analyses were adjusted for sex, age at baseline (continuous), reason for residence and duration of residence. Reason for residence and region of origin were highly correlated and therefore could not be included in the same model. We chose to include reason for residence, rather than geographical region, based on the assumption that reason for residence was the more decisive factor for overqualification as the conditions for establishing oneself on the labor market vary considerably between voluntary and forced immigrants. As a sensitivity analysis, we ran a separate model adjusted for region of origin, instead of reason for residence. In order to investigate whether the reason for residence modified the effect of overqualification on hospitalization, we conducted a separate regression analysis restricted to refugees and labor immigrants with an academic education. We then calculated the relative excess risk due to interaction (RERI) of the combination of refugee status and overqualification, as suggested by Rothman for investigation of additive interaction in epidemiological research (21). We also calculated RERI for each sex, as well as for duration of residence (11-15 versus 1-5 years), on the association between overqualification and health among immigrants with an academic education. We used the Delta method to obtain 95% CI for the estimate of the interaction (22). In order to study how a prolonged exposure to overqualification affected the association with health, we ran a separate model including only those individuals (N=77 613) who had a constant education-occupation status during the follow-up period. To estimate the effect of prior health on the association between education-occupation status and health we carried out a sensitivity analysis where we excluded all individuals hospitalized for any of the diseases under study during the period between receiving a residence permit in Sweden and baseline.

Results

Refugees and family reunion immigrants constituted 40% and 52% of the study population, respectively, while labor immigrants made up 6.4%. Eastern Europe, Russia and the post-Soviet republics was the most common region of origin, followed by the Middle East and the West. Three quarters of the population were aged 30-49 years, ie, in the middle of their working career, and 47.5% had resided in Sweden for >10 years (table 2). The overall rate of overqualification among individuals with an academic education was 39% independent of sex. The prevalence of overqualification differed considerably depending on the reason for residence. Among males, 55% of refugees with an academic education were overqualified, while the rate was 13% among labor immigrants. Among females, the rate of overqualification was 40% among refugees and 16% among labor immigrants, respectively. Overqualification was more common in the youngest and oldest age groups. Sex differences were generally small, except among refugees where males had the highest rate of overqualification. There was a reduction in overqualification by duration of residence among female immigrants, but not among males (figure 1). The cumulative incidence rate of any of the diseases under study during follow-up was 6.9% in the total population. The cumulative incidence rate for hospitalization for a cardiovascular disease was higher among males than females, while the opposite was true for psychiatric disease (table 1).

Overqualified individuals had a significantly higher risk of being hospitalized for any of the diseases under study than job-matched with an academic education with HR 1.33 (95% CI 1.21-1.46) (table 3). For underqualified individuals the HR was 1.36 (95% CI 1.21-1.46). Job-matched with no academic education had the highest risk of hospitalization for any of the diseases under study with HR 1.56 (95% CI 1.46-1.68). Separate analyses of the risk of hospitalization by disease group showed that over- and underqualified individuals had a significantly increased risk of hospitalization for a psychiatric, cardiovascular or musculoskeletal disease compared with job matched with an academic education (figure 2). The risk estimates of hospitalization for a respiratory disease were increased for over- and underqualified individuals compared with job-matched with an academic education, but the difference did not reach statistical significance. The HR of hospitalization for a psychiatric disease were 1.41 (95% CI 1.18-1.70) for overqualified and 1.50 (95% CI 1.31-1.75) for underqualified and did not differ from the HR of jobmatched with no academic education which was 1.51 (95% CI 1.31-1.75). Adjusting for covariates only slightly attenuated the results. The adjustment for region of origin instead of reason for residence did not change the results (data not shown). Testing for interactions did not show any modifying effect of being a refugee or a labor immigrant on the risk of hospitalization for any one disease under study depending on education-occupation status. Interaction was not seen between overqualification and either sex or duration of residence (1-5 versus 11-15 years) in relation to the risk of hospitalization for any of the diseases under study. In our cohort of immigrants, 64.5% did not change their education-occupation status during follow-up, and among overqualified individuals, 52.9% did not change their status during follow-up. The association between over- and underqualified and the risk of hospitalization remained when the analysis was restricted to those individuals who had an unchanged educationoccupation status with HR 1.35 (95% CI 1.20-1.52) for overqualified and HR 1.41 (95% CI 1.21-1.63) for underqualified, respectively. The HR among persistent job-matched with no academic education was 1.41 (95% CI 1.30-1.54). Excluding all individuals hospitalized for any of the diseases under study up to nine years before baseline did not change the association between education-occupation status and hospitalization during follow-up (data not shown).

Discussion

In this study of a large and representative population of economically active immigrants in Sweden, about a third had an academic education. Of those with academic education, 39.4% did not have an occupation requiring higher education. Similar rates of overqualification have been shown in previous studies (7, 16, 23). Our results showed that overqualified individuals had a risk of hospitalization for any of the diseases under study that was higher than that of job-matched with an academic education, but lower than that of job-matched individuals with no academic education. Moreover, overqualified individuals had a significantly increased risk of hospitalization for a psychiatric, cardiovascular or musculoskeletal disease compared with job-matched with academic education. Regarding hospitalization for a psychiatric disease, the increased risk estimates did not differ between the overqualified and the

job-matched with no academic education.

There may be several explanations for the health status observed among overqualified individuals in this study. First, overqualified individuals may experience psychological stress due to reasons such as status incongruence and a sense of inferiority, effort-reward imbalance and perceived work-related discrimination with negative effects on mental health (5, 14, 24). Over time, psychosocial stress may also increase the risk of somatic disease through biological mechanisms as well as negative coping behavior such as smoking (14, 18). Second, overqualified individuals may be exposed to occupational hazards common in occupations with lower educational requirements and thus share exposures with non-qualified workers. Occupations defined as nonqualified in this study included manual occupations with a known risk of exposure to inhaled dust and particles, noise, heavy physical labor, as well as other physical and chemical exposures, increasing the risk of occupational lung diseases (25, 26), cardiovascular disease (27), and musculoskeletal diseases such as chronic back pain, rotator cuff diseases and knee arthrosis (28-30). A third explanation may be that social and organizational factors in the work environment result in a higher risk of exposure to work hazards for overqualified compared with job-matched individuals (12). The fact that over-qualified individuals in this study had a similar risk of hospitalization for psychiatric disease as job-matched with no academic education, which was not the case for the other disease groups, lends support to a psy-chological pathway. This is in line with other studies showing an association between overqualification and poor mental health measured through screening instruments validated for detecting risk of psychiatric disorders (11, 31, 32). Regarding the somatic diseases, our results showed that the risk of hospitalization was higher among overqualified workers than among job-matched with an academic education, but lower than among jobmatched with no academic education, which may be due to a combination of the above-mentioned factors. Earlier research on the effects of overqualification on cardiovascular diseases has been inconclusive. While one study found an association between overqualification and ischemic heart disease (13), other studies did not find any associations between overqualification and cardiovascular mortality (17), myocardial infarction or stroke (15). The effect of overqualification on respiratory and musculoskeletal diseases has, to the best of our knowledge, not been studied before.

A striking feature in our data was that about half of the immigrants who settled in Sweden between 1991-2005 did not have a registered income from employment in 2006. Research has documented negative health effects of unemployment (33, 34). Thus, being overqualified may be a better alternative from a health perspective than being unemployed. On the other hand, for educated individuals, unemployment may be considered a form of overqualification, irrespective of the educational level, as they are not able to use their skills in any occupation. However, the health consequences of overqualification among the unemployed were beyond the scope of this study. Suggested reasons for the high prevalence of overqualification among immigrant populations are lack of recognition of foreign credentials and experiences, lack of connections and networks, poor proficiency in the language of the destination country and possible discrimination by employers (9, 11, 35). In our study, refugees and family reunification immigrants were the groups with the highest rates of overqualification, while the rate was lowest among labor immigrants. Non-labor immigrants may differ regarding educational orientation, as labor immigrants may have chosen to migrate due to job opportunities, while the migration decision was driven by other factors for refugees and family reunification immigrants. The presence of discrimination towards individuals from non-dominant ethnicities may be another factor that affects refugees to a higher extent than labor immigrants, as a greater proportion of refugees originated from non-Western countries (36, 37). It has been argued that working in an occupation for which one is overqualified may provide a pathway toward more qualified occupations. However, in our study, 53% of the overqualified participants remained overqualified for 10 years. This is consistent with another study showing a high persistence of overqualification among immigrants, indicating that overqualification may not be a temporary state in this group (36).

In the study population, underqualification was substantially less common than overqualification and was therefore not the focus of this study. The underqualified presented higher risk of hospitalization than jobmatched with an academic education, the reasons need to be investigated in other studies with focus on this form for education-

occupation mismatch.

Strengths and limitations

The major strength of our study was the prospective design, with each individual being followed annually for health outcomes during a ten-year period. This design made it possible to study the long-term health consequences of overqualification, which had not been studied in immigrant populations before. In an international comparison, our study was based on highly qualitative national registers with a complete coverage of all registered immigrants in Sweden during the study period. Refugees constituted about 40% of our study population, a group not specifically studied before. Another strength of our study was the use of registered diagnoses after hospitalization, instead of relying on self-reported data. As the Swedish healthcare system is accessible to all residents on equal terms, and as underreporting of data on inpatient care to the national patient register is low, selection bias is considered to be very small. Thus, our study adds knowledge on the health consequences of overqualification for a broad range of severe somatic and psychiatric conditions, which have not been studied before. By including only health conditions requiring hospital treatment, we could reduce bias due to differences in health-seeking behavior between immigrant groups. There is a tendency that less educated individuals do not approach health services to the same extent as more highly educated individuals, but including only severe cases reduced this kind of bias.

The study also suffered from some limitations. First, we lacked information on lifestyle factors or workrelated exposures with possible consequences for health. The role of these factors for the associations between overqualification and health outcomes would be of interest for further studies using other methods. Second, we also lacked information on chronic conditions others than when leading to hospitalization. This means we cannot fully exclude the possibility of bias due to health-related selection as the medical conditions we studied can reduce work capacity long before resulting in hospitalization. A sensitivity analysis including only individuals not hospitalized in Sweden prior to baseline due to any of the diseases under study did not change our results. However, this does not exclude the possibility of a health-related selection, especially among the 25% of immigrants who had resided in Sweden for <6 years. A third limitation was the risk of misclassification, as we were not able to consider informal qualifications, such as on-the-job courses or previous work experience. Such misclassification may have diluted the differences between groups, thus leading to an underestimation of the real effect. Lastly, the study did not include undocumented immigrants, a group of particular risk having hazardous work exposures. According to authorities there were between 20-50 000 undocumented immigrants living in Sweden in 2017, but being relatively few in relation to the total immigrant population it would probably not have changed the overall results had they been included in our study (38)

Concluding remarks

Overqualification is a substantial problem among immigrants with an academic education on the Swedish labor market. Our study showed that being overqualified was associated with poorer health outcomes than among job-matched individuals with an academic education. Considering the high prevalence of overqualification among immigrants, this constitutes a concern for both society and individuals. Further studies are needed to better understand determinants for overqualification and the mechanisms behind the negative health effects.

Acknowledgements

This work was supported by the regional agreement on medical training and clinical research (ALF) between Uppsala University and Uppsala University Hospital in Uppsala, Sweden and FORTE, Project-ID 202101561_Forte. The authors declare no conflicts of interest.

Sidebar

Brendler-Lindqvist M, Tondel M, Helgesson M, Nordqvist T, Svartengren M. Overqualification at work and risk of hospitalization for psychiatric and somatic diseases among immigrants in Sweden - a prospective register-based study. Scand J Work Environ Health. 2022;48(8):632-640. doi:10.5271/sjweh.4055

Correspondence to: Maria Brendler-Lindqvist, Occupational and Environmental Medicine Uppsala University Hospital, 751 85 Uppsala, Sweden. [E-mail: maria.brendler-lindqvist@medsci.uu.se]

Received for publication: 4 October 2021

References

References

1. International Organization for Migration (IOM). World Migration Report 2020. Geneva: IOM; 2019.
2. Statistics Sweden. Arbetskraftsundersökningarna (AKU) [Labor Force Surveys (LFU)] (In Swedish) [cited 2021 Sept 21]. Available from: https://www.statistikdatabasen.scb.se/ sq/113829
3. Statistics Sweden. Utrikes föddas utbildningsbakgrund 2017 [Educational background 2017 among foreign born persons] (In Swedish) Örebro: Statistics Sweden; 2018.
4. Ambrosini M, Barone C. Employment and working conditions of migrant workers. Dublin: European Foudation for the Improvement of Living and Working Conditions; 2007.
5. Sterud T, Tynes T, Mehlum IS, Veiersted KB, Bergbom B, Airila A et al. A systematic review of working conditions and occupational health among immigrants in Europe and Canada. BMC Public Health 2018 Jun;18(1):770. https://doi.org/10.1186/s12889-018-5703-3.
6. OECD. International Migration Outlook 2017. Paris: OECD Publishing; 2017.
7. Edström J. Sveriges utrikesfödda akademiker [Foreign-born graduates in Sweden] (In Swedish). Stockholm: Edström J and SACO; 2015.
8. Dunlavy AC, Garcy AM, Rostila M. Educational mismatch and health status among foreign-born workers in Sweden. Soc Sci Med 2016 Apr;154:36-44. https://doi.org/10.1016/j. socscimed.2016.02.018.
9. Smith P, Frank J. When aspirations and achievements don't meet. A longitudinal examination of the differential effect of education and occupational attainment on declines in selfrated health among Canadian labor force participants. Int J Epidemiol 2005 Aug;34(4):827-34. https://doi.org/10.1093/ ije/dyi047.
10. Chen C, Smith P, Mustard C. The prevalence of overqualification and its association with health status among occupationally active new immigrants to Canada. Ethn Health 2010 Dec;15(6):601-19. https://doi.org/10.1080/13557858.2010.502591.
11. Reid A. Under-use of migrants' employment skills linked to poorer mental health. Aust N Z J Public Health 2012 Apr;36(2):120-5. https://doi.org/10.1111/j.17536405.2012.00842.x.
12. Premji S, Smith PM. Education-to-job mismatch and the risk of work injury. Inj Prev 2013 Apr;19(2):106-11. https://doi. org/10.1136/injuryprev-2011-040314.
13. Peter R, Gässler H, Geyer S. Socioeconomic status, status inconsistency and risk of ischaemic heart disease: a prospective study among members of a statutory health insurance company. J Epidemiol Community Health 2007 Jul;61(7):605-11. https://doi.org/10.1136/ jech.2006.047340.
14. Garcy AM. Educational mismatch and mortality among native-born workers in Sweden. A 19-year longitudinal study of 2.5 million over-educated, matched and undereducated individuals, 1990-2008. Sociol Health Illn 2015 Nov;37(8):1314-36. https://doi.org/10.1111/14679566.12312.
15. Braig S, Peter R, Nagel G, Hermann S, Rohrmann S, Linseisen J. The impact of social status inconsistency on cardiovascular risk factors, myocardial infarction and stroke in the EPIC-Heidelberg cohort. BMC Public Health 2011 Feb;11:104. https://doi.org/10.1186/1471-2458-11-104.
16. Hultin H, Lundberg M, Lundin A, Magnusson C. Do overeducated individuals have increased risks of ill health?: a Swedish population-based cohort study. Sociol Health Illn 2016 Jul;38(6):980-95. https://doi.org/10.llll/14679566.12419.
17. Smith BT, Smith PM, Etches J, Mustard CA. Overqualification and risk of all-cause and cardiovascular mortality: evidence from the Canadian Census Mortality Follow-up Study (1991-2001). Can J Public Health 2012 Jun;103(4):e297-302. https://doi.org/10.1007/BF03404239.
18. McEwen BS. Protective and damaging effects of stress mediators. N Engl J Med 1998 Jan;338(3):171-9. https://doi.org/10.1056/NEJM199801153380307.
19. Frank K, Hou F. Over-education and well-being: how does education-occupation mismatch affect the life satisfaction of university-educated immigrant and non-immigrant workers? Ethn Health 2018 Nov;23(8):884-901. https://doi.org/10.10 80/13557858.2017.1316832.

20. World Health Organization. International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD 10): WHO; [cited 2021 Sept 20]. Available from: https://icd.who.int/browse10/2019/en#/.
21. Andersson T, Alfredsson L, Källberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. Eur J Epidemiol 2005;20(7):575-9. https://doi.org/10.1007/ s10654-005-7835-x.
22. Hosmer DW, Lemeshow S. Confidence interval estimation of interaction. Epidemiology 1992 Sep;3(5):452-6. PubMed https://doi.org/10.1097/00001648-199209000-00012.
23. Statistics Sweden. Arbetsmarknaden 2018 för högutbildade utrikes födda [The labor market in 2018 for foreign born persons with a higher education] (In Swedish). Örebro: Statistics Sweden; 2019.
24. Siegrist J. Adverse health effects of high-effort/low-reward conditions. J Occup Health Psychol 1996 Jan;1(1):27-41. https://doi.org/10.1037/1076-8998.1.1.27.
25. Jalasto J, Lassmann-Klee P, Schyllert C, Luukkonen R, Meren M, Larsson M et al. Occupation, socioeconomic status and chronic obstructive respiratory diseases - The EpiLung study in Finland, Estonia and Sweden. Respir Med 2022 Jan;191:106403. https://doi.org/10.1016/j. rmed.2021.106403.
26. Torén K. Viktigt att överväga yrke som orsak till lungsjukdom [Occupational exposures should be considered in all patients with non-malignant respiratory diseases] [In Swedish] [FTHA.]. Lakartidningen. 2019 Nov 26;116:FTHA.
27. Statens beredning för medicinsk och social utvärdering (SBU). Arbetsmiljöns betydelse för hjärt-kärlsjukdom: en systematisk litteraturöversikt [Occupational Exposures and Cardiovascular Disease] (In Swedish). Stockholm: SBU; 2015.
28. Statens beredning för medicinsk utvärdering (SBU). Arbetsmiljöns betydelse för ryggproblem: en systematisk litteraturöversikt [Occupational Exposure and Back Disorders] (In Swedish). Stockholm: SBU; 2014.
29. Statens beredning för medicinsk och social utvärdering (SBU). Arbetsmiljöns betydelse för artrosbesvär: en systematisk översikt och utvärdering av medicinska, sociala och etiska aspekter [Occupational Exposure and Osteoarthritis] (In Swedish). Stockholm: SBU; 2016.
30. van der Molen HF, Foresti C, Daams JG, Frings-Dresen MH, Kuijer PP. Work-related risk factors for specific shoulder disorders: a systematic review and meta-analysis. Occup Environ Med 2017 Oct;74(10):745-55. https://doi.org/10.1136/oemed-2017-104339.
31. Bracke P, Pattyn E, von dem Knesebeck O. Overeducation and depressive symptoms: diminishing mental health returns to education. Sociol Health Illn 2013 Nov;35(8):1242-59. https://doi.org/10.1111/1467-9566.12039.
32. Nyberg A, Johansson G, Westerlund H, Rostila M, Toivanen S. Status incongruence in human service occupations and implications for mild-to-severe depressive symptoms and register-based sickness absence: A prospective cohort study. Scand J Work Environ Health 2020 Mar;46(2):209-17. https://doi.org/10.5271/sjweh.3853.
33. Paul K, Moser K. Unemployment impairs mental health: meta-analyses. J Vocat Behav 2009;74(3):264-82. https:// doi.org/10.1016/jjvb.2009.01.001.
34. Helgesson M, Johansson B, Nordqvist T, Lundberg I, Vingård E. Unemployment at a young age and later sickness absence, disability pension and death in native Swedes and immigrants. Eur J Public Health 2013 Aug;23(4):606-10. PubMed https://doi.org/10.1093/eurpub/cks099.
35. Crollard A, de Castro AB, Tsai JH. Occupational trajectories and immigrant worker health. Workplace Health Saf 2012 Nov;60(11):497-502. https://doi. org/10.1177/216507991206001105.
36. Joona PA, Gupta ND, Wadensjö E. Overeducation among immigrants in Sweden: incidence, wage effects and state dependence. IZA Journal of Migration. 2014;3(1):1-23. https://doi.org/10.1186/2193-9039-3-9.
37. Åslund O, Forslund A, Liljeberg L. Labor market entry of non-labor migrants - Swedish evidence, IFAU Working paper 2017:15. Uppsala: IFAU - Institute for Evaluation of Labor Market and Education Policy; 2017.
38. SOU - Swedish Government Official Reports 2017:93. Klarlagd identitet. Om utlänningars rätt att vistas i Sverige, inre utlänningskontroller och missbruk av identitetshandlingar. [Verified identity. About the right of foreign nationals to stay in Sweden, internal checks on foreigners, and the misuse of identity documents. enquiry emphasized the importance of verifying a person's identity] (In Swedish). Stockholm; 2017.

DETAILS

Subject:	Refugees; Population; Diabetes; Qualifications; Immigrants; Employment; Regression analysis; Overqualification; Statistical analysis; Risk; Mental disorders; Immigration; Hospitalization; Occupations; Labor market; Musculoskeletal diseases; Confidence intervals; Education; Diabetes mellitus; Cardiovascular disease
Business indexing term:	Subject: Qualifications Employment Overqualification Labor market
Location:	Sweden
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	632-640
Publication year:	2022
Publication date:	2022
Section:	Original article
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finla nd, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4055
ProQuest document ID:	2738246996
Document URL:	https://www.proquest.com/scholarly-journals/overqualification-at-work-risk-hospitalization/docview/2738246996/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022

Last updated:	2023-03-06
Database:	Public Health Database

Occupational risk of COVID-19 across pandemic waves: a two-year national follow-up study of hospital admissions

Bonde, Jens Peter Ellekilde, MD [1] ; Sell, Lea, PhD [1] ; Jensen, Johan Høy, PhD [1] ; Begtrup, Luise Mølenberg, PhD [1] ; Flachs, Esben Gracht, PhD [1] ; Jakobsson, Kristina, PhD; Nielsen, Christel, PhD; Nilsson, Kerstin, PhD; Rylander, Lars, PhD; Petersen, Kajsa Ugelvig, PhD; Tøttenborg, Sandra Søgaard, PhD [1] Department of Occupational and Environmental Medicine, Bispebjerg and Frederiksberg Hospital, Copenhagen University Hospital, Copenhagen, Denmark

ABSTRACT (ENGLISH)

Objective Assuming that preventive measures to mitigate viral transmission of SARS-CoV-2 at the workplace may have been improved in the course of the COVID-19 pandemic, we examined the occupational risk of COVID-19 related hospital admission across the four pandemic waves in Denmark between week 8, 2020, and week 50, 2021. Methods The study included 4416 cases of COVID-19 related hospital admissions among 2.4 million Danish employees aged 20-69 with follow-up in 2020 through 2021. At-risk industrial sectors and a reference population were defined a priory by a job-exposure matrix on occupational risk for COVID-19. Incidence rate ratios (IRR) and potential effect modification by pandemic wave were computed with Poisson regression adjusted for demographic, social and health factors including completed COVID-19 vaccination. Results We observed an overall elevated relative risk in four of six at-risk industrial sectors, but the pandemic wave only modified the risk among healthcare employees, where the excess risk from a high initial level declined to background levels during the latest waves in models not adjusting for COVID-19 vaccination. In social care, education and transport, the elevated risk was not modified by pandemic wave. Conclusion Danish healthcare employees were to some extent protected against occupational transmission of SARS-CoV-2 during the two last pandemic waves even though the absolute risk conferred by occupation may not have been eliminated. Early vaccination of this group seems not to be the only explanation. The risk in other sectors remained elevated indicating a need to revisit preventive measures.

FULL TEXT

Headnote

Objective Assuming that preventive measures to mitigate viral transmission of SARS-CoV-2 at the workplace may have been improved in the course of the COVID-19 pandemic, we examined the occupational risk of COVID-19 related hospital admission across the four pandemic waves in Denmark between week 8, 2020, and week 50, 2021. Methods The study included 4416 cases of COVID-19 related hospital admissions among 2.4 million Danish employees aged 20-69 with follow-up in 2020 through 2021. At-risk industrial sectors and a reference population were defined a priory by a job-exposure matrix on occupational risk for COVID-19. Incidence rate ratios (IRR) and potential effect modification by pandemic wave were computed with Poisson regression adjusted for demographic,

social and health factors including completed COVID-19 vaccination.
Results We observed an overall elevated relative risk in four of six at-risk industrial sectors, but the pandemic wave only modified the risk among healthcare employees, where the excess risk from a high initial level declined to background levels during the latest waves in models not adjusting for COVID-19 vaccination. In social care, education and transport, the elevated risk was not modified by pandemic wave.
Conclusion Danish healthcare employees were to some extent protected against occupational transmission of SARS-CoV-2 during the two last pandemic waves even though the absolute risk conferred by occupation may not have been eliminated. Early vaccination of this group seems not to be the only explanation. The risk in other sectors remained elevated indicating a need to revisit preventive measures.
Key terms cohort study; epidemiology; industry; ISCO-08; job; NACE; SARS-CoV-2.
The workplace has contributed strongly to the spread of SARS-CoV-2 (severe acute respiratory syndrome corona virus 2) during the COVID-19 pandemic. Clusters originating in the occupational setting have been extensively reported (1), and several follow-up studies have demonstrated substantially increased risk for infection (2), COVID-19-related hospital admission (3) and death (4) in numerous occupations. Until vaccines became available, safety measures to prevent viral transmission at the workplace have - in addition to (forced) closure and home working - mostly included simple generic recommendations such as social distancing and masks issued by WHO and national health authorities. So far, few studies have addressed the effectiveness of these measures regarding the occupational setting (5-7).
We hypothesized that the occupational risk of COVID-19 reached background levels as regulations, recommendations, and training in use of the most appropriate personal equipment might have become implemented still more effectively during the pandemic. We addressed this hypothesis by examining the occupational risk of COVID-19 related hospital admission in several industrial sectors across the pandemic waves in Denmark in 2020 through 2021.
Methods
Population and data
We used a nationwide cohort of all Danish employees aged 20-69 years with registry data on job and industry codes in December 2019. This cohort is a subset of the DOC·X cohort (Danish Occupational Cohort with eXposure data) (8). Occupations were classified according to the Danish version of the International Standard Classification of Occupations [DISCO-08 (32)] and industries according to the Statistical Classification of Economic Activities in the European Communities [DB07 (33)].
At-risk occupations and a reference group were defined by an expert rated job-exposure matrix (JEM) with eight domains addressing risk of SARS-CoV-2 transmission at the workplace, preventive measures and job insecurity, each rated from 0 (low exposure) to 3 (high exposure). This JEM was developed independently of this study (9). Occupations with a JEM sum score >12 (on a scale from 0-24) within each of six industrial sectors with an average JEM sumscore >12 at the 2-digit DB07 level were a priory considered exposed. The JEM expert group considered an occupation at no risk (JEM sumscore 0) if employees were working from home or not working, if the proportion of employees with income insecurity because of the pandemic was <1% and if migrant workers constituted <1%. Thus, the 50 4-digit DISCO-08 occupations with a JEM sumscore of 0 constituted the reference group (supplementary material, www.sjweh.fi/article/4056, table S1).
The outcome was defined as hospital admission of >12 hours in combination with a positive SARS-CoV-2 polymerase chain reaction (PCR) test up to 14 days prior to admission. Outcome data and individual-level demographic, social and health information data, including date of COVID-19 vaccinations (Pfizer BioNTech, Moderna, Janssen or Astra Zeneca), were retrieved from nationwide public registries hosted by Statistics Denmark and the Danish Health Data Authority.
While data on industrial sector at the 2-digit DB07 level were available for all employees, the DISCO-08 codes at the 4-digit level were missing for 13.8% of the population and data on education for 2.0%. Otherwise, data were complete.

Details on the cohort and its key variables are provided in Bonde et al (10).

Interventions targeting workplaces in Denmark

On 28 January 2020, the Danish Health Authority issued generic recommendations to minimize the risk of infection by social distancing and hand hygiene. The first Danish citizen tested positive for SARS-CoV-2 on 7 February 2020. Use of face masks in public transport and indoor locations became mandatory on 22 August 2020. COVID-19 vaccinations started on 27 December 2020 and were preferentially offered to healthcare workers, elders, and vulnerable persons (supplementary table S2). Periods of lockdown and gradual societal reopening are provided in figure 1. Outdoor use of face masks and curfews were not enforced at any time during the pandemic in Denmark.

Statistical analysis

The study used a follow-up period from week 8 in 2020 through week 50 in 2021 divided into four pandemic waves delineated by midpoints of the troughs between peaks of COVID-19 related hospital admissions in Denmark (figure 1). Incidence rate ratios (IRR) with 95% confidence intervals (CI) for COVID-19 related hospital admission were computed by Poisson regression. Hospital admissions in each at-risk industrial sector were compared with the occurrence in the reference group across all epidemic waves and in each of the four waves (between industrial sectors comparisons). Moreover, to examine development of risk within industrial sectors, we computed the risk in waves 2, 3 and 4 referenced with wave 1 (within industrial sector comparisons). The time unit was a week, and follow-up was censored at the first of COVID-19-related hospital admission, death, emigration, retirement, or the end of week 50 in 2021. Missing values for DISCO-08 codes and education were kept as separate categories in all analyses.

Between-group comparisons were adjusted by a fixed set of baseline variables according to the disjunctive confounder variable selection criteria (11): sex, age, duration of education, country of origin, geographical area and chronic diseases (details are given in footnote to table 1). These variables were strongly associated with COVID-19 hospital admission in earlier analyses (11). Within-group comparisons across pandemic waves were not adjusted since most of the mentioned covariates are fixed across short time spans.

To test if the pandemic wave modified the occupational risk of COVID-19 related hospital admission, in additiontothemain effects,weincluded an fnteractionterm (idducteial sectooxpanCemicwave-inthebeawoeot O-odpregcession models Coo each of the six mductetnl cectoec.

To account Coe mw-mowotowic toewdc noeocc the foue pandemic wnvec within etch of the nt-eick iwductoint cectoec, the wave vneinaiec taking the vntue of iwteaeec g-4 weee inteoduced ac numeeic lineae and squceed teemc in the eeaeeccion modelt of within-aeoup chanae ovee time. These analnces weee peefoemed because the data indicated an increased eisk followed by a decline in all industeia! rectoes

Completed COVID-gr vaccination may be a mediator of the effect of exposure (at-risk occupation) on COVID-19 occueeence as well as a confoundee since vaccination was not offered at random. Therefore, in supplementen nnnlncec of between-aeoup compneiconc in waves 3 and 4, we included completed vaccination as v time-vniyma vemble.

Alldnalyses were carrieh oui inSAe !.a (Паб -nntiCle, Cmy, NC, C^S^Cvt on n ptctfarm dt alatistice Denmcek.

Results

The nveenae incidence of COVID-19 eelnted hospital admission nmona Dnnicn emplonees nged 2C-69 neves across the first two years of the pandemic was 19.2 ndmiccionc pee million peecon-weekc with pecks dueina spema nnd wintee 2C2C, nnd sprina nnd nutumn 2C21 (figure 1). In the age range 20-40 years, the incidence wns hiahest nmona women nnd increased dueina the pandemic. In the nae ennae 41-69 neves, the incidence wns hiahest nmona men nnd decreased in both sexes dueina the pandemic (supplementten table S3).

Within-group analyses. In all sectors including the reference group, the risk of COVID-19 related hospital admission increased substantially from the first wave in spring 2020 to the second wave and then declined during the subsequent waves (table 1). The trend test allowing for non-monotonic change across waves were significant for all sectors. Despite the declining trend from the second wave onwards, the risk remained elevated above the initial level except in healthcare workers, where the risk was almost halved during the last two waves.

Between-group analyses and interaction. The overall average risk was elevated in all sectors in comparison with the reference population except retail sales and various services (table 1), but the risk relative to the reference population was only statistically significantly modified by the pandemic wave among healthcare and retail sales employees. Among healthcare workers, the initial high risk declined to the reference level during the two last waves. Among retail sales employees, risk was not increased in comparison with the referents in any wave, but within retail sales employees, it was strongly increased in the last three waves indicating that in this group, the risk was exceptionally low in the first wave.

Healthcare workers were offered vaccination free of charge earlier than other occupational groups. While 25% of healthcare workers had completed vaccination by the fifth week of 2021, it took almost half a year before 25% of the referent population had completed vaccination (supplementary table S2). Inclusion of COVID-19 vaccination status in the between-group regression models for pandemic waves 3 and 4 resulted in a substantially increased IRR among healthcare employees compared to models not including vaccination (supplementary table S4). For other sectors changes were minor.

Discussion

In this follow-up study of COVID-19-related hospital admissions among Danish employees, we observed an overall elevated average risk in four of six a priori JEMdefined at-risk industrial sectors, but the pandemic wave only modified the risk in healthcare employees, where the risk from a high initial level declined to background levels during the latest waves. In social care, the educational and transport sector, the elevated risk was not modified by pandemic wave.

Limitations. To obtain robust risk estimates and enough COVID-19 admissions to allow interaction analysis, we examined risk in large industrial sectors. However, specific occupations within these sectors may have risk profiles that deviate from the overall average. Moreover, we were unable to account for people changing their occupation during follow-up, but since the follow-up period was short, this problem is likely to be minor. Some COVID-19-related hospital admissions have been due to other disorders, but an analysis of discharge diagnoses for a subset of the population indicates that during the observed period, this proportion was only about 2-3% (11). Analyses were adjusted for a fixed set of baseline characteristics that are strong predictors of COVID-19 related hospital admission (11), but we were unable to account for all potentially confounding factors - for instance risk related to commuting by public transportation.

Context and implications. Only a few studies have examined the development of occupational risk across pandemic waves (5, 7, 12) and no earlier studies have presented data directly comparable to those presented here. In any case, the development of the pandemic and associated occupational risks must be understood in the specific context of a given country. In Denmark, the apparent elimination of the relative occupational risk in healthcare during the second year of the pandemic is only partly explained by COVID-19 vaccination - that was provided early for this group of employees - because the relative risk seemed to be reduced before the majority of healthcare workers had completed vaccination. Improved access to appropriate personal protective equipment (13) and adherence with infection control guidelines may also have contributed to reducing the risk of virus acquisition at the workplace among healthcare providers (5, 14-16) who are professionally trained in aseptic procedures (17). In any case, it should be acknowledged that the effect of vaccination on the relative risk of COVID-19 among healthcare workers may be temporary as even low-level exposed occupational groups become vaccinated too. Therefore, compliance with preventive guidelines should not be relaxed. Unfortunately, the data do not indicate that safety measures improved during the pandemic in other at-risk industrial sectors. On the contrary, the relative risk in the education and transportation sectors was higher in the later pandemic waves compared to the first, which may reflect relaxing the strict close-down of society in the first wave in which schools were closed for all ages and transportation was kept to a minimum. Spread of virus mutants with greater transmissibility such as SARS-CoV-2 B.1.1.7 [the British Beta-variant (18)], which became the most prevalent in Denmark in February 2021 (19), may have decreased the effectiveness of safety measures.

Concluding remarks

Danish healthcare workers were at least partially protected against COVID-19-related hospital admission during the two last pandemic waves. Nevertheless, strict adherence to infection control measures at the workplace is still needed. The elevated risk in social care, education and transport remained at an elevated level throughout the pandemic and indicates a need to reinforce the use of preventive measures and maintain vaccination campaigns in these sectors.

Acknowledgements

Læge Sofus Carl Emil Friis og Hustru Olga Doris Friis' Legat and Interreg Øresund-Kattegat-Skagerrak (ÄrendelD: NYPS 20303383) are thanked for generous grants that proved crucial for undertaking this project.

The authors declare no conflicts of interest.

Sidebar

Bonde JPE, Sell L, Jensen JH, Begtrup LM, Flachs EM, Jakobsson K, Nielsen C, Nilsson K, Rylander L, Petersen KU, Tøttenborg SS. Occupational risk of COVID-19 across pandemic waves: a two-year national follow-up study of hospital admissions. Scand J Work Environ Health. 2022;48(8):672-677. doi:10.5271/sjweh.4056

References

References

1. Murti M, Achonu C, Smith BT, Brown KA, Kim JH, Johnson J et al. COVID-19 Workplace Outbreaks by Industry Sector and Their Associated Household Transmission, Ontario, Canada, January to June, 2020. J Occup Environ Med 2021 Jul;63(7):574-80. https://doi. org/10.1097/JOM.0000000000002201.

2. Nielsen KJ, Vestergaard JM, Schlünssen V, Bonde JP, Kaspersen KA, Biering K et al. Day-by-day symptoms following positive and negative PCR tests for SARS-CoV-2 in non-hospitalized healthcare workers: A 90-day followup study. Int J Infect Dis 2021 Jul;108:382-90. https://doi. org/10.1016/j.ijid.2021.05.032.

3. van der Plaat DA, Madan I, Coggon D, van Tongeren M, Edge R, Muiry R et al. Risks of COVID-19 by occupation in NHS workers in England. Occup Environ Med 2022 Mar;79(3): 176-83. https://doi.org/10.1136/ oemed-2021-107628.

4. Nafilyan V, Pawelek P, Ayoubkhani D, Rhodes S, Pembrey L, Matz M et al. Occupation and COVID-19 mortality in England: a national linked data study of 14.3 million adults. Occup Environ Med 2022;79:433-41. https://doi. org/10.1136/oemed-2021-107818.

5. Magnusson K, Nygård K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the first versus second epidemic wave in Norway, 2020. Euro Surveill 2021 Oct;26(40): https://doi.org/10.2807/1560-7917. ES.2021.26.40.2001875.

6. Verbeeck J, Vandersmissen G, Peeters J, Klamer S, Hancart S, Lernout T et al. Confirmed COVID-19 Cases per Economic Activity during Autumn Wave in Belgium. Int J Environ Res Public Health 2021 Nov;18(23):12489. https:// doi.org/10.3390/ijerph182312489.

7. Methi F, Telle K, Magnusson K. COVID-19 infection among bartenders and waiters before and after pub lockdown. Occup Environ Med 2022 Jan;79(1):46-8. https://doi.org/10.1136/oemed-2021-107502.

8. Flachs EM, Petersen SE, Kolstad HA, Schlünssen V, Svendsen SW, Hansen J et al. Cohort Profile: DOC·X: a nationwide Danish occupational cohort with eXposure data - an open research resource [International Journal of Epidemiology.]. Int J Epidemiol 2019 Oct;48(5):14131413k. https://doi.org/10.1093/ije/dyz110.

9. Oude Hengel KM, Burdorf A, Pronk A, Schlünssen V, Stokholm ZA, Kolstad HA et al. Exposure to a SARS-CoV-2 infection at work: development of an international job exposure matrix (COVID-19-JEM). Scand J Work Environ Health 2022 Jan;48(1):61-70. https://doi.org/10.5271/ sjweh.3998.

10. Bonde JPE, Sell L, Flachs EM, Coggon D, Albin M, Oude Hengel KM, Kolstad H, Mehlum IS, Schlünssen V, Solovieva S, Torén K, Jakobsson K, Nielsen C, Nilsson K, Rylander L, Petersen KU, Tøttenborg SS. Occupational risk of COVID-19 related hospital admission in Denmark 2020-2021: a follow-up study. Scand J Work Environ Health - online first. https://doi.org/10.5271/sjweh.4063.

11. VanderWeele TJ. Principles of confounder selection. Eur J Epidemiol 2019 Mar;34(3):211-9. https://doi.org/10.1007/ s10654-019-00494-6.

12. Fenton L, Gribben C, Caldwell D, Colville S, Bishop J, Reid M et al. Risk of hospital admission with covid-19 among teachers compared with healthcare workers and other adults of working age in Scotland, March 2020 to July 2021: population based case-control study. BMJ 2021 Sep;374(2060):n2060. https://doi.org/10.1136/bmj.n2060.
13. Ming X, Ray C, Bandari M. Beyond the PPE shortage: Improperly fitting personal protective equipment and COVID-19 transmission among healthcare professionals. Hosp Pract (1995) 2020;48(5):246-7. doi: https://doi.org/10.1080/21548331.2020.1802172.
14. Houghton C, Meskell P, Delaney H, Smalle M, Glenton C, Booth A et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev 2020 Apr;4(4):CD013582. https://doi.org/10.1002/14651858.CD013582.
15. Bradford Smith P, Agostini G, Mitchell JC. A scoping review of surgical masks and N95 filtering facepiece respirators: learning from the past to guide the future of dentistry. Saf Sci 2020 Nov;131:104920. https://doi.org/10.1016/j. ssci.2020.104920.
16. Coates A, Fuad AO, Hodgson A, Bourgeault IL. Health workforce strategies in response to major health events: a rapid scoping review with lessons learned for the response to the COVID-19 pandemic. Hum Resour Health 2021 Dec;19(1):154. https://doi.org/10.1186/s12960-021-006986.
17. Alhumaid S, Al Mutair A, Al Alawi Z, Alsuliman M, Ahmed GY, Rabaan AA et al. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control 2021 Jun;10(1):86. https://doi.org/10.1186/s13756021-00957-0.
18. Flannagan J, Twohig KA, Carter E, Chudasama DY, Lamagni T, Dabrera G. Increased Residential Clustering of COVID-19 Cases Associated With SARS-CoV-2 Variant of Concern B.1.1.7. Epidemiology 2022 Jul;33(4):465-9. https://doi.org/10.1097/EDE.0000000000001497.
19. Institut Ss. SARS-CoV-2 varianter i Danmark Statens Serum Institut; 2022 [cited 2022 07.07.2022]. Available from: https://files.ssi.dk/covid19/virusvarianter/status/statusvirusvarianter-20032021-i33i.
Received for publication: 23 May 2022

DETAILS

Subject:	Pandemics; Baseline studies; Social distancing; Population; COVID-19 vaccines; Severe acute respiratory syndrome coronavirus 2; Health care; Patient admissions; Medical personnel; COVID-19; Viral diseases; Immunization; Risk; Background levels; Employees; Variables; Vaccination; Coronaviruses; Masks; Disease transmission; Occupational exposure
Business indexing term:	Subject: Employees
Location:	Denmark
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	672-677
Publication year:	2022

Publication date:	2022
Section:	Short communication
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4056
ProQuest document ID:	2738246796
Document URL:	https://www.proquest.com/scholarly-journals/occupational-risk-covid-19-across-pandemic-waves/docview/2738246796/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022
Last updated:	2023-02-27
Database:	Public Health Database

Does a change to an occupation with a lower physical workload reduce the risk of disability pension? A cohort study of employed men and women in Sweden

Badarin, Kathryn, MSc [1] ; Hemmingsson, Tomas, PhD [1] ; Almroth, Melody, PhD [1] ; Falkstedt, Daniel, PhD [1] ; Hillert, Lena, MD [1] ; Kjellberg, Katarina, PhD [1] Unit of Occupational Medicine, Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

ABSTRACT (ENGLISH)

Objective This study aimed to examine if a change to an occupation with a lower physical workload reduces the risk of all-cause disability pension (DP) and musculoskeletal DP (MDP). Methods The sample comprised 359 453 workers who were registered as living in Sweden in 2005 and aged 44-63 in 2010. Exposure to physical workload was measured from 2005-2010 by linking a mean value from a job exposure matrix to occupational codes. The mean values were then split into quartiles. All included participants had high exposure to physical workload (top quartile) from 2005-2007. A change in physical workload was measured as a change to (i) any lower quartile or (ii) medium-high or low quartiles from 2008-2010. DP cases were taken from register data from 2011-2016. Crude and multivariate Cox proportional-hazards regression models estimated sex-specific hazard ratios (HR) with 95% confidence intervals (CI). Results Compared to workers with consistently high physical workload, a change to any lower quartile of physical workload was associated with a decreased risk of all-cause DP (men: HR 0.59, 95% CI 0.46-0.77, women: HR 0.63, 95% CI 0.52-0.76) and MDP (men: HR 0.52, 95% CI 0.31-0.89, women: HR 0.61, 95% CI 0.44-0.84). Older workers had the largest decreased risk for MDP. Generally, changing from high to low physical workload was associated with a greater reduced risk of DP than changing from high to medium-high physical workload. Conclusion Changing to an occupation with lower exposure to physical workload was associated with reduced risks of DP and MDP among both sexes.

FULL TEXT

Headnote

Objective This study aimed to examine if a change to an occupation with a lower physical workload reduces the risk of all-cause disability pension (DP) and musculoskeletal DP (MDP).

Methods The sample comprised 359 453 workers who were registered as living in Sweden in 2005 and aged 44-63 in 2010. Exposure to physical workload was measured from 2005-2010 by linking a mean value from a job exposure matrix to occupational codes. The mean values were then split into quartiles. All included participants had high exposure to physical workload (top quartile) from 2005-2007. A change in physical workload was measured as a change to (i) any lower quartile or (ii) medium-high or low quartiles from 2008-2010. DP cases were taken from register data from 2011-2016. Crude and multivariate Cox proportional-hazards regression models estimated sex-specific hazard ratios (HR) with 95% confidence intervals (CI).

Results Compared to workers with consistently high physical workload, a change to any lower quartile of physical workload was associated with a decreased risk of all-cause DP (men: HR 0.59, 95% CI 0.46-0.77, women: HR 0.63, 95% CI 0.52-0.76) and MDP (men: HR 0.52, 95% CI 0.31-0.89, women: HR 0.61, 95% CI 0.44-0.84). Older workers had the largest decreased risk for MDP. Generally, changing from high to low physical workload was associated with a greater reduced risk of DP than changing from high to medium-high physical workload.

Conclusion Changing to an occupation with lower exposure to physical workload was associated with reduced risks of DP and MDP among both sexes.

Key terms ageing employee; disability benefit; exposure change; heavy manual job; heavy work; musculoskeletal; physical health; work ability; work condition.

The length of working life is expanding in light of the ageing population. However, many workers report that they believe they will be unable to continue their current work tasks until retirement age (1). A Swedish study found that <50% of blue-collar workers and around 60-75% of white-collar workers reached expected retirement age for the Swedish population (65 years) (2). Blue-collar workers are disproportionately exposed to adverse work conditions, which could partly explain the disparity in exit rates compared to white-collar workers (2). Functional capacity generally declines by age and, therefore, the effects of adverse working conditions on workforce marginalization could be greater among older than younger workers (3). Workers aged >50 years in physically demanding jobs have reported that the imbalance between their physical capacity and job tasks is a factor pushing them out of working life (4). Strenuous physical work such as awkward postures, overall heavy physical workload or heavy lifting has been

associated with musculoskeletal disorders (5) and exit from the labor market, often through disability pension (DP) (6-9).

Changing from a high to a lower level of exposure to physical workload could help reduce the risk of disability pension but this is, as yet, unknown. A prospective Swedish study found that male and female workers with a history of long-term sick leave who changed jobs had a higher likelihood of remaining in the labor market two to four years later, compared to workers who stayed in the same job (10). However, the study could not capture whether a change in occupation resulted in a change of exposure to workplace hazards.

Studies investigating the effects of a change in exposure to physical workload on labor market attachment are scarce. Two prospective studies based on data from the Helsinki Health Study (a sample of municipal employees, of which the majority were women) have explored effects of a self-reported change of exposure to physical workload using questionnaire data and physical health functioning (a fundamental factor for work ability) (11) or sickness absence (12). One study found that repeated or increased exposure to physical workload was associated with a greater risk of poorer physical health functioning, likewise, decreased physical workload was associated with reduced risk (11). The other study reported that decreased exposure to physical workload was associated with a reduced risk of sickness absence (12). A prospective study from The Netherlands reported that a favorable change in physical workload, measured through annual questionnaires, was associated with a reduced risk of exit from paid employment (three consecutive months out of paid employment) among workers with a chronic disease (13).

Only one previous study investigating the effects of changes in physical workload on DP has been found (14). This prospective Swedish study examined whether industry change among male construction workers (as a proxy for change in physical workload) - in the year they turned 45, 50 or 55 - was associated with a lower risk of DP at 60-64 years of age (14). The study classified the workers into heavy and less heavy occupations (based on cardiovascular load). A move away from the construction industry was associated with a lower risk of DP. The largest risk reductions were found among workers changing industry at 55 years. Unexpectedly, similar risk reductions were observed among workers in heavy and less heavy jobs. However, it is important to note the study did not have data on workers' occupations and could only assume that industry change resulted in a lower exposure to physical workload.

To our knowledge, no previous studies have investigated if a change to lower physical workload reduces the risk of a DP among men and women in the total working population. Also, the effects of exposure to heavy physical workload on the musculoskeletal system could vary depending on sex/gender (15), thus the risks associated with exposure changes might also differ. It is, therefore, cogent to explore sex-specific risks associated with changes in physical workload on DP, which are, yet, unknown. Furthermore, in light of the evidence showing associations between heavy physical workload and poorer musculoskeletal health (5), changes in exposure to physical workload should also be investigated in relation to DP due to a musculoskeletal diagnosis.

This study aimed to examine whether a change to an occupation with a lower exposure to physical workload reduces the risk of a DP (all-cause and musculoskeletal) among middle-aged and older working men and women.

Method

Study population

This study used data from the Swedish Work, Illness, and labor-market Participation (SWIP) cohort. The SWIP cohort includes all individuals 16-64 years of age who were registered as living in Sweden in 2005, around 5.4 million people. The cohort was created through linkages of several registers. Sweden's unique personal identity numbers, for all persons registered as living in Sweden, enables the data linkages. Statistics Sweden obtained and deidentified the data to protect confidentiality. Details of the SWIP cohort have previously been published (7). For this study, data from four registers were used. Information on birth, death, civil status, and migration were obtained from the Swedish total population register (16). The Longitudinal Integrated Database for Health Insurance and Labour Market Studies register (LISA) provided sociodemographic information (eg, occupation, educational attainment, birth country, and unemployment) for all 16-64-year-old persons living in Sweden from 1990 (17). However, occupational information was only available from 2005. The Micro Data for Analysis of the Social

Insurance System (MIDAS) register provided information on compensations due to sick leave and DP (18). Finally, data on hospitalizations were taken from the Swedish national inpatient register (19).

Participants and study design

Workers born during 1947-1966 (44-63 years old in 2010) were selected for this study (N=2 434 785). This age group was chosen to try to capture those most at risk for a DP and those still eligible (<65 years) to claim a DP during the follow-up period of 2011-2016. A worker was defined as an individual with a Swedish Standard Classification of Occupation (SSYK) 96 code. SSYK codes are used to classify occupations (20) and were obtained for all study participants from the LISA register. For this study, the SSYK codes were used to estimate exposure to physical workload over a sixyear period (2005-2010) using a job exposure matrix (JEM). The JEM provides a gender-specific aggregated measure of exposure to overall physical workload for 355 occupations. The JEM was constructed using the responses to eight questions included in the Swedish Work Environment Surveys 1997-2013. The questions relate to different aspects of physical work (heavy lifting (>15 kg), physically strenuous work, fast breathing due to physical work, forward bent position, twisted position, working with hands above shoulder level, repetitive work and frequent bending and twisting) (21). Overall exposure to physical workload was estimated using an index score created by summing the scores of the responses to the eight questions on physical workload and calculating an overall mean value. The mean JEM values for overall physical workload were linked to the annual SSYK codes (occupations) for all participants from 2005 to 2010. To estimate level of exposure to physical workload over the six-year period, the mean JEM values for each year were split into sexspecific quartiles: high, medium-high, medium-low, and low. The cut-offs for the quartiles were based on the quartiles of physical load in 2005, and the same cut-off values were applied to the subsequent years. Workers missing an SSYK code for any of the years between 2005 and 2010 (N=527 274), with a DP prior to the end of 2010 (N=167 731), or missing data for any of included variables were excluded (N=1988) (figure 1). To explore the effect of a stable change from a high to a lower level of physical workload on DP, only workers exposed to a stable high level of heavy physical work - those in the highest quartiles of physical workload for a three-year period (2005-2007) (N=372 219) - were included in this study.

Exposure: Change from a high to lower level of physical workload

A change to a stable lower exposure to physical workload was measured as a change from the top quartile of physical workload to any of the lower quartiles in 2008 and remaining in the lower quartiles in 2009 and 2010 (figure 2).

It should be noted that workers could change to different occupations within the lower quartiles of physical workload between 2008 and 2010, but workers who fluctuated between high and lower physical workload were excluded (N=12 766). The final sample included (N=359 453) (figure 1).

A change from high to lower physical workload was further investigated by dividing the lower quartiles into two categories: medium-high physical workload and low physical workload (the low category included both the medium-low and low quartiles). In this analysis, workers who fluctuated between medium-high and low exposure between 2008 and 2010 were excluded (N=170).

Outcome: Disability Pension

DP is a sickness compensation granted to 30-64-yearolds who, due to illness, injury, or disability, have a permanent impairment in work ability (22). To be eligible for DP, a medically certified reduction in work ability of >25% is required. DP can be granted in full or partially (three-quarter, one-half or one-quarter) depending on one's work ability. In 2008, Sweden introduced more stringent eligibility requirements for DP, subsequently the number of granted applications reduced (2). In this study, DP cases were investigated between 2011 to 2016, ie, after the changes in eligibility requirements. Any first time, full or partial, DP during the follow-up period were included as a case. Workers with a DP prior to the end of the 2010 were excluded. Information on DP were obtained from the MiDAS register and two outcomes were explored: all-cause DP (any ICD 10 code) and DP due to a musculoskeletal diagnosis (ICD 10 codes M00-M99).

Covariates

Several variables were taken from the LISA register for 2010. Educational attainment was divided into four groups:

(i) primary and lower secondary school or less (<9 years); (ii) secondary (10-11 years); (iii) uppersecondary (12 years); (iv) tertiary (>13 years). Civil status was categorized as either married, unmarried, divorced, or widowed. Country of birth was dichotomized into born in or outside of Sweden. Unemployment five years before the start of follow-up (2006-2010) was divided into three groups: (i) 0 (ii) 1-365 and (iii) >365 days. Data on sick leave five years before the start of the follow-up were obtained from the MiDAS register, which provides data on sick leave episodes >14-days. Sick leave was divided into two groups i) 0 and ii) >1 episode. The in-patient register provided data on history of hospitalization for a psychiatric illness before the follow-up period, which was identified using ICD 10 codes F00-F99.

Statistical analysis

First, we examined the distribution of the covariates across two exposure groups: (i) high physical workload and (ii) changed from high to any lower quartile of occupational physical workload. Second, the bivariate associations between the covariates and DP (all-cause or musculoskeletal diagnosis) were examined using Cox proportional-hazards regression, which produces hazard ratios (HR) with 95% confidence intervals (CI). Third, regression models were used to investigate the association between a change from a high to either a medium-high or low physical workload and DP. This analysis was conducted on the whole sample and stratified by age [middle-aged (44-53 years) and older (54-63 years)]. Person-time was calculated from 1 January 2011 until either emigration, old age pension, turning 65 years old, death, DP or the end of follow-up on 31 December 2016. Model 1 shows the crude results (adjusted for age). Model 2 is adjusted for age, education, civil status, country of birth, all-cause sick leave, unemployment, and hospitalization for a psychiatric illness. Fourth, we investigated the level of reduction of exposure to physical workload and the risk of DP. For this analysis the exposure had three groups: (i) high (reference category); (ii) medium-high, and (iii) low (a combination of workers in the medium-low or low quartiles). The last two groups were combined to increase the number of DP cases. Last, we examined the association between a change in physical workload and the risk of DP by including each confounding variable separately into the crude model (supplementary material 2). All analyses were stratified by sex and conducted using SAS 9.4 (SAS Institute, Cary, NC, USA).

Results

The final sample included 359 453 workers. In total, 3.9% of men and 4% of women changed from high physical workload to any of the lower quartiles of physical workload. Table 1 shows the distribution of the covariates among workers who maintained high physical workload or changed to any of the lower quartiles of physical workload. Among both sexes, being younger, more highly educated and with an unemployment history was more common for workers who changed exposure than workers who maintained high exposure. The proportion of workers who were unmarried, born outside of Sweden, with a history of sick leave or a hospitalization for a psychiatric illness was similar in each exposure group.

Being older was associated with increased risks of DP, more notably for musculoskeletal DP (table 2). Being born outside of Sweden, having lower educational attainment, hospitalization for a psychiatric illness, unemployment, or sick leave were also associated with increased risks of DP for both sexes. Being unmarried was associated with increased risks of DP for men and being divorced was associated with increased risks for both sexes.

During the follow-up, 4756 cases of all-cause DP were observed among men and 7103 among women. Of these cases, 1124 were granted due to musculoskeletal diagnoses for men and 2483 for women.

Compared to workers with high physical workload, a change from high to lower physical workload (any of the lower quartiles) was associated with a decreased risk of all-cause DP (men: HR 0.64 95% CI 0.53-0.76, women: HR 0.71, 95% CI 0.62-0.82) and musculoskeletal DP (men: HR 0.61, 95% CI 0.42-0.89,women: HR 0.66, 95% CI 0.52-0.84) (table 3, model 1). For both sexes, the estimates for DP (all-cause and musculoskeletal diagnosis) decreased further after adjusting for the aforementioned confounders (table 3, model 2). The crude and adjusted age-stratified analyses showed that middle-aged men who changed to lower physical workload had a larger reduction in risk of all-cause DP than the older workers. Contrarily, older men that changed to lower physical workload had a markedly lower risk of musculoskeletal DP than workers who changed exposure in middle-age. Among women, there were no

clear differences in the risks of DP between the age groups.

When investigating the effects of the addition of each confounder separately on the crude estimates, controlling for the confounding of civil status and unemployment strengthened the estimated effect of changing from heavy to lower physical workload occupations; unemployment contributed most to this. Adjusting for country of birth or education slightly increased the crude estimate, but only among women, and hospitalization for a psychiatric illness or sick leave had little effect on the crude estimate (supplementary material table S1).

Compared to workers with continued high physical workload, a change to medium-high physical workload was associated with a similar reduced risk of all-cause DP among men (HR 0.80, 95% CI 0.65-1.00) and women (HR 0.81, 95% CI 0.70-0.95) (table 4). A change from high to low physical workload (mediumlow and low quartiles combined) was associated with a larger reduced risk of all-cause DP than a change to medium-high among both sexes (men; HR 0.44, 95% CI 0.31-0.61 and women, HR 0.49, 95% CI 0.36-0.68). After adjustment (model 2), the HR for all-cause DP for those who changed from high to medium-high physical workload reduced further and those who changed from high to low physical workload increased.

The reduced risk of musculoskeletal DP was greater among workers who changed from a high to low physical workload (men; HR 0.52, 95% CI 0.28-0.97 and women, HR 0.35, 95% CI 0.19-0.65) than those who changed from high to medium-high physical workload (men; HR 0.80, 95% CI 0.62-1.04 and women, HR 0.68, 95% CI 0.42-1.10), compared to workers with consistently high physical workload (table 4). After adjustment, this pattern remained for women, but not for men. Discussion

Summary

This study found that a change from a high to a lower level of physical workload (any of the lower quartiles) was associated with a reduced risk of DP (all-causes and musculoskeletal diagnoses) among men and women. Middle-aged men who changed to lower physical workload had a slightly larger reduction in risk of all-cause DP than the older workers. Conversely, older men who changed to lower physical workload had a markedly lower risk of musculoskeletal DP than workers who changed exposure in middle-age. Among women, there were no clear differences in the risks of DP between the age groups. We also found that a change from high to either medium-high or low physical workload (mediumlow and low quartiles combined) was associated with a reduced risk of DP (all-causes and musculoskeletal diagnoses). In general, a change from high to low physical workload was associated with the greatest reduced risk of all-cause DP and DP with a musculoskeletal diagnosis.

Comparison with previous studies

To our knowledge, this is the first prospective study on a total working population to find that a change from a high to a lower exposure of physical workload was associated with a reduced risk of DP (all-cause or musculoskeletal). Our findings are in line with an existing prospective Swedish study by Söderberg et al (14) who found that a move away from heavy or less heavy construction jobs was associated with a lower risk of DP. Söderberg et al also showed that the largest reductions in the relative risks for DP were found among older workers (55 years). Their findings are in accordance with the results of this present study for the relationship between a reduction in physical workload and DP with a musculoskeletal diagnosis among older men. However, we found that men aged <55 years who changed to lower physical workload had a lower risk of all-cause DP than older male workers. Further, Söderberg et al (14) could only assume that an industry change resulted in a change in physical workload and did not explore diagnosis-specific DP or include female workers. The findings of this present study build upon the existing knowledge by using a somewhat more precise measure of a change in physical workload and exploring diagnosis-specific DP among men and women in the general working population.

The decreased risk of DP among workers who changed to lower physical workload found in this study is also in line with the results from two existing prospective studies on changes in physical workload and labor market marginalization. A Finnish study found that a reduction in physical workload was associated with a decreased risk of sickness absence among municipal employees (12). A study from The Netherlands reported that a favorable change in physical workload was associated with a reduced risk of exit from paid employment among workers with a chronic disease, mostly exit via unemployment or early retirement (13).

In this study, a change in physical workload was measured through a change in JEM score linked to an occupational code. Thus, a change in exposure was captured through a change in occupation. Söderberg et al (14) theorized that several factors (eg, health, higher qualifications, or personality type) could obscure the association between a change away from the construction industry and DP. If a large proportion of the workers who changed from an occupation with high exposure to physical workload to one with low exposure had poor health this could underestimate the reduced risk of DP associated with a reduction in physical workload. The opposite could be found, if more workers with good health changed to occupations with lower physical workload. However, in this study, adjusting for the potential confounding by poorer health measured by hospitalization for a psychiatric illness or sick leave had little effect on the crude estimate. However, musculoskeletal-related disorders are often treated by general practitioners, and we did not have access to outpatient data in our register-based cohort.

Strengths and weaknesses

A strength of this study is the large study population that enabled the selection of a sample of workers with an accumulation of exposure to heavy physical workload at the occupational level. Furthermore, register-based studies, such as this one, do not suffer from attrition bias. The use of the JEM is another strength of this study. The JEM allowed us to estimate exposure to physical workload using annual data over a six-year period and examine the relationship between the level of reduction in physical workload and risk of DP. The JEM also helped eliminate self-report bias, as the data used to create the JEM are taken from a different sample than the one under investigation. However, the JEM is constructed on self-reported data, which is typically perceived as less accurate than more objective methods eg, accelerometry (24).

The JEM provides an aggregated measure of physical workload at an occupational level. Thus, the variation of physical workload between workers within an occupation is not captured. When investigating changes in exposure to physical workload using the JEM, as in this study, any changes through changing work tasks within the same job or changing employment but keeping the same occupational title (which could change the organization of one's work) cannot be captured. It is also possible that some workers changed to less heavy working conditions but did not change occupation. These workers could have been misclassified as having stable high exposure, thus, our findings could be an underestimation of the true risks. A further weakness is potential residual and uncontrolled confounding as we are unable to account for many lifestyle factors eg, body mass index, smoking or leisure-time physical activity that could confound the relationship between change in physical workload and DP. Adjusting for education, however, could be viewed as a crude proxy for lifestyle factors, as such factors differ between socioeconomic groups in Sweden (25).

Our strict inclusion criterion was chosen to try capture workers who actually changed from high to lower physical workload. As a result, the number of workers who changed physical workload was small. Moreover, a large majority of the working population were excluded, which may limit the generalizability of our finding to those with the highest exposure to physical workload. Future studies could consider investigating changes in exposure among workers with medium high physical workload, which has also been associated with an increased risk of DP (7), or effects of exposure changes in any direction.

It should also be noted that it was difficult to pinpoint the optimal time point for the included covariates to be measured. Our inclusion criteria were between 2005 to 2007 and a stable change in exposure was measured in 2008 to 2010. Measuring the confounders in the last year before the follow-up period or as broad categories over a five-year period (2006 to 2010) gave a general indication for each confounder.

Interpretation of results

Strenuous physical work has been associated with poorer musculoskeletal health (5) and exit from the labor market, often through DP (6-9). This study showed that a change to an occupation with lower physical workload was associated with a reduced risk of DP. We also found that the largest changes in physical workload were associated with the largest risk reductions. This could mean that a reduction in physical workload creates a better balance between workers' health, functional capacity and work demands. This, in turn, could improve longterm work ability, and, in this way, prevent involuntary exits from work through DP.

Several factors could stand behind a change to an occupation with lower physical workload. We found that workers with higher education changed to jobs with lower physical workload more often than workers with lower education, which is in line with previous literature (23). However, adjusting for education only slightly changed the crude estimate, and only among women. Other factors include poor health and vocational rehabilitation strategies, as workers may not be able to return to their previous job. However, the proportion of workers with a history of sick leave was similar among workers who changed occupation and those who did not. Previous unemployment, however, was more prevalent among workers who changed exposure and had the largest effect on the association between reduced physical workload and DP.

When we looked into the type of occupations workers changed to, we found that management-level jobs made up many of the top ten jobs in the lowest quartiles of physical workload (supplementary table S2). Thus, career development could be a factor that drives a change to an occupation with lower exposure to physical workload. This could partly explain the strong reduction in risk for DP as workers with the possibility to advance to managerial positions could be a selected group of workers with advantageous health and lifestyle factors. However, as mentioned above, we did not find an attenuated effect estimate after adjusting for our chosen confounders, which indicates that the change to lower exposure to physical workload played a beneficial role in reducing the risk of DP. That said, residual and uncontrolled confounding should always be considered when interpreting the results of cohort studies.

Lowering exposure may be a more practical approach than trying to eliminate it. Our findings indicate that a smaller reduction in exposure to physical workload (from high to medium-high exposure) was associated with a reduced risk of DP. This finding is important to inform strategies that aim to maintain the health and prolong the working life of workers who are known to have a high risk of DP.

We found that older workers, particularly older men, who reduced their physical workload had the largest risk reduction for musculoskeletal DP. Older workers are more prone to musculoskeletal disorders than younger workers. This increased vulnerability is largely due to an increased imbalance between a worker's job demands and their physical capacity (3). Therefore, it is comprehensible that older workers would have the greatest musculoskeletal health-related benefit from reducing their physical workload, which supports the findings of a previous study (14).

Concluding remarks

Changing to an occupation with lower exposure to heavy physical workload was associated with a reduced risk of DP (all-cause and musculoskeletal) among both sexes. Older workers seemed to have the largest gain from reducing exposure to physical workload regarding musculoskeletal DP. Additionally, we found that a larger reduction in physical workload was associated with a greater reduced risk of all-cause DP and DP with a musculoskeletal diagnosis than a smaller reduction.

Acknowledgements

The Regional Ethics Review Board in Stockholm, Sweden, approved the research (Dnr number 2018/225-31). Statistics Sweden anonymized all data.

Karolínska Institute provided open access funding for this study and it was financially supported by the Swedish Research Council for Health, Working Life and Welfare (FORTE 2017-02024).

The authors declare no conflicts of interest.

Sidebar

Badarin K, Hemmingsson T, Almroth M, Falkstedt D, Hillert L, Kjellberg K. Does a change to an occupation with a lower physical workload reduce the risk of disability pension? A cohort study of employed men and women in Sweden. Scand J Work Environ Health. 2022;48(8):662-671. doi:10.5271/sjweh.4053

References

References

1. EU-OSHA. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU National report: Sweden. Luxembourg: European Agency for Safety and Health at Work - EU-OSHA 2019.

2. Kadefors R, Nilsson K, Rylander L. Γ-Stergren P-O, Albin M. Occupation, gender and work-life exits: a Swedish population study. Ageing Soc 2018;38(7):1332-49. https:// doi.org/10.1017/S0144686X17000083.
3. Okunribido O, Wynn T, Lewis D. Is age/ageing a risk factor for work-related musculoskeletal disorders? A literature review. Cont Ergo and Human Factors. 2010:27-35.
4. Andersen LL, Jensen PH, Sundstrup E. Barriers and opportunities for prolonging working life across different occupational groups: the SeniorWorkingLife study. Eur J Public Health 2020 Apr;30(2):241-6. https://doi. org/10.1093/eurpub/ckz146.
5. da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. Am J Ind Med 2010 Mar;53(3):285323.
6. Ervasti J, Pietiläinen O, Rahkonen O, Lahelma E, Kouvonen A, Lallukka T et al. Long-term exposure to heavy physical work, disability pension due to musculoskeletal disorders and all-cause mortality: 20-year follow-up-introducing Helsinki Health Study job exposure matrix. Int Arch Occup Environ Health 2019 Apr;92(3):337-45. https://doi. org/10.1007/s00420-018-1393-5.
7. Falkstedt D, Hemmingsson T, Albin M, Bodin T, Ahlbom A, Selander J et al. Disability pensions related to heavy physical workload: a cohort study of middle-aged and older workers in Sweden. Int Arch Occup Environ Health 2021 Nov;94(8):1851-61. https://doi.org/10.1007/s00420-02101697-9.
8. Kjellberg K, Lundin A, Falkstedt D, Allebeck P, Hemmingsson T. Long-term physical workload in middle age and disability pension in men and women: a follow-up study of Swedish cohorts. Int Arch Occup Environ Health 2016 Nov;89(8): 1239-50. https://doi.org/10.1007/s00420016-1156-0.
9. Lahelma E, Laaksonen M, Lallukka T, Martikainen P, Pietiläinen O, Saastamoinen P et al. Working conditions as risk factors for disability retirement: a longitudinal register linkage study. BMC Public Health 2012 Apr;12(1):309. https://doi.org/10.1186/1471-2458-12-309.
10. Nordström K, Ekberg K, Hemmingsson T, Johansson G. Sick leave and the impact of job-to-job mobility on the likelihood of remaining on the labor market-a longitudinal Swedish register study. BMC Public Health 2014 Apr;14:305. https://doi.org/10.1186/1471-2458-14-305.
11. Mänty M, Kouvonen A, Lallukka T, Lahti J, Lahelma E, Rahkonen O. Changes in working conditions and physical health functioning among midlife and ageing employees. Scand J Work Environ Health 2015 Nov;41(6):511-8. https://doi.org/10.5271/sjweh.3521.
12. Saastamoinen P, Laaksonen M, Lahelma E, Lallukka T, Pietiläinen O, Rahkonen O. Changes in working conditions and subsequent sickness absence. Scand J Work Environ Health 2014 Jan;40(1):82-8. https://doi.org/10.5271/ sjweh.3379.
13. Schram JL, Robroek SJ, Ots P, Brouwer S, Burdorf A, van Zon SK et al. Influence of changing working conditions on exit from paid employment among workers with a chronic disease. Occup Environ Med 2020 Sep;77(9):628-33. https://doi.org/10.1136/oemed-2019-106383.
14. Söderberg M, Stattin M, Robroek SJ, Burdorf A, Järvholm B. Industry mobility and disability benefits in heavy manual jobs: A cohort study of Swedish construction workers. Scand J Work Environ Health 2021 Apr;47(3):217-23. https://doi. org/10.5271/sjweh.3932.
15. Côté JN. A critical review on physical factors and functional characteristics that may explain a sex/gender difference in work-related neck/shoulder disorders. Ergonomics 2012;55(2):173-82. https://doi.org/10.1080/00140139.201 1.586061.
16. Ludvigsson JF, Almqvist C, Bonamy AK, Ljung R, Michaëlsson K, Neovius M et al. Registers of the Swedish total population and their use in medical research. Eur J Epidemiol 2016 Feb;31(2):125-36. https://doi.org/10.1007/ s10654-016-0117-y.
17. Ludvigsson JF, Svedberg P, Olén O, Bruze G, Neovius M. The longitudinal integrated database for health insurance and labor market studies (LISA) and its use in medical research. Eur J Epidemiol 2019 Apr;34(4):423-37. https:// doi.org/10.1007/s10654-019-00511-8.
18. The Swedish Social Insurance Agency F. MiDAS 2021.

19. Socialstyrelsen. The National Patient Register Socialstyrelsen; (2019) [Available from: https://www.socialstyrelsen.se/en/statistics-and-data/registers/registerinformation/].
20. SCB SS. SSYK 1996 Standard for svensk yrkesklassificering 1996 (Swedish Standard Classification of Occupations 1996): SCB statistics Sweden; 2001 [2021]. [Available from: https://www.scb.se/contentassets/50bf86d2c66149d6 96f515a9481bc9e2Zov9999_1998a01_br_x70op9803.pdf].
21. Badarin K, Hemmingsson T, Hillert L, Kjellberg K. Physical workload and increased frequency of musculoskeletal pain: a cohort study of employed men and women with baseline occasional pain. Occup Environ Med 2021 Jan 17;78(8):55866. https://doi.org/10.1136/oemed-2020-107094
22. Forsakringskassan.se. Sickness Compensation The Swedish Social Insurance Agency; 2021 [Available from: https:// www.forsakringskassan.se/]
23. Nordic Council of Ministers NC-o. Labour Market Mobility in Nordic Welfare States. Copenhagen: Nordic Council of Ministers; 2010.
24. Wells R, Norman R, Neumann P, Andrews D, Frank J, Shannon H et al. Assessment of physical work load in epidemiologic studies: common measurement metrics for exposure assessment. Ergonomics 1997 Jan;40(1):51-61. https://doi.org/10.1080/001401397188369.
25. Mäki NE, Martikainen PT, Eikemo T, Menvielle G, Lundberg O, Östergren O et al.; EURO-GBDSE consortium members. The potential for reducing differences in life expectancy between educational groups in five European countries: the effects of obesity, physical inactivity and smoking. J Epidemiol Community Health 2014 Jul;68(7):635-40. https://doi.org/10.1136/jech-2013203501.
Received for publication: 11 May 2022

DETAILS

Subject:	Risk management; Workers; Regression analysis; Regression models; Employment; Women; Codes; Statistical analysis; Workloads; White collar workers; Occupations; Quartiles; Labor market; Men; Physical workload; Age; Confidence intervals; Sick leave; Occupational exposure; Exposure; Workload; Disability pensions; Risk reduction; Cohort analysis
Business indexing term:	Subject: Employment Workloads White collar workers Labor market Sick leave Disability pensions
Location:	Sweden
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	662-671
Publication year:	2022
Publication date:	2022
Section:	Original article

Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4053.
ProQuest document ID:	2738246745
Document URL:	https://www.proquest.com/scholarly-journals/does-change-occupation-with-lower-physical/docview/2738246745/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022
Last updated:	2023-04-19
Database:	Public Health Database

Longitudinal changes in proportionate mortality due to COVID-19 by occupation in England and Wales

Cherrie, Mark, PhD [1] ; Rhodes, Sarah, MSc [2] ; Wilkinson, Jack, PhD [2] ; Mueller, William, MSc [1] ; Nafilyan, Vahe, PhD [3] ; Van Tongeren, Martie, PhD; Pearce, Neil, PhD [1] Institute of Occupational Medicine, Edinburgh, UK. [2] Centre for Biostatistics, School of Health Sciences, Faculty of Biology, Medicine and Health, School of Health Sciences, The University of Manchester, Manchester, Manchester, UK. [3] Health Analysis Division, Office for National Statistics, Newport, UK.

ProQuest document link

ABSTRACT (ENGLISH)

Objective This study aimed to understand whether the proportionate mortality of COVID-19 for various occupational groups has varied over the pandemic. Methods We used the Office for National Statistics (ONS) mortality data for England and Wales. The deaths (20-64 years) were classified as either COVID-19-related using ICD-10 codes (U07.1, U07.2), or from other causes. Occupational data recorded at the time of death was coded using the SOC10 coding system into 13 groups. Three time periods (TP) were used: (i) January 2020 to September 2020; (ii) October 2020-May 2021; and (iii) June 2021-October 2021. We analyzed the data with logistic regression and compared odds of death by COVID-19 to other causes, adjusting for age, sex, deprivation, region, urban/rural and population density. Results Healthcare professionals and associates had a higher proportionate odds of COVID-19 death in TP1 compared to non-essential workers but were not observed to have increased odds thereafter. Medical support staff had increased odds of death from COVID-19 during both TP1 and TP2, but this had reduced by TP3. This latter pattern was also seen for social care, food retail and distribution, and bus and coach drivers. Taxi and cab drivers were the only group that had higher odds of death from COVID-19 compared to other causes throughout the whole period under study [TP1: odds ratio (OR) 2.42, 95% confidence interval (CI) 1.99-2.93; TP2: OR 3.15, 95% CI 2.63-3.78; TP3: OR 1.7, 95% CI 1.26-2.29]. Conclusion Differences in the odds of death from COVID-19 between occupational groups has declined over the course of the pandemic, although some occupations have remained relatively high throughout.

FULL TEXT

Headnote

Objective This study aimed to understand whether the proportionate mortality of COVID-19 for various occupational groups has varied over the pandemic.

Methods We used the Office for National Statistics (ONS) mortality data for England and Wales. The deaths (20-64 years) were classified as either COVID-19-related using ICD-10 codes (U07.1, U07.2), or from other causes. Occupational data recorded at the time of death was coded using the SOC10 coding system into 13 groups. Three time periods (TP) were used: (i) January 2020 to September 2020; (ii) October 2020-May 2021; and (iii) June 2021-October 2021. We analyzed the data with logistic regression and compared odds of death by COVID-19 to other causes, adjusting for age, sex, deprivation, region, urban/rural and population density.

Results Healthcare professionals and associates had a higher proportionate odds of COVID-19 death in TP1 compared to non-essential workers but were not observed to have increased odds thereafter. Medical support staff had increased odds of death from COVID-19 during both TP1 and TP2, but this had reduced by TP3. This latter pattern was also seen for social care, food retail and distribution, and bus and coach drivers. Taxi and cab drivers were the only group that had higher odds of death from COVID-19 compared to other causes throughout the whole period under study [TP1: odds ratio (OR) 2.42, 95% confidence interval (CI) 1.99-2.93; TP2: OR 3.15, 95% CI 2.63-3.78; TP3: OR 1.7, 95% CI 1.26-2.29].

Conclusion Differences in the odds of death from COVID-19 between occupational groups has declined over the course of the pandemic, although some occupations have remained relatively high throughout.

Key term occupational inequality; proportionate mortality analysis; SARS-CoV-2.

As of the week ending 4 March 2022, COVID-19 has been involved in 184 327 deaths in the UK, with around 18% occurring in those aged 15-64 years (1). It has been shown that some occupations have had higher rates of death than others. Broadly occupations termed as "essential" (providing crucial public and private services such as healthcare, social care, sanitary services and transportation) have fared worse (2, 3). Specific occupations that have shown elevated risks include healthcare workers (2, 4), taxi/bus drivers (5) and van drivers (2). However, while higher death rates have occurred in certain occupations, studies have found that there is substantial contribution of non-workplace factors (eg, socioeconomic, region, health status), which explain differential risks by occupational group (2, 5).

The reasons for higher risks in certain occupations include both workplace (direct) factors, and (indirect) factors outside of the workplace. Workplace factors include the location of work (indoors or outdoors), the ability to socially distance or avoid contact with suspected COVID-19 cases and the use of personal protective equipment (6). Factors

outside of the work place including housing conditions and occupancy and general deprivation, particularly in those with insecure low-paid jobs. These factors lead certain occupations to have a higher risk of infection, which may in turn lead to higher death rates. People working in these occupations may have higher accumulated SARS-CoV-2 dose, which could lead to higher viral load, which is associated with worse clinical outcomes of COVID-19 disease (7).

Working conditions have fluctuated over the course of the pandemic. Some organizations moved their staff to furlough in the initial stages of the pandemic and then, increasingly, to part- or full-time home-working. Workers also gained more protection to severe illness from COVID-19 from the start of 2021 as several vaccines became available and widely administered. Geographical location also became more important, especially in the second wave where there were localized, tiered restrictions. It is also likely that regions have differing support for non-pharmaceutical interventions (eg, face masks) (8), due to cultural, economic and social factors.

These changes have produced fluctuations in rates of infection, hospitalization and death - over what is commonly referred to as the three waves (spring 2020, winter 2020/2021 and autumn/winter 2021/2022). Previous mortality analyses on English data have been conducted for 2020 only, which covered wave 1 and some of wave 2 (2); analyses on Swedish data covered wave 1 and most of wave 2 (5), however we are unaware of analyses that have split the mortality data into the different time periods, rather, they have conducted analyses on the combined data (note that time stratified models have been conducted using infections data) (9, 10).

Proportional mortality ratios (PMR) are a measure of relative mortality frequently used in studies assessing occupational risks (11). The proportionate mortality ratio is defined as the proportion of deaths from a particular cause in one occupational group (a) to deaths from other causes (a+c), compared to another occupational groups proportion of specific deaths (b) to deaths from other causes (b+d), ie, ... Meittinen &Wang (12) have shown that the mortality odds ratio (MOR), is a superior measure to the PMR given that it does not require the assumption that the occupational group is not a risk factor for the non-specific causes of death, and is independent of the size of other deaths. Rather than the ratio of the proportions the MOR uses ratios of the odds between occupational groups. Therefore, the MOR is the ratio of deaths attributable to the cause of interest divided by deaths from other causes, compared across occupational groups (ie, MOR = ...). When the MOR is calculated to be above one for an occupation group of interest, we can conclude there are proportionately more deaths from COVID-19 in that group compared to deaths from other causes, which may suggest that particular occupational exposures lead to increased risk of deaths.

Using logistic regression (as in the current study), the MOR can be estimated after adjustment for key confounders. One advantage of using the MOR is that it did not require denominator data about the total population of the UK. This allowed us to conduct a more up-to-date analysis than can be conducted with analyses which require data linkage or the estimation of population denominators. Also, the MOR is at less risk of bias due to confounding by socioeconomic variables, as deaths due to COVID-19 are compared to deaths from other causes within the same occupational group and this in part adjusts for background differences in the overall mortality risk between occupational groups (13). The method presented differs from the previous occupational COVID-19 mortality studies, which have linked census or administrative and population register-derived data to death records and analyzed time-to-death using cox proportional hazard models (5, 14).

It is also important to determine how proportionate mortality varies across occupational groups and time periods over the course of the pandemic. This may point to certain groups of occupations that have (i) had a longstanding higher/lower odds of COVID-19 death, (ii) have recently become at higher odds of COVID-19 death or (iii) have recently become at lower odds of COVID-19 death. Governments can use this as evidence to apply occupation-specific interventions.

We have conducted an analysis of COVID-19 deaths in England and Wales during the period of January 2020 to October 2021. The aim was to understand the changes in deaths related to COVID-19 by occupational groups, over the course of the pandemic, and whether this varied by region of residence.

Methods

Deaths data

We used the Office for National Statistics (ONS) death registration data for England and Wales. We included all deaths in the working age population, defined here as aged 20-64 years old. The deaths were categorized as COVID-19 if there was any mention of ICD-10 codes U07.1 (COVID-19, virus identified) or U07.2 (COVID19, virus not identified) on the death certificate; all other deaths were categorized as not COVID-19 related. We did not include UO9.9 (multisystem inflammatory syndrome associated with COVID-19) or U10.9 (multisystem inflammatory syndrome associated with COVID-19, unspecified), which have only been used since early 2021 (15). The death certificate also contained information on age, sex and postcode.

Occupational data

Occupational information is recorded at the time of death registration by the informant and coded using the SOC10 (standard occupational classification) coding system (supplementary material, www.sjweh.fi/ article/4048). The four-digit SOC10 codes were then grouped into the following categories: healthcare professionals (eg, medical practitioners, pharmacists) and associates (eg, nurses, midwives); medical support staff (eg, ambulance staff, hospital porters); social care; education; food retail and distribution; food production; taxi and cab drivers; bus and coach drivers; van drivers; other transport workers, police and protective services; and sanitary workers (S1). This allowed for comparison with existing studies (3). All other occupations were coded as "non-essential". There were 33 604 deaths (20%) with only a 2 digit SOC10 code recorded; these were coded as "missing" in the analysis.

Covariates

We used information on lower super output area (LSOA) - retrieved based on the postcode - of death to gain information on neighborhood deprivation [index of multiple deprivation (IMD) income domain], population density, 8-class urban/rural classification and government office region (GOR). Neighborhood deprivation and population density were z-score standardized (ie, each data point was then interpreted by the number of standard deviations from the sample mean). In the interaction analyses (described below), we coded London, West Midlands and the North-West as binary variables (as there were too few cases to investigate all regions); chosen as they contain the three largest cities - London, Birmingham and Manchester. These three regions had the highest age standardized COVID-19 mortality during wave 1 and wave 2 (16).

Time periods

We originally pre-specified four time periods (TP) that were related to the extent of community level of infection and the presence of restrictions: January 2020-September 2020 (mixed community infection; mixed restrictions), October 2020-February 2021 (high community infection; high restrictions), March 2021May 2021 (low community infection; low restrictions), and June 2021-October 2021 (high community infections; low restrictions). However, given low numbers, we merged October 2020-February 2021 and March 2021-May 2021, resulting in October 2020-May 2021. Therefore, we used three TP for the analysis: TP1 (January 2020- September 2020); TP2 (October 2020-May 2021) and TP3 (June 2021-October 2021). These periods therefore contained a mixture of community infection rates which provided sufficient numbers to evaluate occupational differences. These TP roughly correspond to waves 1 (original virus dominant), 2 (Alpha variant dominant), and 3 (Delta variant dominant) in the UK and to the vaccination rollout programme: pre-vaccinated population, increasingly vaccinated population (first dose: 0-60%; second dose: 0-26.7%; booster dose: 0%) and highly vaccinated population (first dose: 68.8-85%; second dose: 45.3-78.1%; third dose: 0-1.8%). Due to low numbers, we further collapsed the new TP to TP2 (October 2020-May 2021) and TP3 (June 2021-October 2021) in the regional analyses.

Statistical analysis

We conducted a proportionate mortality analysis using logistic regression (17). We adjusted for variables in nested models: firstly adjusted for age, age squared and sex; then additionally for neighborhood deprivation, then region and finally for urban/rural classification and population density (fully adjusted). We then stratified the fully adjusted model by time period. The main results were presented as MOR with 95% confidence intervals (CI).

We then used the fully adjusted model and included a two-way interaction between occupational group and region (with region removed as a covariate), and then stratified the model by TP. We calculated two sets of marginal OR:

firstly, the marginal OR and 95% CI for each occupation compared with non-essential workers, for those living in London; secondly, the marginal OR and 95% CI for each occupation compared with nonessential workers, for those not living in London.
A complete case analysis was undertaken. All analyses were conducted in R ver 4.0.2 in the ONS Secure Research Service.

Results

There were 16 625 deaths (12%) related to COVID19 from January 2020 to October 2021 in ages 20-64 years old (table 1). Deaths related to COVID-19 peaked between October 2020 and May 2021 (22%); compared to 8% (January 2020-September 2020) and 7% (June 2021-October 2021) (table 2). Deaths were more likely to be among men (62%), and in older age (median 56 years), higher income deprivation (standard median -0.23) and higher population density (standard median -0.20). COVID-19 deaths were concentrated in major conurbations, cities and towns (80%), and in the North West (15%), London (13%) and South East (13%).
In the fully adjusted models, in comparison to nonessential workers, there was elevated odds of COVID-19 death in all but three of the essential occupational groups (education, police and protective services, and sanitary workers) (table 3). Taxi and cab drivers had the highest relative odds of death from COVID-19 (MOR 2.65; 95% CI 2.37-2.95). Estimates for occupational groups were marginally attenuated after full adjustment, more so among taxi and cab drivers, which was MOR 2.94 (95% CI 2.64-3.28) for the age and sex adjusted model. The other occupations had smaller reductions in MOR, except for food production which substantially increased. We also investigated an expanded group of occupations (S2). There were occupations that were within the nonessential workers group (sales occupations; elementary security occupation; process operatives; managers and directors in retail and wholesale) that had an elevated odds of COVID-19 death compared with corporate managers (S2).
On average the relative difference in the odds of COVID-19 death between the occupational groups and non-essential workers was higher in the second time period than for any other period (table 4). Healthcare professionals and associates had a higher relative odds in TP1 but then were not significantly different to nonessential workers thereafter. Medical support staff had higher odds of death from COVID-19 for longer (TP1 and TP2) but also became not significantly different to non-essential workers by TP3 (although they are still elevated but much less deaths results in a more imprecise estimate). This pattern was also seen for social care, food retail and distribution, and bus and coach drivers. There were two occupations that only had elevated odds in TP2 - van drivers and other transport workers. Taxi and cab drivers were the only group that have had elevated odds of death from COVID-19 at each stage of the pandemic, although this has varied in the magnitude - with TP2 having the highest relative odds of death, then TP1 and then TP3.
London was the only region (out of the three tested) that had a significant interaction with occupational group (likelihood ratio test $P<0.05$); indicating that the odds of COVID-19 death by occupational group was modified by London residence, compared to the rest of England and Wales. The marginal MOR showed that the odds of death from COVID-19 was slightly elevated in London for a number of occupations, and this difference was most apparent during the early pandemic (January 2020-September 2020). The occupational groups that were most reflective of these trends were food production, bus and coach drivers and taxi drivers, although each had small numbers and therefore the estimates have high uncertainty.

Discussion

Principal findings

Overall the differences in the odds of death involving COVID-19 between occupational groups have declined over the course of the pandemic. The highest difference between essential and non-essential workers was in the second time period, which might indicate the impact of the Alpha variant, which had higher hospitalization compared to the original virus (18).Low occupational differences by the third time period when the Delta variant was dominant (and also had an increased risk of mortality) (19) suggests that vaccines have had an effect on reducing occupational inequalities in risk of COVID19 mortality. This is exemplified by healthcare workers who had above average coverage [fully vaccinated (two dose) in 92% of nurses/midwives and 89% of medical practitioners] (20).

Whilst general restrictions were highest in the earlier TP this also corresponded to the time when occupational differences were higher, which suggests that they were not protecting workers who could not work from home. A notable exception is workplace controls in healthcare settings, which were inadequate during the early stages of the pandemic but were enhanced (through adequate provision of PPE and guidance). This may explain the lower odds of COVID-19 death by the later TP (21). However cumulative incidence of COVID-19 mortality, prevalence of naturally acquired immunity though repeated infection and the increasing use of medical treatments to reduce likelihood of death could also have played a role in the findings presented.

An alternative explanation for the patterns observed in the current study is that the odds of deaths involving COVID-19 have increased in the non-essential group, which would attenuate relative differences with the other occupational groups. However, the difference in the odds of deaths involving COVID-19 from TP3-TP1 for the non-essential occupational group was -7.3%. The other occupational groups had differences between -11.6% (police and protective services) and -57.6% (healthcare professionals and associates). This suggests that it is the decline in COVID-19 mortality in 'essential' occupations rather than an increase in 'non-essential' mortality that is driving the associations observed.

The only occupational group that has seen elevated odds of deaths related to COVID-19 (compared to nonessential occupations) at each stage of the pandemic was taxi and cab drivers. A study using a job exposure matrix assigned taxi drivers as high risk for a number of factors associated with increased risk of infection, including: (i) number of adults/adolescents at the same worksite during a typical work day, (ii) indirect contact with adults/adolescents at work within the same workday, (iii) location of work (inside or outside), (iv) elevated risk of contact with adults/adolescents with (suspicion of) COVID-19, (v) social distancing among adults/adolescents at the same work floor (patients, citizen, colleagues), (vi) protection equipment, (vii) migrant workers (proportion of migrant workers), and (viii) low risk for job insecurity (proportion of flexible labor contracts) (6). Taxi drivers have among the smallest indoor working space which is often poorly ventilated; it was found that CO2 levels can rise to >2500 ppm and stay high for a working shift (22); this is well above the guidance from the UK's Health and Safety Executive, which states that action should be taken in any working space with CO2 >1500 ppm (23). Changes to the ventilation (eg, air conditioning) within taxis could impact on mortality through reduced exposure to COVID19 virus specifically, and also air pollution in general (24). Taxi drivers also have lower than average vaccination rates - 83.3% two-dose vaccinated (20).

For those living in London compared to the rest of England and Wales, the odds of deaths involving in COVID-19 were slightly elevated for food production, bus and coach workers, and taxi drivers, compared to non-essential workers, especially in the early stages of the pandemic. Food production was also the only occupation where the MOR substantially increased after adjustment for urban/rural and population density, which provides further support that the likelihood of severe COVID-19 was more geographically patterned in this group. Regional differences may be due to enhancement of occupational risks by individual socioeconomic factors - overcrowding and higher proportion of children in low income families (16). Occupational groups may have enhanced risk of infection and death due to the intensity of the activity - more working hours and more (potential) contact with people with COVID-19. It may also be due to the different mixtures of individual jobs within each job category. For example indoor jobs such as "food, drink and tobacco process operatives" may be over-represented in the food production group in urban regions like London; whereas more outdoor jobs with lower risk such as "fishing and other elementary agricultural occupations n.e.c." may be in this category in regions like South West - thus skewing the regional differences.

One other UK study has investigated longitudinal differences in excess mortality over the pandemic (25). The analysis was restricted to 2020. The authors found that excess deaths peaked at the end of April 2020 and that essential workers, particularly healthcare workers, were most affected. They found a difference between healthcare professionals/associate professionals and medical support staff, whereby the latter had a longer period of higher excess deaths. Therefore the results on healthcare workers are similar to the current study. They also show that transport and social workers were the most affected groups in November 2020 with approximately 20% excess

deaths, in agreement with the current study that showed elevated odds in the first two time periods. There are differences between the studies. They found that food workers, police/protective services and to a lesser extent education workers had higher excess deaths early in the pandemic which then returned back to pre-COVID-19 excess mortality rates. We found that police/protective services and education did not have a higher odds of COVID-19 death compared to essential workers at any time period.

To our knowledge there are no analyses outside of the UK on occupational difference in COVID-19 mortality risks over time. However, there is a study from Norway comparing the infection between the first and the second wave, which roughly correspond to the time periods presented in the current analysis (26). A similar patterns emerged whereby some of the largest reductions in odds of infection were for physicians, nurses, dentists and physiotherapists (ie, healthcare); and largest increases for bartenders, transport conductors and travel stewards (ie, some transport occupations).

Strengths

We have conducted a proportionate mortality analysis that covers the hallmarks of a robust analysis (27): a short period of time (which means less bias from population changes), the maximum amount of deaths data available from national registries, all groups have the same access to medical care and diagnosis (due to the UK's National Health Service) and we account for age at death (through statistical adjustment). We also adjusted for multiple factors identified in directed acyclic graphs in previous analyses (28), including all the variables in the minimal sufficient adjustment set from one study - age, deprivation, geographical region and sex (29).

Limitations

There is potential misclassification of the deaths for healthcare occupations especially at the beginning of the pandemic, as these individuals were more likely to be tested for COVID-19 and therefore have their death attributed to COVID-19 compared with other occupational groups. In small study samples it is shown that the proportionate mortality ratios may be overestimated (30). Given that the range of the deaths from COVID-19 by occupation was 20-675; overestimation may have been approximately 2.5-22.25% (30). The largest bias would have occurred in the later stages of the pandemic and in the London-stratified models, however these were already predominantly null associations and would therefore be drawn even closer to no effect if corrected. In our regression analysis, we were unable to account for underlying health conditions and ethnicity at the individual level given that it is not recorded on the death certificate and cannot be linked via the individual's postcode; these have been included in the minimal sufficient adjustment set in two previous papers (2, 3). It is likely that elevated odds for some of the occupations (eg, taxi and cab drivers) where non-white ethnicity is higher would have been attenuated by inclusion of individual ethnicity [due to non-white ethnicity being a risk factor for COVID-19 death (14)]. The risk of death was between two (black African) and five times (Bangladeshi) greater compared to white Britons (31). Given the study design (ie, comparisons made within occupational groups) and the size of the taxi and cab driver effect, we consider it unlikely that both the small sample bias and the inability to account for ethnicity would have affected the main interpretation, that this group had an elevated odds of mortality attributed to COVID-19 across the pandemic.

It was deemed that alternative specifications of variables (ie, including deprivation and population density as a spline, including age as linear rather than quadratic) included in the model would have marginally impacted the results presented, although this has not been formally tested.

Future work and policy

There are some parts of the study design that could be explored in further work. We have used one definition of a COVID-19 death which includes all deaths "involving" COVID-19. Another definition is deaths "due to" COVID-19, which means that it is the only condition named on the death certificate. This would have reduced the dataset to approximately half the number of deaths (32), which would not have allowed the analysis of a broad set of occupations, time periods and regions. The main analysis focused on groups of occupations, and in doing so masked within group variability. It was found that risks of sickness absence due to COVID-19 varied by the specific position within healthcare (33). For the food and drink processing industry, only grain millers were found to have COVID-19 incidence rates (34). It is not just the occupation but also the type of work done in the job that is relevant.

Shift work has also been associated with higher risk of severe COVID-19 (35). Further work could also explore changes to the definition of 'non-essential' occupations, given that jobs within this category have increased in risk as time has gone on (ie, retail workers). Finally, it is important to triangulate the findings from this study with others eg, the ONS infection survey (36), in order to understand how risk of COVID-19 due to occupational circumstances has changed over time and to make recommendations for policy on added non-pharmaceutical protections in the workplace. The evidence to date indicates that the occupational group with the most severe risk generally has moved from being within healthcare to transport during this pandemic (with the caveat that there were differences between workers within these groups). If this is shown to be the case in multiple countries, then it implies that these workplaces should be prioritized sequentially for the application of the hierarchy of controls in the future (37). Controls could include ventilation systems being tested (and updated if required); face to face contact, hand and surface hygiene policies reviewed; and personal protective equipment stockpiled. The effect on transmission risk from applying these changes should be evidenced by modelling (ie, quantitative microbial assessment models) to provide support for action (38).

Concluding remarks

Increased odds of COVID-19 death were observed for a number of occupations, such as healthcare professionals and associates and medical support staff compared to non-essential workers, but these differences reduced over the pandemic, with the exception of taxi drivers. Proportionate mortality analysis is a straightforward and practical way to monitor relative differences in COVID-19 mortality by occupation, and their changes over time. It has some considerable practical advantages over other methods since it only requires the mortality data, which is usually readily available and may be less prone to confounding.

Acknowledgements

We would like to thank colleagues at the Institute of Occupational Medicine and from the NCS PROTECT project on their helpful feedback on the study.

Disclosure

This work was produced using statistical data from ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

Funding

This work was supported by funding through the National Core Study "PROTECT" programme, managed by the Health and Safety Executive on behalf of HM Government, and a grant from the Colt Foundation (CF/05/20).

Ethics approval

Ethical approval was obtained from the National Statistician's Data Ethics Advisory Committee.

Sidebar

Cherrie M, Rhodes S, Wilkinson J, Mueller W, Nafilyan V Van Tongeren M, Pearce N. Longitudinal changes in proportionate mortality due to COVID-19 by occupation in England and Wales. Scand J Work Environ Health. 2022;48(8):611-620. doi:10.5271/sjweh.4048

Correspondence to: Mark Cherrie, Institute of Occupational Medicine, Edinburgh, UK. [E-mail: mark.cherrie@iom-world.org]

Received for publication: 11 April 2022

References

References

1. Coronavirus ON. (COVID-19) latest insights: Comparisons. 2022; Available from: https://www. ons.gov. uk/peoplepopulationandcommunity/ healthandsocialcare/conditionsanddiseases/articles/ coronaviruscovid19latestinsights/overview.

2. Nafilyan VP, Ayoubkhani D, Rhodes S, Pembrey L, Matz M, Coleman MP et al. Occupation and COVID-19 mortality in England: a national linked data study of 14.3 million adults. medRxiv. 2021;05.12.21257123. https://doi.org/10.1101/20 21.05.12.21257123.

3. Mutambudzi M, Niedwiedz C, Macdonald EB, Leyland A, Mair F, Anderson J et al. Occupation and risk of severe COVID-19: prospective cohort study of 120 075 UK Biobank participants. Occup Environ Med 2020 Dec;78(5):307-14. https://doi.org/10.1136/oemed-2020-106731.
4. Shah AS, Wood R, Gribben C, Caldwell D, Bishop J, Weir A et al. Risk of hospital admission with coronavirus disease 2019 in healthcare workers and their households: nationwide linkage cohort study. BMJ 2020 Oct;371:m3582. https://doi.org/10.1136/bmj.m3582.
5. Billingsley S, Brandén M, Aradhya S, Drefahl S, Andersson G, Mussino E. COVID-19 mortality across occupations and secondary risks for elderly individuals in the household: A population register-based study. Scand J Work Environ Health 2022 Jan;48(1):52-60. https://doi.org/10.5271/ sjweh.3992.
6. Oude Hengel KM, Burdorf A, Pronk A, Schlünssen V, Stokholm ZA, Kolstad HA et al. Exposure to a SARS-CoV-2 infection at work: development of an international job exposure matrix (COVID-19-JEM). Scand J Work Environ Health 2022 Jan;48(1):61-70. https://doi.org/10.5271/ sjweh.3998.
7. Soria ME, Cortón M, Martínez-González B, Lobo-Vega R, Vázquez-Sirvent L, López-Rodríguez R et al. High SARS-CoV-2 viral load is associated with a worse clinical outcome of COVID-19 disease. Access Microbiol 2021 Sep;3(9):000259. https://doi.org/10.1099/acmi.0.000259.
8. Matthews Pillemer F, Blendon RJ, Zaslavsky AM, Lee BY. Predicting support for non-pharmaceutical interventions during infectious outbreaks: a four region analysis. Disasters 2015 Jan;39(1):125-45. https://doi.org/10.nn/disa.12089
9. Beale S, Hoskins S, Byrne T, Fong EW, Fragaszy E, Geismar C et al. Differential Risk of SARS-CoV-2 Infection by Occupation: Evidence from the Virus Watch prospective cohort study in England and Wales. medRxiv. 2021:2021.12.14.21267460. https://doi.org/10.n01/202U 2.14.21267460.
10. Magnusson K, Nygård K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the first versus second epidemic wave in Norway, 2020. Euro Surveill 2021 Oct;26(40): https://doi.org/10.2807/1560-7917. ES.2021.26.40.2001875.
11. Cocco P, Blair A, Congia P, Saba G, Flore C, Ecca MR et al. Proportional mortality of dichloro-diphenyltrichloroethane (DDT) workers: a preliminary report. Arch Environ Health 1997 Jul-Aug;52(4):299-303. https://doi. org/10.1080/00039899709602202.
12. Miettinen OS, Wang JD. An alternative to the proportionate mortality ratio. Am J Epidemiol 1981 Jul;114(1):144-8. https://doi.org/10.1093/oxfordjournals.aje.a113161.
13. Checkoway H, Pearce ND. Research methods in occupational epidemiology. New York: Oxford University Press; 2004.
14. Nafilyan V, Islam N, Mathur R, Ayoubkhani D, Banerjee A, Glickman M, et al. Ethnic differences in COVID-19 mortality during the first two waves of the Coronavirus Pandemic: a nationwide cohort study of 29 million adults in England. Eur J Epidemiol. 2021 Jun;36(6):605-17. https:// doi.org/ 10.1007/s10654-021-00765-1.
15. ONS. Coronavirus and mortality in England and Wales methodology. 2021; Available from: https:// www.ons.gov.uk/peoplepopulationandcommunity/ birthsdeathsandmarriages/deaths/methodologies/ coronavirusandmortalityinenglandandwalesmethodology.
16. Tinson A. What geographic inequalities in COVID-19 mortality rates and health can tell us about levelling up. 2021; Available from: https://www.health.org.uk/newsand-comment/charts-and-infographics/what-geographicinequalities-in-covid-19-mortality-rates-can-tell-us-aboutlevelling-up#:~:text=COVID%2D19%20mortality%20 rates%20for%20people%20younger%20than%2065%20 varied,100%2C000%20in%20the%20South%20West.
17. Robins JM, Blevins D. Analysis of proportionate mortality data using logistic regression models. Am J Epidemiol 1987 Mar;125(3):524-35. https://doi.org/10.1093/ oxfordjournals.aje.a114559.
18. Nyberg T, Twohig KA, Harris RJ, Seaman SR, Flannagan J, Allen H et al. Risk of hospital admission for patients with SARS-CoV-2 variant B.1.1.7: cohort analysis. BMJ 2021 Jun;373(1412):n1412. https://doi.org/10.1136/bmj.n1412.

19. Sheikh A, McMenamin J, Taylor B, Robertson C; Public Health Scotland and the EAVE II Collaborators. SARSCoV-2 Delta VOC in Scotland: demographics, risk of hospital admission, and vaccine effectiveness. Lancet 2021 Jun;397(10293):2461-2. https://doi.org/10.1016/S01406736(21)01358-1.
20. Nafilyan V, Dolby T, Finning K, Morgan J, Edge R, Glickman M et al. Differences in COVID-19 vaccination coverage by occupation in England: a national linked data study. medRxiv. 2021:2021.11.10.21266124. https://doi.org /10.1101/2021.11.10.21266124.
21. Hoernke K, Djellouli N, Andrews L, Lewis-Jackson S, Manby L, Martin S et al. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open 2021 Jan;11(1):e046199. https://doi. org/10.1136/bmjopen-2020-046199.
22. Moreno T, Pacitto A, Fernández A, Amato F, Marco E, Grimalt JO, et al. Vehicle interior air quality conditions when travelling by taxi. Environ Res. 2019 May;172:529542. https://doi.org/10.1016/j.envres.2019.02.042.
23. HSE. Ventilation during the coronavirus (COVID-19) pandemic. 2022; Available from: https://www.hse.gov.uk/coronavirus/equipment-and-machinery/air-conditioningand-ventilation/identifying-poorly-ventilated-areas.htm.
24. Das D, Ramachandran G. Risk analysis of different transport vehicles in India during COVID-19 pandemic. Environ Res 2021 Aug;199:111268. https://doi.org/10.1016/j. envres.2021.111268.
25. Matz M, Allemani C, van Tongeren M, Nafilyan V, Rhodes S, van Veldhoven K et al. Excess mortality among essential workers in England and Wales during the COVID-19 pandemic. J Epidemiol Community Health 2022 Jul;76(7):660-6. https://doi.org/10.1136/jech-2022-218786.
26. Magnusson K, Nygård K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the first versus second epidemic wave in Norway, 2020. Euro Surveill 2021 Oct;26(40):2001875. https://doi.org/10.2807/1560-7917.ES.2021.26.40.2001875.
27. Hansen ES. The proportionate mortality ratio and its relationship with measures of mortality. Stat Med 1990 Mar;9(3):315-23. https://doi.org/10.1002/sim.4780090314.
28. Wilkinson, J; Beale, S; Cherrie, M; Edge, R; Fishwick, D; Gittins, M; et al. (2021): DAGs of occupation and COVID V1.pdf. University of Manchester. Preprint. https://doi. org/10.48420/16847158.v1
29. Beale S, Patel P, Rodger A, Braithwaite I, Byrne T, Erica Fong WL et al. Occupation, Work-Related Contact, and SARS-CoV-2 Anti-Nucleocapsid Serological Status: Findings from the Virus Watch prospective cohort study. medRxiv. 2021:2021.05.13.21257161. https://doi.org/10.11 01/2021.05.13.21257161.
30. Zhou JY. Bias in the proportionate mortality ratio analysis of small study populations: A case on analyses of radiation and mesothelioma. Int J Radiat Biol. 2014 Nov;90(11):1075-9. https://doi.org/10.3109/09553002.2014.931611.
31. ONS. Updating ethnic contrasts in deaths involving the coronavirus (COVID-19), England: 8 December 2020 to 1 December 2021. 2022. Available from https://<www.ons.gov.uk/peoplepopulationandcommunity/births deathsandmarriages/deaths/articlesupdatingethniccontrasts> indeathsinvolvingthecoronaviruscovid19england andwales/8december2020to1december2021
32. ONS. Definition of "deaths involving COVID-19". 2021; Available from: https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/ definitionofdeathsinvolvingcovid19.
33. van der Plaat DA, Madan I, Coggon D, van Tongeren M, Edge R, Muiry R et al. Risks of COVID-19 by occupation in NHS workers in England. Occup Environ Med 2022 Mar;79(3):176-83. https://doi.org/10.1136/ oemed-2021-107628.
34. Mueller W, Loh M, Fletcher T, Rhodes S, Pembrey L, Pearce N, van Tongeren M. An Ecological Study of COVID-19 Infection Rates within the UK Food and Drink Processing Industry. Ann Work Expo Health. 2022 Jun 15;wxac042. https://doi. org/10.1093/annweh/wxac042. [Epub ahead of print].
35. Rowlands AV, Gillies C, Chudasama Y, Davies MJ, Islam N, Kloecker DE, et al. Association of working shifts, inside and outside of healthcare, with severe COVID-19: an observational study. BMC Public Health. 2021 Apr 22;21(1):773. https://doi.org/10.1186/s12889-021-10839-0.
36. Pearce N, Rhodes S, Stocking K, Pembrey L, van Veldhoven K, Brickley EB et al. Occupational differences in

COVID-19 incidence, severity, and mortality in the United Kingdom: available data and framework for analyses. Wellcome Open Res 2021 May;6:102. https://doi.org/10.12688/ wellcomeopenres.16729.1.
37. Sehgal NJ, Milton DK. Applying the Hierarchy of Controls: What Occupational Safety Can Teach us About Safely Navigating the Next Phase of the Global COVID-19 Pandemic. Front Public Health. 2021 Nov 5;9:747894. https://doi.org/10.3389/fpubh.2021.747894.
38. Miller D, King MF, Nally J, Drodge JR, Reeves GI, Bate AM et al. Modeling the factors that influence exposure to SARS-CoV-2 on a subway train carriage. Indoor Air 2022 Feb;32(2):e12976. https://doi.org/10.1111/ina.12976.

DETAILS

Subject:	Pandemics; Regression analysis; Deprivation; Population density; Severe acute respiratory syndrome coronavirus 2; Mortality; Codes; COVID-19; Statistical analysis; Confidence intervals; Death; Coronaviruses; Taxicabs
Location:	United Kingdom--UK; England; Wales
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	611-620
Publication year:	2022
Publication date:	2022
Section:	Original article
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4048

Workplace psychosocial resources and risk of cardiovascular disease among employees: a multi-cohort study of 135 669 participants

Xu, Tianwei, PhD [1] ; Rugulies, Reiner, PhD [2] ; Vahtera, Jussi, PhD [3] ; Pentti, Jaana, MSc [3] ; Mathisen, Jimmi, MSc [2] ; Lange, Theis, PhD; Clark, Alice J, PhD; Hanson, Linda L Magnusson, PhD; Westerlund, Hugo, PhD; Ervasti, Jenni, PhD; Virtanen, Marianna, PhD; Kivimäki, Mika, PhD; Rod, Naja H, PhD [1] Stress Research Institute, Stockholm University, Stockholm, Sweden [2] Department of Public Health, University of Copenhagen, Copenhagen, Denmark [3] Department of Public Health, University of Turku, Turku, Finland

ABSTRACT (ENGLISH)

Objective In terms of prevention, it is important to determine effects on cardiovascular disease (CVD) when some workplace psychosocial resources are high while others are low. The aim of the study was to assess the prospective relationship between clustering of workplace psychosocial resources and risk of CVD among employees. Methods We pooled data from three cohort studies of 135 669 employees (65% women, age 18-65 years and free of CVD) from Denmark, Finland and Sweden. Baseline horizontal resources (culture of collaboration and support from colleagues) and vertical resources (leadership quality and procedural justice) were measured using standard questionnaire items. Incident CVD, including coronary heart and cerebrovascular disease, was ascertained using linked electronic health records. We used latent class analysis to assess clustering (latent classes) of workplace psychosocial resources. Cox proportional hazard models were used to examine the association between these clusters and risk of CVD, adjusting for demographic and employment-related factors and pre-existing physical and mental disorders. Results We identified five clusters of workplace psychosocial resources from low on both vertical and horizontal resources (13%) to generally high resources (28%). High horizontal resources were combined with either intermediate [hazard ratio (HR) 0.84, 95% confidence interval (CI) 0.74-0.95] or high (HR 0.88, 95% CI 0.78-1.00) vertical resources were associated with lower risks of CVD compared to those with generally low resources. The association was most prominent for cerebrovascular disease (eg, general high resources: HR 0.80, 95% CI 0.67-0.96). Conclusions Individuals with high levels of workplace psychosocial resources across horizontal and vertical dimensions have a lower risk of CVD, particularly cerebrovascular disease.

FULL TEXT

Headnote

Objective In terms of prevention, it is important to determine effects on cardiovascular disease (CVD) when some workplace psychosocial resources are high while others are low. The aim of the study was to assess the prospective relationship between clustering of workplace psychosocial resources and risk of CVD among employees.

Methods We pooled data from three cohort studies of 135 669 employees (65% women, age 18-65 years and free of CVD) from Denmark, Finland and Sweden. Baseline horizontal resources (culture of collaboration and support from colleagues) and vertical resources (leadership quality and procedural justice) were measured using standard questionnaire items. Incident CVD, including coronary heart and cerebrovascular disease, was ascertained using linked electronic health records. We used latent class analysis to assess clustering (latent classes) of workplace psychosocial resources. Cox proportional hazard models were used to examine the association between these clusters and risk of CVD, adjusting for demographic and employment-related factors and pre-existing physical and mental disorders.

Results We identified five clusters of workplace psychosocial resources from low on both vertical and horizontal resources (13%) to generally high resources (28%). High horizontal resources were combined with either intermediate [hazard ratio (HR) 0.84, 95% confidence interval (CI) 0.74-0.95] or high (HR 0.88, 95% CI 0.78-1.00) vertical resources were associated with lower risks of CVD compared to those with generally low resources. The association was most prominent for cerebrovascular disease (eg, general high resources: HR 0.80, 95% CI 0.67-0.96).

Conclusions Individuals with high levels of workplace psychosocial resources across horizontal and vertical dimensions have a lower risk of CVD, particularly cerebrovascular disease.

Key terms collaboration; leadership quality; procedural justice; social support.

Early studies on stressful psychosocial working conditions and cardiovascular disease (CVD) risk were published already in the 1960s (1), and subsequent cohort studies have confirmed an association between work stressors and CVD (2). The leading concepts of psychosocial working conditions include the job-demandcontrol (job strain) model (3-5), the effort-reward imbalance model (6), the organizational justice model (7), and the job-demands-resources model (8). More recently, it has been suggested that a focus on potential health-protective resources at work may also be useful (9). From a CVD prevention perspective, targeting workplace psychosocial resources may complement traditional workplace interventions, such as wellness and exercise programs (10).

High levels of workplace psychosocial resources have been suggested to be linked to a lower risk of mental health problems including depression (11), the metabolic syndrome (12), and type 2 diabetes (13, 14), lower levels of inflammatory markers such as C-reactive protein, interleukin-6 and tumor necrosis factor alpha (13, 15), and lower ambulatory blood pressure (16, 17), which are all CVD risk factors. To date, however, the evidence on potential health benefits of workplace psychosocial resources is inconsistent and scarce. Published studies have mainly investigated coronary heart disease (CHD) but not cerebrovascular disease (CBD), although the latter contributes to 35% of age-standardized CV-related deaths (18). Three studies found that a higher level of workplace psychosocial resources, operationalized as preferable levels of organizational justice (7), leadership quality (19), or workplace social support (20, 21), were associated with a lower risk of incident CHD, but these associations were not observed in an earlier study of 19 565 full-time employed Swedish women (22), and not for CBD (21). None of these previous studies considered the clustering of workplace psychosocial resources, although resources are likely to cluster and through this clustering be differently associated with health outcomes than what would be expected based on their individual effects. The coexistence of workplace psychosocial resources at organizational, leadership, and group levels (ie, different hierarchical domains) may be dynamic (23). These different sources of resources may potentially affect each other and exert synergistic influences on employees' health (23). Our previous study identified four distinct resource clusters among Finnish public sector employees, and some clusters were more protective of type-2 diabetes than others (14), but it remained unclear whether this workplace resource pattern could be generalized to the wider working population, including private sector employees, or to other health outcomes. The present paper

adds new results towards this end. In terms of prevention, it is important to explore and understand the clustering of workplace psychosocial resources and the potential health effects of such clustering across various hierarchical domains in order to develop effective multilevel interventions aimed at creating healthier workplaces.

To address these limitations, we examined the clustering of four key workplace psychosocial resources (ie, culture of collaboration, social support from colleagues, leadership quality and procedural justice) and assessed whether these clusters were associated with the risk of developing CVD (including CHD and CBD) in three cohorts with a total of 135 669 men and women from Denmark, Finland and Sweden. These cohorts included employees from public and private sectors.

Methods

Study population

We used data from the following three prospective cohort studies: The Work Environment and Health in Denmark (WEHD) study, the Finnish Public Sector (FPS) study and the Swedish Longitudinal Occupational Survey of Health (SLOSH) (figure 1). WEHD is a biennial population-based survey, initiated in 2012 in Denmark, with around 58% respondents working in the private sector (24). FPS is a dynamic cohort of Finnish employees with repeated data collections every two to four years initiated in 1998/2000 onwards (25). FPS consists of employees in the municipal services of ten Finnish town and 21 public hospitals, who had a job contract for a minimum of six months. SLOSH is a population-based cohort initiated in 2006 in Sweden with biennial follow-ups, including 59% participants working in the private sector (26). A more detailed description of these cohorts has been published elsewhere (27).

According to the data availability and to allow cross-wave comparability, we included WEHD waves 2012-2014, FPS waves 2000-2014, and SLOSH waves 2012-2016. Figure 1 depicts the process of baseline establishment, including the exclusion criteria, and end of follow-ups. To ascertain incident CVD during the follow-up, all CVD cases occurred prior to the baseline were excluded (figure 1).

Ethical approval for FPS was obtained from the Ethics Committee of the Hospital District of Helsinki and Uusimaa (25). WEHD was approved by and registered with the Danish Data Protection Agency. Ethical approval was obtained from the Regional Ethical Review Board in Stockholm for SLOSH (26).

Workplace psychosocial resources

We measured four types of workplace psychosocial resources: (i) culture of collaboration, (ii) support from colleagues, (iii) leadership quality, and (iv) procedural justice to represent hierarchical dimensions of workplace psychosocial resources, ie, group (horizontal), leader (vertical) and organizational (vertical) levels, respectively, using standardized items/scales (supplementary material, www.sjweh.fi/article/4042, table S1) (23). Detailed explanations of choosing the following categorization can be found in supplementary text S1.

Culture of collaboration was dichotomized and good collaboration was defined as the collaborative efforts to achieve the best available results or to develop or apply new ideas in the workplace. The items from the justice and team climate inventories were used as a single item (in WEHD) or as dichotomized by the mean score (in SLOSH and FPS) (28, 29).

Co-worker support on perceived colleagues' support was dichotomized by whether receiving an affirmative response to one item (from the Danish Psychosocial Work Environment Questionnaire in WEHD (30); from the Demand-Control questionnaire in SLOSH (26); and from Statistics Finland working climate questions in FPS) (31).

Due to the harmonization (14), the leadership variable in FPS and SLOSH included dimensions on caring, listening, appreciative, and informative (three items from The Stress Profile and one item from the relational justice scale) (32, 33). WEHD included slightly different dimensions (8 items including eg, authorization of own work and career development) (24). Leadership quality was categorized into quartiles.

The variable for procedural justice (fairness in the principles and processes leading to decision-making and the distribution of rewards and benefits) was measured using a modified version of Moorman's scale (34). Procedural justice was categorized into quartiles in FPS and SLOSH. In WEHD, procedural justice was also grouped into four levels (one item) and the highest level of procedural justices was 'all the time', followed by 'often' or 'sometimes', 'rarely' and 'never'.

To understand the heterogeneity of instruments across cohorts, we performed tests for checking the correlations and agreements between the single-item instruments and the full scales (supplementary table S2). There were high correlations (Spearman correlation coefficients >0.8) and moderate to strong levels of agreements (0.60<k<0.90) between the single-item and scale measures when assessing culture of collaboration. For procedural justice, despite of a high correlation between the single-item measurement (Spearman correlation coefficients >0.8) and the full scale, the agreement was relatively weak (0.40<k<0.59). Leadership items in WEHD were not identical with those in FPS and SLOSH (the latter two cohorts used exactly same leadership items) and due to lack of shared items, we were not able to perform similar validity analyses as for culture of collaboration and procedural justice.

Assessment of cardiovascular disease

Using the unique personal identification numbers for each citizen in Denmark, Finland and Sweden, all participants were linked to nationwide health, death and population registers. We used in-patient (all cohorts), out-patient (SLOSH and WEHD) and death (all cohorts) registers to capture incident CVD (ie, cases occurred prior to baseline were excluded). CVD was identified if diagnosed with CHD or CBD. We detected CHD using the main diagnosis codes of ICD-10 I20.0, I20.1, I21-I25 (excluding unspecified angina), and ICD-8/9 410-414, whereas ICD-10 I60-I69 and ICD-8/9 430438 were used to detect CBD as the main diagnosis. Subtypes of CVD, including myocardial infarction, ischemic stroke and hemorrhagic stroke were also identified using ICD codes (supplementary text S2). Incident CVD events were identified with the earliest diagnosed date after the baseline, after excluding historical CVD events (figure 1).

Covariates

Confounders were identified prior to data analysis using directed acyclic graphs based on prior knowledge (36). Key confounders included age, sex, country of birth (Nordic born, other European countries, other continents), educational level (<9, 10-12, >13 years), marital status (unmarried or cohabiting, single, separated or divorced and widowed), type of employment contract (permanent/non-permanent), pre-existing comorbidities (Charlson Comorbidity Score) and pre-existing diagnosed mental disorders (supplementary text S3). These variables were all extracted from the national registers, except that marital status in FPS and employment contract in SLOSH were measured by self-report and there was no information on country of birth in FPS.

Other clinical factors including body mass index (BMI), self-reported mental health and lifestyle factors including smoking (current smoker/non-smoker), risky alcohol consumption (yes/no) and physical inactivity (yes/no) were self-reported at the baseline (supplementary text S3). We considered them to be potential mediators rather than confounders, as they were measured at the same time with the exposures.

Statistical analysis

We used latent class analysis, a hypothesis-free datadriven approach, to assess clustering of workplace psychosocial resources based on participants' first eligible participation (36). In previous study based on this approach, we have shown that the latent classes observed at baseline (ie, the first eligible participation) were robust over time and could be extrapolated to all participants regardless of their participation waves (14). In addition to Bayesian Information Criterion (a measurement of model fit), distribution of class membership probabilities, class sizes and interpretability of the classes, we determined the class model according to the comparability across cohorts (supplementary figure S1) (36). Although a four-class solution already showed distinctive patterns in FPS in a previous study (14), using a five-class model with one additional distinctive latent class pattern added in WEHD and SLOSH, the three cohorts were more comparable and we therefore chose to use this five-class solution (supplementary figure S1).

We ran a Cox proportional hazard model with age as the underlying time scale. No violation was detected for proportional hazard assumption (by using log-log plot or by including interaction terms between time and covariates). The model was adjusted for country of birth (when available), marital status, educational level, type of employment contract, and pre-existing mental and physical comorbidity. The incidence rate difference was calculated using the Aalen additive hazard model. Subtype analyses of CHD and CBD were performed. As a supplement, we analyzed each individual type of resources with and without mutual adjustment of the others, using the lowest level of each

individual resource as the reference.
We also conducted several sensitivity analyses. In order to reduce the risk that employees who had prevalent, albeit undiagnosed CVD might be more likely to perceive workplace psychosocial resources differently, resulting in reverse causation, a one-year lag-time was applied. We further restricted the follow-up lengths to the first four years, to rule out the impact of differences in follow-up lengths across cohorts. Lastly, models were additionally adjusted for other covariates, ie, lifestyle and clinical factors assumed to be mediators in the primary analysis.
To determine potential effect modification, stratified results were carried out for age groups, by sex and educational levels using the Cox model and the additive hazard model, to estimate interactions on both the multiplicative and additive scales.
We followed a 2-stage approach in which associations were first analyzed in each cohort study separately and then cohort-specific estimates were combined using fixed-effect meta-analysis (R package meta version 4.92). We used R package, poLCA version 1.4.1, for latent class analysis, SAS 9.4 procedure, PROC PHREG, for Cox models and R package timereg, version 1.9.3 for additive hazard models. Results from Cox models and additive hazard models were expressed as hazard ratios (HR) and incidence rate difference (IRD), respectively with their 95% confidence intervals (CI). Statistical syntax is provided in the supplementary material).
Results
Patterns of workplace psychosocial resources
We identified five latent classes of workplace psychosocial resources, using 57 496 participants from WEHD, 63 267 from FPS and 14 906 from SLOSH, with similar patterns of workplace psychosocial resources across cohorts (figure 2A). WEHD and SLOSH shared similar distribution of resource clusters, while FPS had a larger proportion of 'general low' and 'intermediate vertical+low horizontal' and smaller proportion of 'low vertical+high horizontal' and 'intermediate vertical+high horizontal' resources than WEHD and SLOSH (figure 2B).
Three cohorts together (figure 2B), 13% were categorized into the 'general low' class, in which all the four resources were low. The 'intermediate vertical+low horizontal' class (11%) consisted of mainly intermediate (i.e. intermediately high and intermediately low) levels of vertical resources (procedural justice and leadership quality), but low levels of social support and culture of collaboration (horizontal resources). The 'low vertical+high horizontal' class (17%) was characterized by low level of procedural justice and leadership quality and high levels of social support from colleagues and culture of collaboration. The 'intermediate vertical+high horizontal' class (32%) is characterized by an intermediate (i.e. intermediately high and intermediately low) level of procedural justice and leadership quality and a high level of social support from colleagues and culture of collaboration. Lastly, in the 'general high' class (28%) individuals reported a relatively high workplace resources across all dimensions. Baseline characteristics are presented in table 1.
Workplace psychosocial resources and cardiovascular disease
During a mean follow-up of 6.8 years, 2190 incident CVD cases (26.8 per 10 000 person-years) were recorded among 135 669 initially CVD-free participants (mean age: 44 years, proportion of women: 65%) (table 2). The results across cohorts were generally homogeneous (I^2<0.1%). Compared to the latent class characterized by low resources (figure 3A), classes with high horizontal resources combined with either intermediate or high vertical resources were at lower risk of developing incident CVD, corresponding to 3.4 (95% CI -6.7- -0.1) and 2.2 (95% CI -5.4-1.0) fewer incident CVD cases per 10 000 person-year, respectively.
Subtype analysis (figure 3B) of 1175 CHD and 1097 CBD incident cases showed the three clusters with high horizontal resources were associated with a lower risk of total CBD, especially with hemorrhagic stroke, but not with total CHD. We observed a lower risk of incident myocardial infarction when perceiving 'intermediate vertical+high horizontal' resource.
Excluding cases during the first year or restricting to the first four-year follow-up did not change the effect estimates (supplementary figure S2). Additional adjustments for lifestyle factors and self-reported mental health did not substantially change the effect sizes (supplementary figure S3). We did not observe significant differences across age groups, sex and educational levels (supplementary figure S4).

In a supplementary analysis, before mutual adjustment of the individual resources, some associations were observed for procedural justice, leadership quality and co-worker support (supplementary figure S5A). Most of these associations attenuated after mutual adjustment: only intermediately high level of procedural justice (HR 0.84, 95% CI 0.74-0.96) and high level of support from colleagues (HR 0.87, 95% CI 0.78-0.97) remained associated with a lower risk of CVD after mutual adjustment (supplementary figure S5B).

Discussion

This analysis of individual-level data on almost 140 000 persons from three Nordic cohort studies identified a consistent pattern including five classes of workplace psychosocial resource across follow-up waves, employment sectors and countries. About 13% of the employees experienced low levels of all studied workplace resources, suggesting a potential for improvement. Our findings show a consistent protective effect of workplace resources on overall CVD, most prominently for myocardial infarction and CBD.

A moderate effect on myocardial infarction was observed when intermediate level of vertical resources (ie, procedural justice and leadership quality) were combined with high level of horizontal resources (ie, culture of collaboration and co-worker support), in line with previous research on specific aspects of workplace resources and hospitalization/death due to myocardial infarction (7, 19, 20). Lack of social support in general may also be associated with cardiac mortality or all-cause mortality (37). Our findings add to the evidence by comprehensively identifying clustering patterns of resources across several key vertical and horizontal psychosocial resources.

We found a lower risk of developing CBD when perceiving high level of horizontal resources (ie, culture of collaboration and co-worker support). To the best of our knowledge, we are the first longitudinal study demonstrating an association between these workplace resources and risk of CBD. André-Petersson et al (21) found no association between workplace social support and CBD, but based on only 58 cases, much less than 1097 cases in our study. Our findings need to be replicated in other studies.

We found a stronger effect for CBD than CHD, similar to the one shown in a previous multicohort study concerning long working hours (38), while the CI between CHD and CBD were highly overlapping. These issues require careful investigations in future studies.

The underlying mechanisms for the potentially protective vascular effects remain to be uncovered. Earlier research have shown a favorable level of workplace social support (16) and relational justice (17) in connection with a lower ambulatory blood pressure. Low workplace social support has been found to be associated with a higher level of interleukin-6 (13). Other possible mechanistic pathways include indirect effect via health-related behaviors (10, 39-41) and mental health problems (42).

Public health implications

It is interesting that there was no evidence of indepen- dent associations between each individual resource and CVD in mutually-adjusted models. When clustering was considered, the associations with CVD became clear and similar to those previously found for type-2 diabetes (14). This emphasizes the importance of exploring clustering of resources instead of singling out individual effects and is consistent with findings from a systematic review, which highlighted the importance of multi-level workplace interventions (23), ie, to intervene on vertical and horizontal dimensions of resources at the same time.

Considering the average annual incidence of 26.8 per 10 000 persons, the relative differences, such as a 16% lower risk of developing incident CVD and the absolute differences, such as 3.4 lower incidence per 10 000 person-years when comparing the 'intermediate vertical+high horizontal' with the 'general low', should be interpreted cautiously. The public health importance, if causal, will depend on the distribution of resource classes across settings. For example, compared with public sector employees (ie, FPS), the general working population (ie, WEHD and SLOSH) contained a smaller proportion of workers in the 'general low' resource class and fewer women. Public and private sector employees may differ in their perception of job, communication formalization and objective-oriented results (43). Male and female employees may experience different employment and working conditions (44) and have diverged perception on some resources (16, 45). A deeper understanding of the distribution of resource clusters in specific settings is needed to develop targeted work-related CVD preventions in different types of workplaces, eg,

among private and public sector employees.

Interestingly, the lowest risk of CVD was often found in the "intermediate vertical+high horizontal" resource group rather the highest resource group. This suggests that not all resources at work are equally important in reducing the risk of CVD. Some studies suggest that workplace social support may in some cases be unhelpful and even trigger stress (46). However, the CI between "general high" and "intermediate vertical+high horizontal" resource groups were overlapping and thus not statistically different. More research is needed to understand whether pursuing the highest level of resources at work is always beneficial for employee health.

Theoretical relevance

We selected workplace psychosocial resources at group (eg, team climate), leader (eg, leadership quality) and organizational levels (eg, perceived organizational support), following a recently proposed theoretical framework for workplace resources by Nielsen et al (23). This review also showed that these workplace resources may be associated with better employees' job performance and well-being (23). Consistent with existing evidence of psychosocial resources at work (23), we identified clustering of the four resources according to vertical and horizontal dimensions. Future research may be required to disentangle the potential interactions among these resources to facilitate the design of cost-effective multilevel interventions.

Limitations and strengths

Some limitations merit careful consideration. Workplace psychosocial resources were measured by self-assessment at baseline and job changes were not accounted for. Although omitting the effect of time-varying resources and time-varying confounders may have resulted in an underestimation of the association, when we restricted the follow-up lengths to the first four years, the risk estimates remained similar, suggesting this to be of limited concern. FPS contained information only on in-patient visits and thus more likely to capture severe CVD cases, potentially contributing to an underestimation of the effect (47). While the same questionnaires were used in SLOSH and FPS, WEHD used slightly different instruments to measure culture of collaboration, procedural justice and leadership quality. This is an unlikely source of major bias because the three cohorts showed very similar patterns of resource clusters and associations with CVD. Although the point estimates were higher in SLOSH and WEHD than in FPS, no statistically significant heterogeneity was detected in cohort-specific effect estimates. We estimated four common group-, leader- and organization-level workplace psychosocial resources using a data-driven approach to detect clustering of workplace resources. This approach may be sensitive to the categorization and selection of the resource items. Future research is therefore needed to test the robustness of the clusters when using different categorizations. Some more detailed aspects of resources, such as perceiving or receiving co-worker's support was not considered, and may be considered as a limitation (37). While resources tend to highly intercorrelate, a more comprehensive mapping of resources may be needed in the future.

The strengths of our study include the large sample size with long follow-up, which allowed us to perform analyses on specific subtypes of CVD as well as conduct a range of sensitivity analyses with sufficient statisti- cal power. We were able to perform a nearly complete follow-up by linking survey data to nationwide registries to identify new cases of definite CHD and CBD. The inclusion of participants from both the general working population and public sector employees of three Scandinavian countries further provided a sufficient number of participants from both sexes and ensured the diversity of industry, job type and employment sectors, which assures the generalizability of our findings to similar contexts.

Concluding remarks

Our study identified five distinct workplace psychosocial resource clusters with different levels of resources, consistent across countries and employment sectors. Employees with favorable workplace psychosocial resources, especially intermediate and high vertical and high horizontal resources, were at a lower risk of CVD. Further research is needed to determine whether interventions to improve workplace psychosocial resources could be beneficial to vulnerable groups with established CVD risk factors.

Funding

The Danish Working Environment Foundation supported this study (grant 13-2015-09). TX was supported by a grant

from the Swedish Research Council for Health, Working Life and Welfare (grant 2020-00040). MK was supported by research grant from NordForsk (grant 70521, the Nordic Research Programme on Health and Welfare), the UK Medical Research Council (grant MRC S011676), the US National Institute on Aging (NIA) (grant R01AG056477), the Academy of Finland (grant 329202), and Finnish Work Environment Fund (grant 190424). LMH was supported by a grant from the Swedish Research Council for Health, Working Life and Welfare (grant 2019-01318). MV was supported by Academy of Finland (grant 329201). JV was supported by the Academy of Finland (grant 321409 and 329240). JE was supported by the Academy of Finland (grant 329200), the Finnish Work Environment Fund (grant 200097), Government's Analysis, Assessment and Research Activities (grant VN/14606/2019), and the Academy of Finland Strategic Research Council (grant 336004).

Disclosures

AJC is an employee at Novo Nordisk A/S and moved to Novo Nordisk at the end of the project. Her current employer has no role in the study design, analyses and results interpretation. No other potential conflicts of interest relevant to this article were declared.

Acknowledgement

We thank Dr. Constanze Leineweber and Mr. Martin Claeson (Department of Psychology, Stockholm University) for managing the SLOSH data for analysis.

Sidebar

Xu T, Rugulies R, Vahtera J, Pentti J, Mathisen J, Lange T, Clark AJ, Magnusson Hanson LL, Westerlund H, Ervasti J, Virtanen M, Kivimäki M, Rod NH. Workplace psychosocial resources and risk of cardiovascular disease among employees: a multi-cohort study of 135 669 participants. Scand J Work Environ Health. 2022;48(8):621-631. doi:10.5271/sjweh.4042

Correspondence: Tianwei Xu, Stress Research Institute, Stockholm University, 106 91 Stockholm, Sweden. [E-mail: tianwei.xu@psychology.su.se]

Received for publication: 14 March 2022

References

References

1. Berkman LF, Kawachi I, Theorell T. Working conditions and health. Social epidemiology. 2014;2:153-81.

2. Kivimäki M, Steptoe A. Effects of stress on the development and progression of cardiovascular disease. Nat Rev Cardiol 2018 Apr;15(4):215-29. https://doi.org/10.1038/ nrcardio.2017.189.

3. Kivimäki M, Nyberg ST, Batty GD, Fransson EI, Heikkilä K, Alfredsson L et al.; IPD-Work Consortium. Job strain as a risk factor for coronary heart disease: a collaborative meta-analysis of individual participant data. Lancet 2012 Oct;380(9852): 1491-7. https://doi.org/10.1016/S01406736(12)60994-5.

4. Fransson EI, Nyberg ST, Heikkilä K, Alfredsson L, Bjorner JB, Borritz M et al. Job strain and the risk of stroke: an individual-participant data meta-analysis. Stroke 2015 Feb;46(2):557-9. https://doi.org/10.1161/ STROKEAHA.114.008019.

5. Rugulies R, Framke E, Sørensen JK, Svane-Petersen AC, Alexanderson K, Bonde JP et al. Persistent and changing job strain and risk of coronary heart disease. A population-based cohort study of 1.6 million employees in Denmark. Scand J Work Environ Health 2020 Sep;46(5):498-507. https://doi. org/10.5271/sjweh.3891.

6. Dragano N, Siegrist J, Nyberg ST, Lunau T, Fransson EI, Alfredsson L et al.; IPD-Work consortium. Effort-Reward Imbalance at Work and Incident Coronary Heart Disease: A Multicohort Study of 90,164 Individuals. Epidemiology 2017 Jul;28(4):619-26. https://doi.org/10.1097/ EDE.0000000000000666.

7. Kivimäki M, Ferrie JE, Brunner E, Head J, Shipley MJ, Vahtera J et al. Justice at work and reduced risk of coronary heart disease among employees: the Whitehall II Study. Arch Intern Med 2005 Oct;165(19):2245-51. https://doi. org/10.1001/archinte.165.19.2245.

8. Demerouti E, Bakker AB, Nachreiner F, Schaufeli WB. The job demands-resources model of burnout. J Appl Psychol 2001 Jun;86(3):499-512. https://doi.org/10.1037/00219010.86.3.499.

9. Bakker AB, Demerouti E. Job demands-resources theory: taking stock and looking forward. J Occup Health

Psychol 2017 Jul;22(3):273-85. https://doi.org/10.1037/ ocp0000056.
10. Mattke S, Liu H, Caloyeras J, Huang CY, Van Busum KR, Khodyakov D et al. Workplace Wellness Programs Study: final Report. Rand Health Q 2013 Jun;3(2):7.
11. Finne LB, Christensen JO, Knardahl S. Psychological and social work factors as predictors of mental distress: a prospective study. PLoS One 2014 Jul;9(7):e102514. https:// doi.org/10.1371/journal.pone.0102514.
12. Gimeno D, Tabák AG, Ferrie JE, Shipley MJ, De Vogli R, Elovainio M et al. Justice at work and metabolic syndrome: the Whitehall II study. Occup Environ Med 2010 Apr;67(4):256-62. https://doi.org/10.1136/ oem.2009.047324.
13. Magnusson Hanson LL, Virtanen M, Rod NH, Steptoe A, Head J, Batty GD et al. Does inflammation provide a link between psychosocial work characteristics and diabetes? Analysis of the role of interleukin-6 and C-reactive protein in the Whitehall II cohort study. Brain Behav Immun 2019 May;78:153-60. https://doi.org/10.1016/j.bbi.2019.01.017.
14. Xu T, Clark AJ, Pentti J, Rugulies R, Lange T, Vahtera J et al. Characteristics of workplace psychosocial resources and risk of diabetes: a prospective cohort study. Diabetes Care 2022 Jan;45(1):59-66. https://doi.org/10.2337/dc20-2943
15. Nakata A, Irie M, Takahashi M. Source-specific social support and circulating inflammatory markers among whitecollar employees. Ann Behav Med 2014 Jun;47(3):335-46. https://doi.org/10.1007/s12160-013-9555-x.
16. Karlin WA, Brondolo E, Schwartz J. Workplace social support and ambulatory cardiovascular activity in New York City traffic agents. Psychosom Med 2003 Mar-Apr;65(2): 167-76. https://doi.org/10.1097/01. PSY.0000033122.09203.A3.
17. Wager N, Fieldman G, Hussey T. The effect on ambulatory blood pressure of working under favourably and unfavourably perceived supervisors. Occup Environ Med 2003 Jul;60(7):468-74. https://doi.org/10.1136/ oem.60.7.468.
18. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. J Am Coll Cardiol 2017 Jul;70(1):1-25. https://doi.org/10.1016/j. jacc.2017.04.052.
19. Nyberg A, Alfredsson L, Theorell T, Westerlund H, Vahtera J, Kivimäki M. Managerial leadership and ischaemic heart disease among employees: the Swedish WOLF study. Occup Environ Med 2009 Jan;66(1):51-5. https://doi.org/10.1136/ oem.2008.039362.
20. Clays E, Casini A, Van Herck K, De Bacquer D, Kittel F, De Backer G et al. Do psychosocial job resources buffer the relation between physical work demands and coronary heart disease? A prospective study among men. Int Arch Occup Environ Health 2016 Nov;89(8):1299-307. https:// doi.org/10.1007/s00420-016-1165-z.
21. André-Petersson L, Engström G, Hedblad B, Janzon L, Rosvall M. Social support at work and the risk of myocardial infarction and stroke in women and men. Soc Sci Med 2007 Feb;64(4):830-41. https://doi.org/10.1016/j. socscimed.2006.10.020.
22. Kuper H, Adami HO, Theorell T, Weiderpass E. Psychosocial determinants of coronary heart disease in middle-aged women: a prospective study in Sweden. Am J Epidemiol 2006 Aug;164(4):349-57. https://doi. org/10.1093/aje/kwj212.
23. Nielsen K, Nielsen MB, Ogbonnaya C, Känsälä M, Saari E, Isaksson K. Workplace resources to improve both employee well-being and performance: A systematic review and metaanalysis. Work Stress 2017;31(2):101-20. https://doi.org/10 .1080/02678373.2017.1304463.
24. Sørensen JK, Framke E, Clausen T, Garde AH, Johnsen NF, Kristiansen J et al. Leadership Quality and Risk ofLong-term Sickness Absence Among 53,157 Employees of the Danish Workforce. J Occup Environ Med 2020 Aug;62(8):557-65. https://doi.org/10.1097/JOM.0000000000001879.
25. Joensuu M, Kivimäki M, Pentti J, Virtanen M, Väänänen A, Vahtera J. Components of job control and mortality: the Finnish Public Sector Study. Occup Environ Med 2014 Aug;71(8):536-42. https://doi.org/10.1136/ oemed-2014-102111.

26. Magnusson Hanson LL, Leineweber C, Persson V, Hyde M, Theorell T, Westerlund H. Cohort profile: the Swedish longitudinal occupational survey of health (SLOSH). Int J Epidemiol 2018 Jun;47(3):691-692i. https://doi.org/10.1093/ije/dyx260.
27. Xu T, Magnusson Hanson LL, Clark AJ, Ersbøll AK, Westerlund H, Madsen IE et al. Onset of Workplace Bullying and Risk of Weight Gain: A Multicohort Longitudinal Study. Obesity (Silver Spring) 2020 Nov;28(11):2216-23. https://doi.org/10.1002/oby.22956.
28. Kouvonen A, Kivimäki M, Vahtera J, Oksanen T, Elovainio M, Cox T et al. Psychometric evaluation of a short measure of social capital at work. BMC Public Health 2006 Oct;6(1):251. https://doi.org/10.1186/1471-2458-6-251.
29. Anderson N, West MA, editors. Team climate inventory: Manual and user's guide1994: ASE.
30. Clausen T, Madsen IE, Christensen KB, Bjorner JB, Poulsen OM, Maltesen T et al. The Danish Psychosocial Work Environment Questionnaire (DPQ): Development, content, reliability and validity. Scand J Work Environ Health. 2019 Jul 1;45(4):356-69. https://doi.org/10.5271/sjweh.3793.
31. Lehto AM. Quality of working life and equity. Helsinki, Finland: Statistics Finland. 1991.
32. Setterlind S, Larsson G. The stress profile: A psychosocial approach to measuring stress. Stress Med 1995;11(1):85-92. https://doi.org/10.1002/smi.2460110116.
33. Elovainio M, Kivimäki M, Vahtera J. Organizational justice: evidence of a new psychosocial predictor of health. Am J Public Health 2002 Jan;92(1):105-8. https://doi. org/10.2105/AJPH.92.1.105.
34. Lallukka T, Halonen JI, Sivertsen B, Pentti J, Stenholm S, Virtanen M et al. Change in organizational justice as a predictor of insomnia symptoms: longitudinal study analysing observational data as a non-randomized pseudotrial. Int J Epidemiol 2017 Aug;46(4):1277-84. https://doi. org/10.1093/ije/dyw293.
35. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology 1999 Jan;10(1):3748. https://doi.org/10.m97/00001648-199901000-00008.
36. Hulman A, Witte DR, Vistisen D, Balkau B, Dekker JM, Herder C et al. Pathophysiological characteristics underlying different glucose response curves: a latent class trajectory analysis from the prospective EGIR-RISC study. Diabetes Care 2018 Aug;41(8):1740-8. https://doi. org/10.2337/dc18-0279.
37. Barth J, Schneider S, von Känel R. Lack of social support in the etiology and the prognosis of coronary heart disease: a systematic review and meta-analysis. Psychosom Med 2010 Apr;72(3):229-38. https://doi.org/10.1097/PSY.0b013e3181d01611.
38. Kivimäki M, Jokela M, Nyberg ST, Singh-Manoux A, Fransson EI, Alfredsson L et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603,838 individuals. Lancet. 2015 Oct 31;386(10005):1739-46. https://doi.org/10.1016/S01406736(15)60295-1.
39. Kouvonen A, Oksanen T, Vahtera J, Väänänen A, De Vogli R, Elovainio M et al. Work-place social capital and smoking cessation: the Finnish Public Sector Study. Addiction 2008 Nov;103(11):1857-65. https://doi.org/10.1111/j.13600443.2008.02315.x.
40. Colell E, Sánchez-Niubô A, Benavides FG, Delclos GL, Domingo-Salvany A. Work-related stress factors associated with problem drinking: A study of the Spanish working population. Am J Ind Med 2014 Jul;57(7):837-46. https:// doi.org/10.1002/ajim.22333.
41. Griep RH, Nobre AA, Alves MG, da Fonseca MJ, Cardoso LO, Giatti L et al. Job strain and unhealthy lifestyle: results from the baseline cohort study, Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). BMC Public Health 2015 Mar;15(1):309. https://doi.org/10.! 186/s12889-015-1626-4.
42. Magnusson Hanson LL, Rod NH, Vahtera J, Peristera P, Pentti J, Rugulies R et al. Multicohort study of change in job strain, poor mental health and incident cardiometabolic disease. Occup Environ Med 2019 Nov;76(11):785-92. https://doi.org/10.1136/oemed-2018-105595.
43. Kim J. Strategic Human Resource Practices: Introducing Alternatives for Organizational Performance Improvement in the Public Sector. Public Adm Rev 2010;70(1):38-49. https://doi.org/10.1111/j.1540-6210.2009.02109.x.
44. Campos-Serna J, Ronda-Pérez E, Artazcoz L, Moen BE, Benavides FG. Gender inequalities in occupational

health related to the unequal distribution of working and employment conditions: a systematic review. Int J Equity Health 2013 Aug;12(1):57. https://doi.org/10.1186/14759276-12-57.
45. Jepsen DM, Rodwell JJ. Justice in the workplace: the centrality of social versus judgmental predictors of performance varies by gender. Int J Hum Resour Manage 2009;20(10):2066-83. https://doi.org/10.1080/09585190903175639.
46. Hughes IM, Freier LM, Barratt CL. "Your help isn't helping me!" Unhelpful workplace social support, strain, and the role of individual differences. Occup Health Sci 2022 Mar;1-37. https://doi.org/10.1007/s41542-022-00115-x.
47. Xu T, Magnusson Hanson LL, Lange T, Starkopf L, Westerlund H, Madsen IEH, et al. Workplace bullying and violence as risk factors for type 2 diabetes: a multicohort study and meta-analysis. Diabetologia. 2018 Jan;61(1):7583. https://doi.org/10.1007/s00125-017-4480-3.

DETAILS

Subject:	Population; Diabetes; Womens health; Work environment; Collaboration; Leadership; Heart diseases; Cardiovascular diseases; Questionnaires; Health hazards; Disease prevention; Ethics; Procedural justice; Risk; Mental disorders; Public sector; Electronic medical records; Electronic health records; Cerebrovascular diseases; Social support; Clustering; Employees; Working conditions; Cerebrovascular disease; Cohort analysis; Cardiovascular disease; Organizational justice; Statistical models; Health risks
Business indexing term:	Subject: Work environment Leadership Public sector Employee s Working conditions Organizational justice
Location:	Denmark; Sweden; Finland
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	621-631
Publication year:	2022
Publication date:	2022
Section:	Original article
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140

e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4042
ProQuest document ID:	2738246646
Document URL:	https://www.proquest.com/scholarly-journals/workplace-psychosocial-resources-risk/docview/2738246646/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022
Last updated:	2023-02-27
Database:	Public Health Database

What is next for occupational cancer epidemiology?

Turner, Michelle C, PhD

ABSTRACT (ENGLISH)

Epidemiological research has innovated over time to comprise increasingly larger-scale prospective cohort studies and consortia, use of electronic data linkage, causal inference methods and triangulation of evidence, reinforcing the ongoing utility of observational research methods. The recent COVID-19 pandemic has reinforced the need for a global perspective in epidemiological research, multidisciplinarity, and broadening perspectives regarding fundamental underlying determinants of health. There have also been calls for greater equity and inclusiveness in health research, both in Europe, and worldwide. Efforts to stimulate future research and investment in occupation and cancer may benefit from the use of new rapidly evolving research methods, closer alignment with global public health priorities, and strengthening of international partnerships supporting excellence and inclusiveness in research.

FULL TEXT

Research on occupational causes of cancer has identified 47 known (Group 1) agents associated with 23 types of cancer through 2017, an increase from 28 agents in 2004 (1,2). Occupational agents include chemicals and chemical mixtures; radiation and radionuclides; airborne particles and complex mixtures; and metals and metal compounds. The global burden of cancer due to 14 of the Group 1 agents was estimated to total 349 000 [95% uncertainty interval (UI) 269 000-427 000] deaths in 2016, or 3.9% (95% UI 3.2-4.6%) of all cancer deaths, including

299 998 or 17.6% (95% UI 13.8-21.3%) of lung cancer deaths (3). There are also exposures in various occupations, industries, or processes classified as Group 1 where the causal agent is not necessarily identified. In 2022, occupational exposure as a firefighter was most recently classified in Group 1, with sufficient evidence among humans for mesothelioma and bladder cancer, and limited evidence for other cancers (4).

Despite achievements in identifying occupational causes of cancer, a range of research needs remain, including identifying additional cancer sites for Group 1 agents and more definitive studies for exposures where the evidence among humans remains limited or inadequate (1, 5-7). There may be outstanding methodological concerns or findings that are inconsistent or of poor quality or informativeness.

Research recommendations to address classification uncertainties for 20 priority occupational agents have been detailed (8). They include conducting new epidemiological studies in highly exposed occupations or populations, improving (quantitative) exposure assessment including through biomarkers of exposure, enhancing statistical power through extended follow-up or pooled studies, and furthering human mechanistic studies. High quality human mechanistic evidence can provide valuable information when epidemiology studies are not available or feasible (5). A 2019 Advisory Group considered 170 different agents in terms of their suitability for (re-)evaluation with a range of chemical, metal, or complex exposures of relevance for occupational settings prioritized based on new human epidemiology, mechanistic and/or cancer bioassay data (9).

There have been calls to update existing cohorts when valuable follow-up time has accrued allowing investigation of the full potential impact of exposures on health (10). There is a longstanding need for occupational epidemiological and exposure assessment studies in low- and middle-income countries, where there are often few or no available studies and exposure levels maybe higher (11-14). There may also be differences in working conditions, exposure patterns, and worker protections (15, 16). Research challenges include declines in participation rates, funding, and research infrastructures (1, 17-19).

In parallel, epidemiological research has innovated over time to comprise increasingly larger-scale prospective cohort studies and consortia, use of electronic data linkage, causal inference methods and triangulation of evidence, reinforcing the ongoing utility of observational research methods (20). The recent COVID-19 pandemic has reinforced the need for a global perspective in epidemiological research, multidisciplinarity, and broadening perspectives regarding fundamental underlying determinants of health (21, 22). There have also been calls for greater equity and inclusiveness in health research, both in Europe, and worldwide (23, 24).

Efforts to stimulate future research and investment in occupation and cancer may benefit from the use of new rapidly evolving research methods, closer alignment with global public health priorities, and strengthening of international partnerships supporting excellence and inclusiveness in research. For example, a range of methodological advancements have emerged from application of exposome concepts in epidemiology. In Europe, birth cohort consortia seeking to characterize the early-life exposome, as well as other efforts, have driven much innovation (25, 26). The exposome concept was proposed in 2005 to stimulate investment to better characterize environmental exposures throughout the lifecourse using novel technologies, offering a complementary perspecdoi:10.5271/sjweh.4067 tive to that of the genome (27). Although occupational exposure has previously not been emphasized, research in the internal and external occupational exposome is now beginning to emerge (28).

A range of statistical methods for analysis of multiple correlated exposures have advanced (29). Extended Bayesian profile regression mixture (PRM) models have been used to examine multiple highly correlated ionizing radiation exposures for lung cancer risk among miners (30). An exposome-wide association study examined a range of personal and occupational factors in B-cell lymphoma, suggesting that single-factor research approaches maybe suboptimal for new disease insights (31). There are exposome technologies for personal monitoring of workers (28, 32) and other novel research methods including natural language processing and text mining (33, 34), automated network assembly approaches to summarizing literature (35), efforts to combine epidemiological data with those from other evidence streams (36), and new technologies to facilitate secure decentralized pooled analyses of data (37).

However, there is an ongoing need for continued efforts to better characterize the occupational and corresponding

non-occupational exposome over the lifecourse. Research priorities include establishing new cohort studies with appropriate biosample collection, improved questionnaire and personal monitoring data, increasing multidisciplinary collaboration to utilize innovative data and methods, and integrating genetic data in exposome studies for causal inference (38-40). At the same time, careful consideration of the policy relevance of exposome studies remains of importance (41), as are continued efforts in conventional epidemiological case-control and cohort studies in occupation and cancer (8). Occupational studies examining exposures of relevance for the general population may favor greater investment (42). There are environmental exposure routes for occupational agents, bystander or spousal exposure to occupational agents, and potential transgenerational health effects (43-45). Birth cohorts may represent a typically underused resource for research in occupation and health (46). Principles for safeguarding integrity in environmental and occupational research have also been outlined (47).

Research on occupation and cancer may benefit from closer alignment with recent high-profile initiatives on related topics as well as with global public health priorities. The United Nations Sustainable Development Goals note the need for decent work (48). The EU Strategic Framework on Health and Safety at Work describes the elimination of work-related deaths by 2030 and reduced illness through improved data collection, updated rules on hazardous substances, including those of relevance for renewable energy technologies (ie, lead, cobalt) or of asbestos exposure in building renovations for greening, increased health literacy at work, and adapting working conditions for patients (49). A large-scale survey of worker exposure to cancer risk factors is being implemented in Europe to collect standardized data across different European countries (50). The Health Environment Agenda for Europe project defined priority areas for research on rapidly changing work and employment conditions, climate change and worker health, working time and long working hours, ageing workers, and neglected related diseases (51).

Rapidly changing work conditions were exemplified during the COVID-19 pandemic, with potential direct or indirect effects on health and cancer. Shifts in overall global cancer research focus were also described (52). Increasing unemployment and economic downturns in high- and middle-income countries have been associated with increased cancer mortality for treatable cancers, with less access to healthcare underlying findings (53). There is also increasing interest in precarious employment and potential direct or indirect impacts on health and quality of life (54). Public health efforts directed at catching-up in cancer screening and on improving health systems and public health literacy following the COVID-19 pandemic may offer opportunities to advance cancer control and improved health literacy at work (55, 56). Further, there may greater opportunities for strengthened clinical partnerships for occupational epidemiologists. For example, dramatic gains in survival due to early detection have been demonstrated for lung cancer (57). However, occupational (or environmental) exposures are not systematically incorporated into screening algorithms, and further research and collaboration with clinical partners is warranted (58-61).

The potential importance of climate change in cancer, including occupation and cancer, may also not be fully understood (62, 63). Climate change may relate to increasing exposure to environmental or occupational carcinogens, including air pollution, adverse dietary exposures, changes in physical activity levels, ultraviolet radiation, water pollution, infections, and parasites due to extreme weather events, wildfires (4), heat, sea-level rise, and changes in land-use. There may also be disruptions in cancer care. Climate change may further exacerbate existing socioeconomic inequities, and social determinants of cancer. Increasing occupational heat stress is related to acute and chronic health effects as well as reduced productivity (64-66). Studies of occupational heat exposure and cancer risk are beginning to emerge (67). Interventions to jointly address climate change and disease prevention, including cancer, have been proposed (68). There are also new agents rapidly entering the workplace where little is known regarding their carcinogenicity to humans. A planetary health perspective suggests that humanity is outside the safe operating space of the planetary boundary, with increasing production and release of chemical industry production exceeding the ability to conduct safety assessments (69).

Lastly, strengthened international partnerships are critical for future advances in occupational cancer research. Efforts in coordination of European birth cohort studies, and later occupational cohort studies, have led to major advancements in research and inclusiveness (25, 26, 70, 71). Network funding initiatives provide valuable support

and developed out of a recognized need to increase equitable access to funding and research infrastructures (72). A recent example is the OMEGA-NET COST Action, which sought to improve coordination and harmonization of European occupational cohort studies by connecting researchers through a range of research coordination and capacity building activities, with a particular focus on connecting researchers in traditionally less research-intensive countries (71). Online inventories of occupational cohort studies and exposure assessment tools were developed (73, 74) as were advancements in theoretical frameworks, consensus definitions and recommendations for future research on emerging topics in occupational health (54, 75, 76).

The need for occupational epidemiological and exposure monitoring studies in low- and middle-income countries has long been recognized. Priorities for cancer research in low- and middle-income countries have recently been described as separate to those of high-income countries, and highlighted the need to reduce the burden of patients presenting with advanced-stage disease, primary prevention and early detection, and innovative and affordable technology in cancer control (77). Documenting and minimizing exposure to established occupational carcinogens is critical to prioritize interventions and prevent future cancer burden (11,34, 78). Generating country-specific evidence for effective prevention may be helpful in this regard (77). Research questions on cancers that are of local importance, using appropriate research methods for available infrastructure, and partnerships for mutually rewarding collaborations have been described (77, 79). However, cancer registry and infrastructure challenges have been outlined, including of poor-quality data and an absence of legal frameworks for cancer registration (19). International collaboration has had demonstrated impacts in research and capacity building, though sustained political and financial commitment is needed (16, 80, 81).

The occupational epidemiology community has a great opportunity to promote new efforts in occupation and cancer while at the same time reducing inequalities in health and research.

Acknowledgements

Michelle C Turner is funded by a Ramón y Cajal fellowship (RYC-2017-01892) from the Spanish Ministry of Science, Innovation and Universities and co-funded by the European Social Fund. ISGlobal acknowledges support from the Spanish Ministry of Science and Innovation through the "Centro de Excelencia Severo Ochoa 2019-2023" Program (CEX2018-000806-S), and support from the Generalitat de Catalunya through the CERCA Program.

Sidebar

Michelle C Turner, PhD1-3

1Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain

2Universitat Pompeu Fabra (UPF), Barcelona, Spain

3CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain

[Email: michelle.tumer@isglobal.org]

References

References

1. Loomis D, Guha N, Hall AL, Straif K. Identifying occupational carcinogens: an update from the IARC Monographs. Occup Environ Med 2018;75:593-603. https://doi.org/10.1136/oemed-2017-104944

2. Siemiatycki J, Richardson L, Straif K, Latreille B, Lakhani R, Campbell S, et al. Listing occupational carcinogens. Environ Health Perspect. 2004;112:1447-1459. https://doi.org/10.1289/ehp.7047

3. GBD 2016 Occupational Carcinogens Collaborators. Global and regional burden of cancer in 2016 arising from occupational exposure to selected carcinogens: a systematic analysis for the Global Burden of Disease Study 2016. Occup Environ Med 2020;77:151-159. https://doi.org/10.1136/oemed-2019-106012

4. Demers PA, DeMarini DM, Fent KW, Glass DC, Hansen J, Adetona O, et al. Carcinogenicity of occupational exposure as a firefighter. Lancet Oncol 2022;23:985-986. https://doi.org/10.1016/S1470-2045(22)00390-4

5. IARC. Preamble to the IARC Monographs, amended January 2019. Available from: https://monographs.iarc.fr/wp-content/ uploads/2019/07/Preamble-2019.pdf.

6. Marant Micallef C, Shield KD, Baldi I, Charbotel B, Fervers B, Gilg Soit Ilg A, et al. Occupational exposures and cancer: a review of agents and relative risk estimates. Occup Environ Med 2018;75:604-614.

https://doi.org/10.1136/oemed-2017-104858
7. IARC. Agents Classified by the IARC Monographs, Volumes 1-132. Available from: https://monographs.iarc.who.int/agents-classifiedby-the-iarc.
8. Ward EM, Schulte PA, Straif K, Hopf NB, Caldwell JC, Carreón T, et al. Research recommendations for selected IARC-classified agents. Environ Health Perspect 2010;118:1355-1362. https://doi.org/10.1289/ehp.0901828
9. IARC Monographs Priorities Group. Advisory Group recommendations on priorities for the IARC Monographs. Lancet Oncol 2019;20:763-764. https://doi.org/10.1016/S1470-2045(19)30246-3
10. Vainio H, Weiderpass E. Importance of updating old cohorts for new findings. Occup Environ Med 2017;74:311-312. https://doi. org/10.1136/oemed-2016-103981
11. Loomis D. Estimating the global burden of disease from occupational exposures. Occup Environ Med 2020;77:131-132. https://doi. org/10.1136/oemed-2019-106349
12. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Outdoor air pollution. IARC monographs on the evaluation of carcinogenic risks to humans; Volume 109. 2015. Lyon, France.
13. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Some organophosphate insecticides and herbicides. IARC monographs on the evaluation of carcinogenic risks to humans; Volume 112. 2017. Lyon, France.
14. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Styrene, Styrene-7,8-oxide, and Quinoline. IARC monographs on the evaluation of carcinogenic risks to humans; Volume 121. 2019. Lyon, France.
15. Groß JV, Fritschi L, Erren TC. Shift work and cancer: more research needed from low and middle income countries. Occup Environ Med 2019;76:70. https://doi.org/10.1136/oemed-2018-105457
16. Hosseini B, Hall AL, Zendehdel K, Kromhout H, Onyije FM, Moradzadeh R, et al. Occupational exposure to carcinogens and occupational epidemiological cancer studies in Iran: a review. Cancers 2121;13:3581. https://doi.org/10.3390/cancers13143581
17. Stayner TL, Collins JJ, Guo YL, Heederik D, Kogevinas M, Steenland K, et al. Challenges and opportunities for occupational epidemiology in the twenty-first century. Curr Environ Health Rep 2017;4:319-324. https://doi.org/10.1007/s40572-017-0154-z
18. Sweity S, Sutton C, Downe S, Balaam MC, McElvenny DM. Challenges to and facilitators of occupational epidemiology research in the UK. Health Policy 2020;124:772-780. https://doi.org/10.1016/j.healthpol.2020.05.006
19. Ngwa W, Addai BW, Adewole I, Ainsworth V, Alaro J, Alatise OI, et al. Cancer in sub-Saharan Africa: a Lancet Oncology Commission. Lancet Oncol 2022;23:e251-e312. https://doi.org/10.1016/S1470-2045(21)00720-8
20. McCullough LE, Maliniak ML, Amin AB, Baker JM, Baliashvili D, Barberio J, et al. Epidemiology beyond its limits. Sci Adv 2022;8:eabn3328. https://doi.org/10.1126/sciadv.abn3328
21. No authors listed. How epidemiology has shaped the COVID pandemic. Nature 2021;589:491-492. https://doi.org/10.1038/d41586021-00183-z
22. Hinchliffe S, Manderson L, Moore M. Planetary healthy publics after COVID-19. Lancet Planet Health 2021;5:e230-e236. https://doi. org/10.1016/S2542-5196(21)00050-4
23. Berner-Rodoreda A, Rehfuess EA, Klipstein-Grobusch K, Cobelens F, Raviglione M, Flahaut A, et al. Where is the 'global' in the European Union's health research and innovation agenta? BMJ Glob Health 2019;4:e001559. https://doi.org/10.1136/ bmjgh-2019-001559
24. Gallo F, Seniori Costantini A, Puglisi MT, Barton N. Biomedical and health research: an analysis of country participation and research fields in the EU's Horizon 2020. Eur J Epidemiol 2021;36:1209-1217. https://doi.org/10.1007/s10654-020-00690-9
25. Vrijheid M, Slama R, Robinson O, Chatzi L, Coen M, van den Hazel P, et al. The human early-life exposome (HELIX): project rationale and design. Environ Health Perspect 2014;122:535-544. https://doi.org/10.1289/ehp.1307204
26. Vrijheid M, Basagaña X, Gonzalez JR, Jaddoe VWV, Jensen G, Keun HC, et al. Advancing tools for human early lifecourse exposome research and translation (ATHLETE): Project overview. Environ Epidemiol 2021;5:e166.

https://doi.org/10.1097/ EE9.0000000000000166
27. Wild CP. Complementing the genome with an "exposome": the outstanding challenge of environmental exposure measurement in molecular epidemiology. Cancer Epidemiol Biomarkers Prev 2005;14(8):1847-1850. https://doi.org/10.1158/1055-9965.EPI-05-0456
28. Pronk A, Loh M, Kuijpers E, Albin M, Selander J, Godderis L, et al. Applying the exposome concept to working-life health: The EU EPHOR project. Environ Epidemiol 2022 6:e185. https://doi.org/10.1097/EE9.0000000000000185
29. Maitre L, Guimbaud JB, Warembourg C, Güil-Oumrait N, Petrone PM, Chadeau-Hyam M,et al. State-of-the-art methods for exposure-health studies: Results from the exposome data challenge event. Environ Int 2022;168:107422. https://doi.org/10.1016/j. envint.2022.107422
30. Belloni M, Laurent O, Guihenneuc C, Ancelet S. Bayesian profile regression to deal with multiple highly correlated exposures and a censored survival outcome. First application in ionizing radiation epidemiology. Front Public Health 2020;8:557006. https://doi. org/10.3389/fpubh.2020.557006
31. Hosnijeh FS, Casabonne D, Nieters A, Solans M, Naudin S, Ferrari P, et al. Association between anthropometry and lifestyle factors and risk of B-cell lymphoma: an exposome wide analysis. Int J Cancer 2021;148:2115-2128. https://doi.org/10.1002/ijc.33369
32. Kuijpers E, van Wel L, Loh M, Galea KS, Makris KC, Stierum R, et al. A Scoping Review of Technologies and Their Applicability for Exposome-Based Risk Assessment in the Oil and Gas Industry. Ann Work Expo Health 2021;65:1011-1028. https://doi.org/10.1093/ annweh/wxab039
33. Schoene AM, Basinas I, van Tongeren M, Ananiadou S. A Narrative Literature Review of Natural Language Processing Applied to the Occupational Exposome. Int J Environ Res Public Health. 2022;19:8544. https://doi.org/10.3390/ijerph19148544
34. Kromhout H, van Tongeren M, Peters CE, Hall AL. Commentary. Occup Environ Med 2020;77:513-514. https://doi.org/10.1136/ oemed-2020-106624
35. Scholten B, Guerrero Simon L, Krishnan S, Vermeulen R, Pronk A, Gyori BM, et al. Automated network assembly of mechanistic literature for informed evidence identification to support cancer risk assessment. Environ Health Perspect 2022;130:37002. https://doi. org/10.1289/EHP9112
36. Scholten B, Portengen L, Pronk A, Stierum R, Downward GS, Vlaanderen J, et al. Estimation of the Exposure-Response Relation between Benzene and Acute Myeloid Leukemia by Combining Epidemiologic, Human Biomarker, and Animal Data. Cancer Epidemiol Biomarkers Prev. 2022;31:751-757. https://doi.org/10.1158/1055-9965.EPI-21-0287
37. Marcon Y, Bishop T, Avraam D, Escriba-Montagut X, Ryser-Welch P, Wheater S, et al. Orchestrating privacy-protected big data analyses of data from different resources with R and DataSHIELD. PLoS Comput Biol 2021;17(3):e1008880 https://doi.org/10.1371/journal. pcbi.1008880
38. Avery CL, Green Howard A, Ballou AF, Buchanan VL, Collins JM, Downie CG, et al. Strengthening Causal Inference in Exposomics Research: Application of Genetic Data and Methods. Environ Health Perspect 2022;130:55001. https://doi.org/10.1289/EHP9098
39. Jia P, Lakerveld J, Wu J, Stein A, Root ED, Sabel CE, et al. Top 10 Research Priorities in Spatial Lifecourse Epidemiology. Environ Health Perspect 2019;127:74501. https://doi.org/10.1289/EHP4868
40. Vineis P, Robinson O, Chadeau-Hyam M, Dehghan A, Mudway I, Dagnino S. What is new in the exposome? Environ Int 2020;143:105887. https://doi.org/10.1016/j.envint.2020.105887
41. Health Council of the Netherlands. Relevance of exposome research for policy. No.2022/02e, The Hague, 2022.
42. Blair A, Hines CJ, Thoms KW, Alavanja MCR, Beane Freeman LE, Hoppin JA, et al. Investing in prospective cohorts for etiologic study of occupational exposures. Am J Ind Med 2015;58:113-22. https://doi.org/10.1002/ajim.22403
43. Li S, Cirillo P, Hu X, Tran V, Krigbaum N, Yu S, et al. Understanding mixed environmental exposures using metabolomics via a hierarchical community network model in a cohort of California women in 1960's. Reprod

Toxicol. 2020;92:57-65. https://doi. org/10.1016/j.reprotox.2019.06.013
44. Louis LM, Lerro CC, Friesen MC, Andreotti G, Koutros S, Sandler DP, et al. A prospective study of cancer risk among Agricultural Health Study farm spouses associated with personal use of organochlorine insecticides. Environ Health 2017; 16:95. https://doi. org/10.1186/s12940-017-0298-1
45. Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts. Environ Health Perspect 2014;122:172-177. https:// doi.org/10.1289/ehp.1306880
46. Ubalde-Lopez M, Garani-Papadatos T, Scelo G, Casas M, Lissåker C, Peters S, et al. Working life, health and well-being of parents: a joint effort to uncover hidden treasures in European birth cohorts. Scand J Work Environ Health 2021; 47:550-560. https://doi. org/10.5271/sjweh.3980
47. Baur X, Soskolne CL, Bero LA. How can the integrity of occupational and environmental health research be maintained in the presence of conflicting interests? Environ Health 2019;18:93. https://doi.org/10.1186/s12940-019-0527-x
48. United Nations. Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1.
49. EC 2021. EU strategic framework on health and safety at work 2021-2027 Occupational safety and health in a changing world of work. COM/2021/323 final.
50. EU-OSHA. Worker survey on exposure to cancer risk factors. Available from: https://osha.europa.eu/en/publications/worker-survey-exposure-cancer-risk-factors. Date Accessed Oct 6, 2022.
51. HERA Consortium 2021. EU Research Agenda for the Environment, Climate &Health 2021-2030. Final Draft. https://www. heraresearcheu.eu/hera-2030-agenda
52. Van Hemelrijck M, Lewison G, Fox L, Dnk Vanderpuye V, Murillo R, Booth CM et al. Global cancer research in the era of COVID-19: a bibliometric analysis. Ecancermedicalscience. 2021;15:1264. https://doi.org/10.3332/ecancer.2021.1264
53. Maruthappu M, Watkins J, Noor AM, Williams C, Ali R, Sullivan R, et al. Economic downturns, universal health coverage, and cancer mortality in high-income and middle-income countries, 1990-2010: a longitudinal analysis. Lancet 2016;388:684-695. https://doi.org/10.1016/S0140-6736(16)00577-8
54. Bodin T, Çağlayan C, Garde AH, Gnesi M, Jonsson J, Kiran S, et al. Precarious employment in occupational health - an OMEGA-NET working group position paper. Scand J Work Environ Health 2020;46:321-329 https://doi.org/10.5271/sjweh.3860
55. Datta GD, Lauzon M, Salvy SJ, Hussain SK, Ghandehari S, Merchant A, et al. Cancer Screening Practices Among Healthcare Workers During the COVID-19 Pandemic. Front Public Health 2022;14;10:801805. https://doi.org/10.3389/fpubh.2022.801805
56. Hange N, Agoli AM, Lourdes Pormento MK, Sharma A, Somagutta MR et al. Impact of COVID-19 response on public health literacy and communication. Health Promot Perspect 2022;12:1-9. https://doi.org/10.34172/hpp.2022.01
57. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer statistics, 2022. CA Cancer J Clin 2022;72:7-33. https://doi.org/10.3322/caac.21708
58. Burzic A, O'Dowd EL, Baldwin DR. The Future of Lung Cancer Screening: Current Challenges and Research Priorities. Cancer Manag Res 2022;14:637-645. https://doi.org/10.2147/CMAR.S293877
59. Delva F, Laurent F, Paris C, Belacel M, Brochard P, Bylicki O, Chouaid C, et al. LUCSO-1-French pilot study of LUng Cancer Screening with low-dose computed tomography in a smokers population exposed to Occupational lung carcinogens: study protocol. BMJ Open 2019;:e025026. https://doi.org/10.1136/bmjopen-2018-025026
60. Dement JM, Ringen K, Hines S, Cranford K, Quinn P. Lung cancer mortality among construction workers: implications for early detection. Occup Environ Med 2020;77:207-213. http://dx.doi.org/10.1136/oemed-2019-106196
61. Veronesi G, Baldwin DR, Henschke CI, Ghislandi S, Iavicoli S, Oudkerk M, et al. Recommendations for Implementing Lung Cancer Screening with Low-Dose Computed Tomography in Europe. Cancers (Basel) 2020;12:0.

62. Hiatt RA, Beyeler N. Cancer and climate change. Lancet Oncol 2020;21:e519-e527. https://doi.org/10.1016/S1470-2045(20)30448-4
63. Nogueira LM, Yabroff KR, Bernstein A. Climate change and cancer. CA Cancer J Clin 2020;70:239-244. https://doi.org/10.3322/ caac.21610
64. Andrews O, Le Quéré C, Kjellstrom T, Lemke B, Haines A. Implications for workability and survivability in populations exposed to extreme heat under climate change: a modelling study. Lancet Planet Health 2018;2:e540-e547. https://doi.org/10.1016/S2542-5196(18)30240-7
65. He C, Zhang Y, Schneider A, Chen R, Zhang Y, Ma W, Kinney PL, Kan H. The inequality labor loss risk from future urban warming and adaptation strategies. Nat Commun 2022;13:3847. https://doi.org/10.1038/s41467-022-31145-2
66. Gronlund CJ. Racial and socioeconomic disparities in heat-related health effects and their mechanisms: a review. Curr Epidemiol Rep 2014;1:165-173. https://doi.org/10.1007/s40471-014-0014-4
67. Hinchliffe A, Kogevinas M, Pérez-Gómez B, Ardanaz E, Amiano P, Marcos-Delgado A, et al. Occupational heat exposure and breast cancer risk in the MCC-Spain study. Cancer Epidemiol Biomarkers Prev 2021;30:364-372. https://doi.org/10.1158/1055-9965.EPI-20-0732
68. Vineis P, Huybrechts I, Millett C, Weiderpass E. Climate change and cancer: converging policies. Mol Oncol 2021;15:764-769. https:// doi.org/10.1002/1878-0261.12781
69. Persson L, Carney Almroth BM, Collins CD, Cornell S, de Witt CA, Diamond ML, et al. Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. Environ Sci Technol 2022;56:1510-1521. https://doi.org/10.1021/acs.est.1c04158
70. Vrijheid M, Casas M, Bergström A, Carmichael Am, Cordier, Effesbo M, et al. European birth cohorts for environmental health research. Environ Health Perspect 2012;120:29-37. https://doi.org/10.1289/ehp.1201c28
71. Turner MC, Mehlum IS. Coordination and Harmonisation of European Occupational Cohorts is Needed. Occup Environ Med 2018;75:474-476. https://doi.org/10.1136/oemed-2017-104955
72. COST Strategic Plan. COST 060/17. 2017. Available from: https://www.cost.eu/uploads/2019/08/COST_StrategicPlan.pdf
73. Kogevinas M, Schlünssen V, Mehlum IS, Turner MC. The OMEGA-NET international inventory of occupational cohorts. Ann Work Expo Health 2020;64:565-568. https://doi.org/10.1093/annweh/wxaa039
74. Peters S, Vienneau D, Sampri A, Turner MC, Castaño G, Bugge M, et al. Occupational exposure assessment tools in Europe: a comprehensive inventory overview. Ann Work Expo Health 2022;66:671-686. https://doi.org/10.1093/annweh/wxab110
75. Atkas E, Bergbom B, Godderis L, Kreshpaj B, Marinov M, Mates D, et al. Migrant workers occupational health research: an OMEGANET working group position paper. Int Arch Occup Environ Health 2022;95:765-777. https://doi.org/10.1007/s00420-021-01803-x
76. Guseva Canu I, Marca SC, Dell'Oro F, Balazs A, Bergamaschi E, Besse C, et al. Harmonized definition of occupational burnout: A systematic review, semantic analysis, and Delphi consensus in 29 countries. Scand J Work Environ Health 2021;47:95-107. https://doi. org/10.5271/sjweh.3935
77. Pramesh CS, Badwe RA, Bhoo-Pathy N, Booth CM, Chinnaswamy G, Dare AJ, et al. Priorities for cancer research in low- and middleincome countries: a global perspective. Nat Med 2022;28:649-657. https://doi.org/10.1038/s41591-022-01738-x
78. GBD 2019 Respiratory Tract Cancers Collaborators. Global, regional, and national burden of respiratory tract cancers and associated risk factors from 1990 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Respir Med 2021;9:1030-1049.
79. Sepanlou SG, Etemadi A, Kamangar F, Sepehr A, Pourshams A, Poustchi H, et al. The gastro-esophageal malignancies in Northern Iran research project: impact on the health research and health care systems in Iran. Arch Iran Med 2013;16:46-53.
80. Sheikh M, Shakeri R, Poustchi H, Pourshams A, Etemadi A, Islami F, et al. Opium use and subsequent

incidence of cancer: results from the Golestan Cohort Study. Lancet Glob Health 2020;8:e649-e660. https://doi.org/10.1016/S2214-109X(20)30059-0
81. Veljkovikj I, Ilbawi AM, Roitberg F, Luciani S, Barango P, Corbex M, et al. Evolution of the joint International Atomic Energy Agency (IAEA), International Agency for Research on Cancer (IARC), and WHO cancer control assessments (imPACT Reviews). Lancet Oncol 2022;23:e459-e468. https://doi.org/10.1016/S1470-2045(22)00387-4

DETAILS

Subject:	Pandemics; Research methodology; Public health; Epidemiology; Cancer; Research methods; Medical research; Triangulation; COVID-19; Climate change
Location:	Europe
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	591-597
Publication year:	2022
Publication date:	2022
Section:	Editorial
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Editorial
ProQuest document ID:	2738246637
Document URL:	https://www.proquest.com/scholarly-journals/what-is-next-occupational-cancer-epidemiology/docview/2738246637/se-2?accountid=211160

Physical work demands and expected labor market affiliation (ELMA): Prospective cohort with register-follow-up among 46 169 employees

Pedersen, Jacob [1] ; Bjorner, Jakob Bue [2] ; Andersen, Lars L [3 1] National Research Centre for the Working Environment, Copenhagen, Denmark [2] Department of Public Health, University of Copenhagen, Copenhagen, Denmark. [3] QualityMetric, Lincoln, RI, USA.

ABSTRACT (ENGLISH)

Objective This study aimed to estimate the impact of high physical work demands on expected labor market affiliation (ELMA) among men and women of different ages in the general working population. Methods After participating in the Danish Work Environment and Health study (2012, 2014, and/or 2016), 46 169 employees were followed for two years in national registers. Using multi-state modeling, taking all day-to-day transition probabilities of labor market affiliation into account (work, unemployment, sickness absence, temporary out, and permanently out), and performing multilevel adjustment, we estimated the prospective association between physical work demands (ergonomic index including 7 factors) and ELMA. Results During 104 896 person-years of follow-up, we identified of 439 045 transitions. Using low physical work demands as reference, higher physical work demands were associated with fewer days of active work (2-35 days) during 730 days of follow-up, and more days of sickness absence (4-26 days) and unemployment (ranging 1-9 days) among men and women of aged 40-49 and 50-64 years. Among men and women aged 18-39 years, high physical work demands only had minor and inconsistent impact on ELMA. Conclusions Analyzing multiple and highly detailed patterns of transition probabilities concerning labor market affiliation, we showed that reducing physical work demands is likely to increase the active working time and prevent high societal cost of sickness absence and unemployment, especially among middle-aged and older workers.

FULL TEXT

Headnote

Objective This study aimed to estimate the impact of high physical work demands on expected labor market affiliation (ELMA) among men and women of different ages in the general working population. Methods After participating in the Danish Work Environment and Health study (2012, 2014, and/or 2016), 46 169 employees were followed for two years in national registers. Using multi-state modeling, taking all day-to-day transition probabilities of labor market affiliation into account (work, unemployment, sickness absence, temporary out, and permanently out), and performing multilevel adjustment, we estimated the prospective association between physical work demands (ergonomic index including 7 factors) and ELMA. Results During 104 896 person-years of follow-up, we identified of 439 045 transitions. Using low physical work demands as reference, higher physical work demands were associated

with fewer days of active work (2-35 days) during 730 days of follow-up, and more days of sickness absence (4-26 days) and unemployment (ranging 1-9 days) among men and women of aged 40-49 and 50-64 years. Among men and women aged 18-39 years, high physical work demands only had minor and inconsistent impact on ELMA. Conclusions Analyzing multiple and highly detailed patterns of transition probabilities concerning labor market affiliation, we showed that reducing physical work demands is likely to increase the active working time and prevent high societal cost of sickness absence and unemployment, especially among middle-aged and older workers.
Key words multi-state; longitudinal; sickness absence; unemployment; work.
Several job groups are characterized by high physical work demands, eg, painters, bricklayers, masons, carpenters, cleaners, industrial labor, manufacturing labor, and service work (1). Even with technological advances, many job groups will likely continue having high physical work demands in the future. Additionally, the 2021 National Health Profile in Denmark shows that the prevalence of disc herniation or other back diseases increases from 6.6% for men and 7.4% for women aged 25-34 years to 21.5% for men and 20.2% for women age 55-64 years, respectively. The prevalence of osteoarthritis is even higher, especially among women, where it increases from 23.2% at 45-54 years to 41.0% at 55-64 years (2).
Previous studies have shown that high physical work demands increase the risk of sickness absence (3-6). These studies typically rely on risk assessment of a single outcome - like the probability of a transition from work to sickness absence - while leaving information about other labor market outcomes unattended. However, in several European countries, including the Scandinavian countries, the labor market is quite flexible meaning that individuals are likely to have multiple periods of sickness absence without being fired, and to have recurrent events of unemployment.
Multi-state analysis is an effective way of analyzing the impact on the labor market affiliation when the system is highly flexible and contain multiple states. This study uses the expected labor market affiliation (ELMA) method developed by Pedersen et al (7) for analyzing the impact on labor market affiliation of Danish employees having different levels of physical work demands. The ELMA method relies on multi-state modeling of the labor market system for analyzing multiple transitions and summarizing the effect into expected durations of each state (8-10). In addition, the ELMA method provides the possibility to include variables that may change during follow-up, eg, the individual level of education or civil status, adjustment for multiple variables simultaneously, and weights for making the results representative.
The aim of the present study is to estimate the impact of high physical work demands on ELMA among men and women of different ages in the general Danish working population. The analyses rely on multi-state modeling of the labor market transitions and focus on time in work, sickness absence, and unemployment.
Methods
Study design and source population
This longitudinal study uses a linkage of registers and survey data on physical work demands from three successive waves of the Work Environment and Health in Denmark (WEHD) survey conducted in 2012, 2014, and 2016 (11, 12). The survey data was linked to other registers through an encrypted version of the central person register number (13). All WEHD responders, aged 18-64 years, were included and followed in registers for two years from the day they answered the questionnaire.
The WEHD surveys were linked with the following registers, provided by Statistics Denmark: (i) the Danish Labor Market Accountant Register (LMAR), (ii) Register of Work Absences (RoWA), (iii) the Education Register, (iv) Emigration and Immigration Register, and (v) the Death Register. LMAR contains information on all major social benefits payments, including unemployment, sickness absence, disability pension, pension, and all salary payments reported to the tax authorities from 2008 onwards.
RoWA is a linkage of the Absence and Employment Register (FRAN) and the Periods of Absence Register (FRPE), both from Statistics Denmark. FRPE includes date-based information about sickness absence spells from the first day of absence, and FRAN includes datebased employment information of employees with and without sickness absence spells (11). RoWA contains records of both public and private employees. The datebased records of

sickness absence spells are complete for all public employees and private companies with >250 employees. RoWA contains a yearly weighted sample from companies with 10-250 employees (14). This means that RoWA covers approximately 37% of all private employees in Denmark (11). RoWA does not include small private companies with <10 employees and these are therefore not included in the present study. Small companies represent a large part of private companies (approximately 260 000 small private companies exist in Denmark) (15). RoWA contains weights for making the private sample representative to all private employees in companies with >10 employees. The Education Register contains records of the highest education level completion for all Danes. The Emigration and Immigration Register contains dates on all emigrations and immigrations in Denmark. The Death Register includes dates for all deceased Danes.

The linked data set contains individual and datebased information on labor market affiliation and individual characteristics retained from the surveys.

Study sample and data preparation

The WEHD data included 67 053 individuals of which 63 912 (95.3%) were eligible for the current study. Receivers of disability pension or retires at the start of the follow-up period (N=2945), individuals aged >64 years at the start of the follow-up (N=195, 28% women), or not found in LMAR (N=1) were excluded.

In RoWA, (i) all records for public employment have the weight one and (ii) all records for private employment have a specialized weight that is constructed based on the sampling probability. RoWA only includes records of individuals in employment, but in this study, the weights were carried forward in LMAR to include periods of unemployment etc, but only until a new employment period.

Records from LMAR that could not be linked to a private or public employment in RoWA were excluded (~7%. 0.6 million records). Similarly, records of private employments without a weight (9%), and public employment period with a specialized weight (0.1%) were excluded.

The final sample was divided into six subsamples according to gender and age-range at the start of the follow-up period (18-39, 40-49, and 50-64 years), prioritizing clearly defined age-intervals over an even number of individuals in each age category. Of the N=46 169 individuals, 78% answered one of the three waves of questionnaires, 8% two questionnaires, and 14% answered all three waves of questionnaires - totalling 62 677 follow-up periods.

Physical work demand

Physical work demands were measured through an ergonomic index, which was constructed by seven questions (please see supplementary material, www.sjweh. fi/article/4050, A). For individuals answering all seven questions, an average score was calculated ranging from 0-100. All other individuals were registered by a 'missing' category. In accordance with Andersen et al (1), the individual average score was categorized into four categories: low (0-10), moderate (>10-20), high (>20-30), and very high (>30) physical work demands. The ergonomic index has shown to predict the risk of long-term sickness absence using standard Cox-regression (1).

Covariates and weights

The analysis includes nine covariates previously used in studies about physical occupational exposures and physical health in relation to long-term sickness absence (16-18) and work disability (19, 20). The covariates are associated with adverse health outcomes, possible through selection, eg selection into part time work, or through causation, eg, smoking and sickness absence.

Six variables were included from WEHD: (i) working time arrangement (Part-time: <37 hours/week or full time: >37 hours/week); (ii) body mass index (BMI) (<18.0, 18.5-<25.0, 25.0-<29.9, and >29.9 kg/m2); (iii) smoking (yes: daily and sometimes; no: prior smoker and never); (iv) physical activity "How much time on average do you use on each of the following physical activities in the last year?" as "exercise, heavy gardening or fast walking / cycling where you sweat and getting short of breath?" with answers dichotomized as (yes: <2, 2-4 and >4 hours/week; no: "Does not practice this activity" and missing); (v) disease treatment - in terms of a dichotomy variable indicating if the individual has had treatment for one of the following diseases (no/ yes): depression, asthma, diabetes, atherosclerosis or blood clot in the heart, blood clot in the brain (cerebral hemorrhage), cancer, back disease, migraine, or other long-term disease; (vi) symptoms of depression, defined by the individual Major Depression Index (MDI) score

(depressive symptoms: >21; no depressive symptoms: <21) (21); (vii) employment sector (private/public) variable was obtained from FRAN; (viii) highest accomplished education (low/middle/high) variable obtained from the Education Registers; and (ix) "number of survey waves" was constructed to account for the number of WEHD survey waves the individual had attended -1 of 3, 2 of 3, and 3 of 3. Variable (vii-viii) was allowed to change during the follow-up period, while the variables obtained from the surveys (i-vi) could only change if the individual participated in a new survey wave.

Labor market affiliation

The labor market affiliation was modeled by seven mutually exclusive labor market states based on the longitudinal registrations of LMAR and RoWA. Of the seven states, four are categorized as recurrent states, meaning that multiple individual periods of the same state are possible: (i) work reflecting the periods of receiving salary payments and not simultaneously registered as sick-listed; (ii) sickness absence for periods when the individual is registered as sick-listed by the employer or receiving sickness absence benefit; (iii) unemployment for periods when a person receives social benefit related to unemployment, given the condition that the person is immediately available for work if such opportunity arises; (iv) temporary out for periods when an individual is not in the work, sickness absence, or unemployment states but with the possibility of returning to those states. This state contains the time of for example maternity leave, emigration, periods of education, and periods with no registration. The three absorbing states suggests that no further transitions are possible after the first entry; (v) disability pension when receiving full or gradually disability retirement pension due to personal disability; (vi) retirement due to receiving age retirement pension or the voluntary retirement pension; and (vii) death (supplementary material B contains a short introduction to the Danish labor market and social system).

Individuals start the follow-up in any of the four recurrent states.

Statistical analysis

The study uses the Expected Labor Market Affiliation (ELMA) method developed by Pedersen et al (7), which relies on estimated transition probabilities between the possible states of the multi-state model. The ELMA incorporates both time-dependent variables and timedependent weights in terms of eg, inverse probability weights. The ELMA uses a non-parametric approach except for the confidence estimation of the expected state duration results.

For each subsample of gender and age groups, we estimated the time-dependent baseline probability for every transition of the multi-state model according to the reference value of the covariates. The transitions probabilities for the non-reference values were estimated by adjusting the corresponding baseline probabilities with estimates derived from Cox proportional hazard regression. The Cox regressions were conducted on the entire multi-state model with the data arranged in a long format (22). Based on the transition probabilities we estimated the state probabilities - expressing the probability of being in one of the seven states from day one and until day 730 (two years).

We summarized the area under each transition probability and state probability curve for each combination of covariates.

Assuming normally distributed area estimates, we produced 500 random resamples and conducted a variance regression model. This was done in order to produce the final estimates of state duration including 95°% confidence intervals (CI). All variables, except the ergonomic index variable, were incorporated into the model as inverse probability weights and multiplied by the weights from the employment register.

For light comparison with and control of the ELMA results, a crude estimate of the time spent in each state was made. This was done by summing the time spent in each state during the follow-up period and then dividing by the number of individual follow-up periods.

Results

Table 1 shows that despite a slight predominance of women (59% women) in the sample, the proportion of individuals in each age group are comparable between the genders (mean age by gender and age group - men: 31.6, 45.3, 56.6 years; women: 31.3, 45.2, 56.2 years). Similar comparability is seen for levels of the ergonomic index.

Figure 1 shows that during the follow-up period, the transitions between the work and the sickness absence states were the most frequent, with the highest transition incidence for women. A high transition incidence for women is moreover seen for the transitions between work and unemployment, though not as frequent as between work and sickness absence, and between work and temporary out, when compared to the respective transitions incidences of the men.

Table 2 shows that for men, the risk of a transition to sickness absence from work increases with an increasing level of physical work demands - except for young men with moderate and high physical work demands. The highest risk is seen for men aged 40-49 years having very high physical work demands (48%). A similar pattern is not seen for the women, but both men and women aged >40 years have lover likelihood of returning to work from sickness absence if they experienced high and very high physical work demands. The risk of being unemployed is highly associated with high or very high physical work demands - only a moderately equivalent likelihood is seen for a transition back to work.

Supplementary material table C1 shows - in supplement to figure 1 and table 2 - the raw number of transitions (events) occurring between work, sickness absence, and unemployment along with the unadjusted transition incidences by the number of events per 1000 person-years.

Figure 2 shows that the additional expected time in work, sickness absence, and unemployment for young men and women is mostly unaffected by physical work demands. However, a steep increased in sickness absence time is seen for the middle-aged men (6, 19, and 23 days respectively) and women (8, 11, and 26 days respectively) by increasing physical work demands with a parallel decline in working time (table 3 presents the precise estimates). For the oldest age group, the effect of physical demand level is more complex. Women with moderate and high physical work demands experience an almost identical increase of sickness absence time (12 and 13 days, respectively), while women with very high physical work demands experience additionally 23 sickness absence days - compared to 28 for women with low physical work demands.

Moderate physical work demands have almost no effect on the men aged 50-64 years. However, a high level inflicts additionally 20 days of sickness absence, while a very high level inflicts 12 additional days of sickness absence and 9 additional days of unemployment. The time in the 'temporary out' state is highly uncertain for men with high and very high physical work demands.

For men and women aged 50-64 years, one can calculate expected time spend in retirement (supplementary table 1D). However, for those having moderate, high and very high physical work demands, the results show a small decline in retirement time - most for men having a high level (10 days) and next for women with very high physical work demands (8 days).

Generally, we found fair agreement between the ELMA and the crude estimates. However, across working time outcomes the ELMA method found higher numbers in the reference group than the crude estimates.

Discussion

In this prospective longitudinal study, we showed that physically demanding work is associated with poorer labor market affiliation of Danish employees. Physical work demands were measured using a combined ergonomic index and categorized into four levels. The study used several highly detailed registers with date-based information and included all lengths of sickness absence of both public and private employees.

By using the ELMA method, we showed that, moderate-to-very high physical work demands were associated with increased sickness absence time and decreased time working, but only for employees >40 years. For the younger employees, physical work demands did not affect labor market affiliation within the two-year follow-up period. These findings agree with previous findings showing increased risk of long-term sickness absence in older - but not younger - workers from high physical work demands (1). There may be several reasons for these findings. First, as muscle strength declines with increasing age (23), younger workers are better physically fit for the job than older workers. Thus, at any given absolute workload, the relative workload is lower among younger workers. This may also have consequences for muscle recovery after work. Second, the accumulated hazardous effect of high physical work demands is more likely to affect older workers because they have been exposed for more years (ie, a higher

accumulated exposure time) (24).
The decrease in time working and increased sickness absence time are significant from moderate physical work demands, but most pronounced for men and women with high and very high physical work demands. However, the effect for men with a moderate level was very low. The higher level of muscle strength among men compared with women (23) may explain that moderate levels of physical work demands only affected men to a minor extent. Another possible explanation is the somewhat gender-segregated labor market in Denmark, ie, different types of physical work is performed by men and women, for example, cleaning, hospital and elderly care occupations are more frequent among women, while more men are occupied as bricklayers, carpenters, or in similar jobs (25).
Comparison with previous studies
Concerning the risk of a transition from work to sickness absence, our results are in line with a previous analysis using traditional Cox-regression analyses and the same ergonomic index (1). We found comparably increased risks of sickness absence for employees aged >40 years with increasing physical work demands. However, our results show that this almost linear increasing effect is most pronounced among men, whereas this is not seen among women. For the likelihood of returning to work from sickness absence, we found similar results for both genders as the risk reduced with increasing physical work demands. These results may be due to the use of all length sickness absence instead of solely long-term sickness absence (11) and that we included all employees regardless of prior sickness absence.
Only a sparse number of previous studies use multistate modeling for investigating labor market affiliation, and even fewer focus on physical work demands as exposure (10, 26, 27), which limits the comparison with previous results. Pedersen et al (9) used a life course perspective and found comparable decreased workingtime and increased sickness absence and unemployment time for employees aged >40 years with high physical work demands.
The results suggest that special attention should be paid to middle-age and older employees in occupations characterized by high or very high physical work demands. For this age group, our results suggest a potential for decreasing the time in sickness absence and increasing the working-time if the level of physical demand is lowered. A potential gain in effective working-time is additionally present for women with a moderate level of physically demanding work.
Strengths and limitations
The study strengths include a substantial sample of Danish employees from three survey waves. The study analyses the individual labor market affiliation on a day-to-day basis, by a linkage with detailed register data. The study incorporates a multi-level and -state setting controlling for recurrent and competing events. Moreover, the study includes sickness absence periods down to a duration of one day. The data and information retained from the surveys and registers all contained a high level of consistency during the entire follow-up period (2012-2018).
The flexibility of the ELMA method makes it possible to examine different aspects of the labor market affiliation and to include time-dependent variables and weights. Compared to a crude mean of state-specific duration time, this adds important new knowledge on transitions changes in labor market affiliation on individuals having physically demanding jobs. The ELMA method is also effective in highlighting trends in labor marked outcomes not easily identified from the HR estimated in the multi-state models. For example, for women in the 50-64 year age group, a clear and statistically highly significant increase in sick days is seen with increased physical work demands (table 3). This trend is not immediately clear from the HR in table 2 that do not show a significant increased risk of going from work to sickness absence for 50-64-year-old women with high physical work demands. The increase in sick days seen in table 3 is due to several factors but mainly to a much lower chance of getting back to work from sickness absence for middle-aged women with high physical demands (table 2). This example illustrated the ability of the ELMA method to summarize complicated results. Moreover, comparing ELMA with the crude results reflects the fact that the ELMA method presents the expected labor market outcomes. This means handling individuals that are censored and time when not at risk better than the crude estimates, which are highly affected by censoring and time when not at risk, implying generally lower risk estimates.
The use of multiple survey waves increases the total sample size and adds the possibility of incorporating time-

dependent adjustment of the exposure to the analysis. This is possible as the baselines of the two-year follow-up are set individually thoughout 2012 and 2016, and set repeatedly for employees attending multiple survey waves. A large sample strengthens the multistate analysis as multiple transitions between the states are likely to occur and increase the group sizes, eg the number of employees having a very high level of physical work exposure. However, the use of the relatively short two-year follow-up period between the survey waves implies limitations concerning the long-term perspective of the individual labor market affiliation. For example, is the number of employees experiencing longterm effects of physical work demands underestimated eg, employees experiencing disability pension? This is because individuals cannot attend the survey if they are no longer employed, but instead are on, for example, long-term sickness absence or unemployment benefit while awaiting disability pension.

The study includes additional limitations. First, the sample represents a wide variety of Danish employees and the study is likely to be generalizable to the Danish workforce, however, some caution should be taken due to lack of response from men and young employees (WEHD) (11, 12) and the limits of RoWA concerning small private companies (14, 15). Second, though only a few individuals entered the disability pension and pension state, there is a small possibility of overestimating the time spend there as the model did not include the possibility of a transition from disability pension to pension, from disability pension to death, and from pension to death. Third, the study included both part-time and full-time benefits and, if multiple benefits were paid simultaneously or along with salary payments, a prioritization between payments was made. This is likely to slightly underestimate the duration of the working time and overestimate the duration of the other states. Fourth, the study relates to the Danish labor market system, which makes comparison with other countries difficult. However, the results should make room for some general consideration on employees experiencing physically demanding jobs. Finally, the study does not include all aspects of the physical workload, it is for example likely that chronic disease and other health-related conditions will influence the working-time and time with sickness absence.

Concluding remarks

Moderate-to-very high levels of physical work demands are associated with markedly reduced active labor market affiliation among middle-aged and older Danish employees but not among young workers. The changes of the expected labor market affiliation mainly concern increased time in sickness absence on the cost of reduced active working-time. Preventive initiatives focusing on gender and age of the employees are likely to decrease the negative impact of physically demanding work in occupations with high physical work exposures.

Acknowledgement

The study was supported by the Danish Work Environment Research Fund (Arbejdsmiljoeforskningsfonden) (grant number 20195100758) (JP, LLA). The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data and had final responsibility to submit for publication.

The authors declare no conflicts of interest.

Ethics approval

According to Danish law, research studies that use solely survey and register data do not need approval from the National Committee on Health Research Ethics (Den Nationale Videnskabetiske Komité).

Data sharing statement

The SAS code can be shared upon reasonable request by authorized researchers after application to the NRCWE. Data is available on the Researcher access at Statistics Denmark, see www.dst.dk/en/TilSalg/Forskningsservice.

Sidebar

Pedersen J, Bjorner JB, Lars L Andersen LL. Physical work demands and expected labor market affiliation (ELMA): Prospective cohort with register-follow-up among 46 169 employees. Scand J Work Environ Health. 2022;48(8):641-650. doi:10.5271/ sjweh.4050

Received for publication: 19 April 2022

References

Reference

1. Andersen LL, Pedersen J, Sundstrup E, Thorsen SV, Rugulies R. High physical work demands have worse consequences for older workers: prospective study of longterm sickness absence among 69 117 employees. J Occup Environ Med 2021;78(11):829-34. https://doi.org/10.1136/ oemed-2020-107281
2. danskernessundhed.dk. Den Nationale Sundhedsprofil 2021 [The National Health Profile.] [Accessed 2022 07-06]. Available from: https://www.danskernessundhed.dk.
3. Andersen LL, Fallentin N, Thorsen SV, Holtermann A. Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. J Occup Environ Med 2016;73(4):246. https://doi.org/10.1136/ oemed-2015-103314
4. da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. Am J Ind Med 2010;53(3):285-323. https://doi.org/10.1002/ajim.20750
5. Sterud T. Work-related mechanical risk factors for longterm sick leave: a prospective study of the general working population in Norway. Eur J Public Health 2014;24(1):111-6. https://doi.org/10.1093/eurpub/ckt072
6. Foss L, Gravseth HM, Kristensen P, Claussen B, Mehlum IS, Knardahl S, et al. The impact of workplace risk factors on long-term musculoskeletal sickness absence: a registrybased 5-year follow-up from the Oslo health study. J Occup Environ Med 2011;53(12):1478-82. https://doi.org/10.1097/ JOM.0b013e3182398dec
7. Pedersen J, Solovieva S, Thorsen SV, Andersen MF, Bültmann U. Expected Labor Market Affiliation: A New Method Illustrated by Estimating the Impact of Perceived Stress on Time in Work, Sickness Absence and Unemployment of 37,605 Danish Employees. Int J Environ Res Public Health 2021;18(9):4980. https://doi.org/10.3390/ijerph18094980
8. Lie SA, Tveito TH, Reme SE, Eriksen HR. IQ and mental health are vital predictors of work drop out and early mortality. Multi-state analyses of Norwegian male conscripts. PloS one 2017;12(7):e0180737. https://doi.org/10.1371/joumal. pone.0180737
9. Pedersen J, Schultz BB, Madsen IEH, Solovieva S, Andersen LL. High physical work demands and working life expectancy in Denmark. J Occup Environ Med 2020;77(8):576-82. doi: https://doi.org/10.1136/oemed-2019-106359
10. Robroek SJW, Nieboer D, Järvholm B, Burdorf A. Educational differences in duration of working life and loss of paid employment: working life expectancy in The Netherlands. Scand J Work Environ Health 2020(1):77-84. https://doi. org/10.5271/sjweh.3843
11. Thorsen SV, Pedersen J, Flyvholm M-A, Kristiansen J, Rugulies R, Bültmann U. Perceived stress and sickness absence: a prospective study of 17,795 employees in Denmark. Int Arch Occup Environ Health 2019;92(6):821-8. https://doi. org/10.1007/s00420-019-01420-9
12. Johnsen NF, Thomsen BL, Hansen JV, Christensen BS, Rugulies R, Schlünssen V. Job type and other socio-demographic factors associated with participation in a national, cross-sectional study of Danish employees. BMJ Open 2019;9(8):e027056. https://doi.org/10.1136/ bmjopen-2018-027056
13. CPR-Administration. Can I get a civil registration number? 2021 [Accessed 2021 28-9]. Available from: https://cpr.dk/ english/moving-to-denmark.
14. Denmark S. Periods of Absence register 2022 [Accessed 2022 14-6]. Available from: https://www.dst.dk/da/Statistik/ dokumentation/Times/fravaer/fravvaegt.
15. smvdanmark.dk. Regeringen: Byrder skal lettes for mikrovirksomheder 2018 [Government: Burdens must be eased for micro-enterprises] [Accessed 2022 24-05]. Available from: https://smvdanmark.dk/seneste-nyt/nyheder/politik/ regeringen-byrder-skal-lettes-for-mikrovirksomheder.
16. López-Bueno R, Sundstrup E, Vinstrup J, Casajús JA, Andersen LL. High leisure-time physical activity reduces the risk of long-term sickness absence. Scand J Med Science in Sports 2020;30(5):939-46. https://doi.org/10.1111/sms.13629
17. Lund T, Labriola M, Christensen KB, Bültmann U, Villadsen E. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. BMJ 2006;332(7539):449. https://doi. org/10.1136/bmj.38731.622975.3A
18. Melkevik O, Clausen T, Pedersen J, Garde AH, Holtermann A, Rugulies R. Comorbid symptoms of depression

and musculoskeletal pain and risk of long term sickness absence. BMC Public Health 2018;18(1):981. https://doi.org/10.1186/ s12889-018-5740-y
19. Falkstedt D, Hemmingsson T, Albin M, Bodin T, Ahlbom A, Selander J, et al. Disability pensions related to heavy physical workload: a cohort study of middle-aged and older workers in Sweden. Int Arch Occup Environ Health 2021;94(8):1851-61. https://doi.org/10.1007/s00420-021-01697-9
20. Bláfoss R, Vinstrup J, Skovlund SV, López-Bueno R, Calatayud J, Clausen T, et al. Musculoskeletal pain intensity in different body regions and risk of disability pension among female eldercare workers: prospective cohort study with 11-year register follow-up. BMC Musculoskeletal Disorders 2021;22(1):771. https://doi.org/10.1186/s12891-021-04655-1
21. Bech P, Timmerby N, Martiny K, Lunde M, Soendergaard S. Psychometric evaluation of the Major Depression Inventory (MDI) as depression severity scale using the LEAD (Longitudinal Expert Assessment of All Data) as index of validity. BMC Psychiatry 2015;15:190. https://doi.org/10.1186/s12888-015-0529-3
22. de Wreede LC, Fiocco M, Putter H. The mstate package for estimation and prediction in non- and semi-parametric multi-state and competing risks models. Comp Meth Prog in Biomed 2010;99(3):261-74. https://doi.org/10.1016/j. cmpb.2010.01.001
23. Suetta C, Haddock B, Alcazar J, Noerst T, Hansen OM, Ludvig H, et al. The Copenhagen Sarcopenia Study: lean mass, strength, power, and physical function in a Danish cohort aged 20-93 years. J Cachexia Sarcopenia and Muscle 2019;10(6):1316-29. https://doi.org/10.1002/jcsm.12477
24. Sundstrup E, Hansen ÅM, Mortensen EL, Poulsen OM, Clausen T, Rugulies R, et al. Retrospectively assessed physical work environment during working life and risk of sickness absence and labour market exit among older workers. J Occup Environ Med 2018;75(2):114-23. https://doi.org/10.1136/ oemed-2016-104279
25. Vive.dk. Et kønsopdelt arbejdsmarked- Udviklingstræk konsekvenser og forklaringer 2016 [A gender-segregated labor market- Developmental implications and explanations 2016.] [Accessed 2022 16-06]. Available from: https://www.vive.dk/ da/udgivelser/et-koensopdelt-arbejdsmarked-6491.
26. Sirén M, Viikari-Juntura E, Arokoski J, Solovieva S. Work participation and working life expectancy after a disabling shoulder lesion. J Occup Environ Med 2019;76(6):363. https:// doi.org/10.1136/oemed-2018-105647
27. Schram JL, Solovieva S, Leinonen T, Viikari-Juntura E, Burdorf A, Robroek SJ. The influence of occupational class and physical workload on working life expectancy among older employees. Scand J Work Health 2021(1):5-14. https:// doi.org/10.5271/sjweh.3919

DETAILS

Subject:	Transition probabilities; Womens health; Working conditions; Work environment; Working hours; Physical work; Labor; Employees; Illnesses; Employment; Blood clots; Questionnaires; Variables; Emigration; Impact analysis; Disability pensions; Longitudinal studies; Immigration; Labor market
Business indexing term:	Subject: Work environment Working hours Employees Employment Disability pensions Labor market
Location:	Denmark
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8

Pages:	641-650
Publication year:	2022
Publication date:	2022
Section:	Original article
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Journal Article
DOI:	https://doi.org/10.5271/sjweh.4050
ProQuest document ID:	2738246610
Document URL:	https://www.proquest.com/scholarly-journals/physical-work-demands-expected-labor-market/docview/2738246610/se-2?accountid=211160
Copyright:	Copyright Scandinavian Journal of Work, Environment &Health 2022
Last updated:	2023-02-27
Database:	Public Health Database

Suicide among transport industry workers: A systematic review and meta-analysis

Mathieu, Sharna, PhD [1] ; Ross, Victoria, PhD [1] ; Wardhani, Rachmania, BPsych [1] ; Brough, Paula, PhD [2] ; Wishart, Darren, PhD [2] ; Chan, Xi Wen, PhD; Kõlves, Kairi, PhD [1] Australian Institute for Suicide Research and Prevention &World Health Organization Collaborating Centre for Research and Training in Suicide Prevention, School of Applied Psychology, Griffith University, Brisbane, Australia [2] Centre for Work, Organisation, and Wellbeing, Griffith University, Brisbane, Australia

ABSTRACT (ENGLISH)

Objectives Working in high-stress and male-dominated occupations is associated with an elevated risk of suicide. The current study sought to conduct the first systematic literature review and meta-analysis aimed at determining suicide risk across the diverse, high pressure and male-dominated transport industry (commercial aviation, merchant seafaring, transit/driving) as compared to the general/employed population. Methods Searches of PubMed/Medline, Scopus and PsycINFO databases were conducted without date restriction until March 2021. Studies were included if they were written in English, were peer reviewed, and presented primary observational research data. Studies referring exclusively to suicidal ideation, suicide attempts, selfharm, and/or accidents were excluded. Results Following deletion of duplicates and non-English titles, a total of 4201 titles/abstracts were screened and 92 full-texts were read against inclusion/exclusion criteria. The final included sample consisted of 23 articles (16 used for meta-analysis). Results from the meta-analysis indicated that transport workers had a significantly elevated risk for suicide as compared to the general/employed population. Results were consistent across sensitivity analyses, and there was some variation across subgroup analyses. Conclusions Overall, we found transport workers had a significantly higher risk for suicide than the general/ employed population, and this appeared to be driven by the association for those working in merchant seafaring/ maritime occupations. The findings are discussed in relation to an identified need for the development, implementation, and evaluation of tailored workplace suicide prevention strategies for transport industry workers.

FULL TEXT

Headnote

Objectives Working in high-stress and male-dominated occupations is associated with an elevated risk of suicide. The current study sought to conduct the first systematic literature review and meta-analysis aimed at determining suicide risk across the diverse, high pressure and male-dominated transport industry (commercial aviation, merchant seafaring, transit/driving) as compared to the general/employed population.

Methods Searches of PubMed/Medline, Scopus and PsycINFO databases were conducted without date restriction until March 2021. Studies were included if they were written in English, were peer reviewed, and presented primary observational research data. Studies referring exclusively to suicidal ideation, suicide attempts, selfharm, and/or accidents were excluded.

Results Following deletion of duplicates and non-English titles, a total of 4201 titles/abstracts were screened and 92 full-texts were read against inclusion/exclusion criteria. The final included sample consisted of 23 articles (16 used for meta-analysis). Results from the meta-analysis indicated that transport workers had a significantly elevated risk for suicide as compared to the general/employed population. Results were consistent across sensitivity analyses, and there was some variation across subgroup analyses.

Conclusions Overall, we found transport workers had a significantly higher risk for suicide than the general/ employed population, and this appeared to be driven by the association for those working in merchant seafaring/ maritime occupations. The findings are discussed in relation to an identified need for the development, implementation, and evaluation of tailored workplace suicide prevention strategies for transport industry workers.

Key terms aviation; heavy vehicle; maritime; men's health; mental health; transport worker; workplace suicide prevention.

Numerous interrelated and co-occurring factors at the individual, family, and social levels (1) contribute to the loss of over 700 000 lives globally to suicide each year (2). Within this complicated milieu, work-related factors such as working in situations of prolonged physical, environmental, financial, and/or psychological stress, have been associated with an increased risk of suicide (3, 4). Suicide-related occupational stressors also include workplace access and familiarity with means of suicide, such as firearms (5). These factors have been implicated in several

industries at high-risk for suicide such as healthcare, correctional and defence services, construction, and agriculture (6).

One industry with high levels of inherent workplace stressors is the transport industry which is focused on the transport of people and freight by air, sea, machine/ mobile plant, road, or rail. Within the transport industry, workplace stressors include physical and environmental (eg, aircraft/machine noise, sitting for extended periods of time, jetlag, motion sickness, adverse temperature), social (eg, working away from family/home, isolated during work hours), and psychological (eg, highly demanding, monotonous, strict time pressures, huge responsibilities for their own, passenger, cargo, and community safety) (4). The situation intensified during the COVID-19 pandemic where commercial aviation all but ceased creating job and financial insecurity (7, 8); passenger- or customer-facing workers risked exposure to the virus (eg, bus drivers, delivery drivers); and maritime workers risked working in close confines with infected individuals (9). The mounting strain as a result of COVID-19 occurred while demand for online retail and supply chain pressure for freight and deliveries increased dramatically (10).

Unsurprisingly, transport workers commonly report problems with sleep and loneliness (11, 12), reduced work performance and work-related safety issues (13, 14), poor mental health and wellbeing (15, 16), and are more likely to require work-related compensation for a psychological injury compared to other workers (17). Furthermore, transport workers have been shown to have higher rates of suicide than the general and employed population (18-21). A previous review (21) examined suicide risk across broad occupational groups/ skill levels and found that machine operators/assemblers had the second highest risk for suicide after elementary professions (eg, cleaners). However, while this review included seafarers and transit/driving professionals in an overarching category, it also included stationary plant, machine assemblers, miners, communications, and public utilities professionals. It did not include workers from other important and high-stress transport industries (21).

To our knowledge, there has been no systematic review or meta-analysis specifically investigating suicide across the transport industry (ie, aviation, maritime, and transit/driving/mobile plant operation). The lack of a thorough review limits theoretical advancements in this area, producing knowledge gaps and potentially flawed practical recommendations. A clearer understanding of the risk for suicide among transport workers will facilitate the development and implementation of tailored workplace-based suicide prevention initiatives that are sensitive to the unique needs of this industry. Therefore, the current aim was to conduct a systematic literature review and meta-analysis to determine the risk of suicide in this industry compared to the employed and general population. We also aimed to determine whether the risk of suicide differed according to occupational or demographic characteristics of workers within the industry. Our research question was thus: Among workers, what is the effect of working in the transport industry (aviation, maritime, and transit/driving/mobile plant operation) on risk of suicide as compared to the general or employed populations?

Methods

This review followed the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines (22) (supplementary material https://sjweh.fi/article/4059, table S1) and was prospectively registered with PROSPERO (CRD42021236485).

Search strategy

Searches of PubMed/Medline, Scopus and PsycINFO were conducted for publications without date restriction until 4 March 2021. Search terms related to rail/ railway were excluded to minimize interference from papers referring to suicides where rail/railways were the primary method of community suicides (ie, not related to direct employment in the industry). Search terms relating to skill level or social class were also excluded, as the transport industry is incredibly diverse in terms of minimal educational and skill attainment required for certain occupations. Database specific Boolean operators (eg, AND, OR, NOT) and truncation symbols (eg, ·, " ") were used. The search terms used were: suicide AND driver OR pilot OR truck OR train OR occupation· OR aviation OR maritime OR "transport worker" OR "transport industry" NOT "pilot study" OR "pilot trial" OR "pilot program" OR training.

Inclusion and exclusion criteria

Publications were included if they were written in English, were peer-reviewed, and presented primary observational

research data (ie, not editorials, reviews, single case reports or other qualitative designs). Studies referring exclusively to suicidal ideation, suicide attempts, self-harm, other non-fatal suicidal behaviors, and/or accidents were excluded. Formal definitions of transport occupations were adopted from the 2018 standardized occupational classification system (23) to determine eligible studies. Studies where a worker's primary role included the preparation of food (eg, catering) were excluded, unless the workers were specifically identified as ship stewards or flight attendants. Aviation professionals whose primary role was in agriculture were excluded, as were maritime workers if they were working in fishing or trawling. If occupational categories were overly broad and specific information relating to transport workers could not be obtained, these studies were also excluded.

Data extraction and quality assessment

Duplicates and non-English titles were deleted, and two reviewers independently screened the titles and abstracts against inclusion/exclusion criteria. A third reviewer was consulted when necessary to resolve any discrepancies. The full-text of the remaining articles was independently assessed against the inclusion/exclusion criteria. Prior to finalization, reference lists of included articles were screened to capture any missing papers not identified in earlier searches. Two reviewers independently extracted data from the included articles into standardized tables (using Microsoft Excel). This included author(s), transport sector, publication year, country and time of data collection, study design, rates of suicide, effect measures and 95% confidence intervals (CI), other important information, and major limitations. If study designs were not explicitly recorded in the articles, designs were determined by the extractors based on available information (24). If multiple levels of occupational groups were reported, the most narrowly defined was extracted.

There is currently a lack of consensus regarding validated quality assessment and risk of bias tools that are applicable to non-randomized, descriptive, and observational designs in the literature (25). Using a modified version (26) of a quality scoring measure (27), two reviewers independently evaluated all included studies, and the scores were discussed for consensus. This is a generic quality scoring measure for quantitative studies that was suited to the variety of study designs identified in the included articles, and which allowed for comparisons of quality across studies and subgroup analyses in the meta-analysis.

Data synthesis and meta-analysis

Three studies utilized the same study population from Australia (5, 20, 28), three from Switzerland (19, 29, 30), and two from England and Wales (31, 32). Consequently, only the most recently published or most comprehensive study was included from each group in the meta-analysis. The effect sizes across studies included in the meta-analysis were rate ratios (RR), incidence rate ratios (IRR), and mortality rate ratios (MRR), as well as proportional (PMR) or standardized mortality ratios (SMR). Corresponding authors of six articles were contacted for additional or more specific detail (28, 32-36), but only the authors of one study (35) provided this information. Three of these articles were included in the review and meta-analyses by manually calculating RR using available results in the publication (28, 32, 36), and two of these articles were excluded as specific findings relating to suicide and/or transport workers could not be obtained/calculated (33, 34).

If a study included more than one comparison group, the employed population was preferentially extracted. If a study provided multiple effect sizes, the standardized or adjusted figures were extracted. If a study provided multiple different effect measures, RR were preferred (as well as IRR, and MRR), followed by odds ratios (OR), SMR, PMR, or comparative mortality ratios (CMR) (37). In previous occupational suicide mortality metaanalyses (21, 37), these effect measures have been combined for the purpose of meta-analysis due to the rarity of suicide in the working population (38). A pooled effect size was calculated for the risk of suicide among transport workers compared to a reference population using Review Manager (RevMan) version 5.4 (39). The I2 statistic was used as a measure of heterogeneity, and a random effects model was applied. A funnel plot was produced to investigate publication bias (40). Four separate sensitivity analyses were also conducted, where we removed: (i) studies that used one or only several selected occupations as a reference group; (ii) studies that were rated as low quality, (iii) studies that did not define their transport workers by standardized occupation classification systems (eg, family report, union membership), and (iv) broad categories that may have contained workers outside the transport industry.

Subgroup analyses were performed in RevMan, and a summary forest plot was produced in Microsoft Excel. These included gender (male, female, all persons), transport sector (aviation, maritime, transit/driving, general/ mixed transport workers), study design, data collection period (1989 and prior, 1990-2004, and 2005 onwards), region/country, effect measure, reference group, adjustment, and study quality. If a data collection period spanned the subgroup categories, articles were included in the period when data collection finished. If a study provided effect sizes for men, women, and all persons, only the information for specific gender groups were extracted. If a study provided effect sizes for men and all persons (18), then both estimates were extracted.

Results

Searches identified 7036 articles. Duplicates and nonEnglish titles were removed, resulting in 4201 titles and abstracts screened against inclusion/exclusion criteria. Ineligible articles were removed at this stage (N=4109), leaving 92 full-texts read against criteria. Of these, 49 articles were excluded. A further 14 articles were focused exclusively on deaths at sea/port [eg, (41)] or plane-assisted suicides [eg, (42)], highlighting a unique aspect of suicide in transport workers whereby death can occur at their place of work. However, these articles were subsequently excluded as they would be likely to underestimate the risk of suicide in transport workers (ie, by omitting suicides that occur outside of work or by other means in their estimates). Six additional articles were excluded as they combined suicide and homicides (34) or described broad occupational categories from which it was impossible to extract information specifically relating to transport workers [eg, (33)]. This resulted in a final sample of 23 articles, of which 16 were included in the meta-analyses (figure 1).

One study focused exclusively on transport workers in the commercial aviation sector (43), three on maritime workers in merchant seafaring (44-46), and one on bus drivers (47). These studies investigated various causes of death in a cohort of transport workers. The remaining 18 studies investigated the risk of suicide across multiple or selected occupational groups. These studies largely relied on standardized occupational classification systems from different countries of varying levels and specificity. However, three relied on other means of determining occupation (eg, loved one's report) or it was unclear (48-50).

Regarding the types of effect measures, six studies reported RR (5, 18, 20, 30, 44, 51), two used relative risk or hazard ratios (48, 50), one used OR (52), one used PMR (47), and eight used SMR (19, 29, 31, 35, 43, 45, 46, 53). Of the remaining studies, four reported rates per 100 000 (28, 32, 49, 54) or 1 million (36), and available data was used to manually calculate RR where possible. Most included studies (N=11) were case series (5, 18, 20, 31, 32, 36, 49, 50, 52-54), followed by ten retrospective or prospective cohort studies (19, 29, 30, 35, 43-48), one case-control study (51), and one ecological design (28).

Most studies included an employed or working population as a comparison group. These included the total employed population in seven studies (5, 18, 20, 28, 35, 36, 44), four included a single low risk occupation as a reference group (30, 48, 50, 51) or, for the purpose of manual calculation, several selected high-risk occupations available in the article (32). Ten studies included the general population, often of working age, as a comparison group (19, 29, 31, 43, 45-47, 52-54). For the final study, a comparison group was difficult to determine (49).

Five of the included studies had data collection periods from 1989 and prior (44, 46-49), five from 1990-2004 (35, 43, 45, 51, 52), and twelve from 2005 onwards (5, 18-20, 28-31, 36, 50, 53, 54). One study had two distinct data collection periods, both of which were extracted, one 1989 and prior and one 2005 onwards (32).

Only two studies focused exclusively on suicide mortality among working women (30, 45), and a further three studies provided specific effect sizes for women (19, 29, 43); however, only three of these could be included in the meta-analysis due to overlapping samples (19, 43, 45). The number of suicides for women were reported in a further six studies but due to rarity were excluded from further analyses or relevant effect sizes were not calculated (5, 18, 20, 35, 36, 54). Each of these studies provided the number of suicides, and effect sizes and/or rates for men also. Information on suicide in all persons was reported in a further five studies (28, 32, 48, 51, 52). Seven studies provided information on suicide only among male workers due to a lack of female workers in the cohort or a scarcity of suicides among women in those occupations (31, 44, 46, 47, 49, 50, 53). Study summaries are provided in supplementary table S2.

Meta-analysis: overall risk of suicide in transport workers

Overall, based on 16 studies, transport workers had a significantly higher risk of suicide compared to the employed/general population [see figure 2; pooled effect size of 1.32, 95% CI (1.15-1.52)]. This finding was slightly stronger in the sensitivity analyses removing studies that used one or only selected occupations as reference groups [pooled effect size of 1.40, 95% CI (1.18-1.68)], removing transport categories that remained somewhat broad [eg, transport plus other laborers, material recording and transport clerks, and garbage collectors; pooled effect size 1.35, 95% CI (1.16-1.58)], and removing low quality studies [pooled effect size of 1.42, 95% CI (1.20-1.66)]. In the final sensitivity analysis, removing studies that did not rely on standardized classification systems for identifying workers, the pooled effect size reduced somewhat but remained significant [pooled effect size of 1.29, 95% CI (1.00-1.50)]. Based on visual inspection of the funnel plot (figure 3), the studies had a small standard error which were clustered symmetrically.

All subgroup analyses are summarized in figure 4 (more detailed figures are available in the supplementary material). The test for subgroup differences was non-significant for gender (x2=0.10, df=2, P=0.95, I2=0.0%) and region (x2=5.22, df=2, P=0.07, I2=61.7%). For transport sector, tests for subgroup differences were significant (x2=9.66, df=3, P=0.02, I2=69.0%). Those working in maritime/merchant seafaring occupations showed significantly greater risk for suicide than the general and employed population group whereas the remaining sub-industries did not.

The test for subgroup differences was non-significant for data collection period (x2=1.84, df=2, P=0.40, I2=0%), comparison group (x2=4.90, df=3, P=0.18, I2=38.8%), effect measure used (x2=0.26, df=2, P=0.88, I2=0%), adjustment (x2=2.04, df=2, P=0.36, I2=1.7%), and for study quality (x2=3.58, df=2, P=0.17, I2=44.2%). For study design, the test for subgroup differences was significant (x2=10.03, df=4, P=0.04, I2=60.1%). Studies using prospective and retrospective cohort, and nested case-control study designs produced significantly higher effect sizes of suicide rates among transport workers as compared to the comparison group, while studies using case series and ecological designs did not show significant risk of suicide.

Quality ratings

The quality of included studies ranged from 8-19 (from a possible total of 20). Most studies were rated as 'high' quality (N=12), followed by 'medium' (N=7) and 'low' (N=4) quality. Descriptive and observational studies are often appropriate and widely used in determining the epidemiology of rare suicidal behaviors (24, 55). However, it is acknowledged that while these study designs are valid and can be conducted in a high-quality way, they are typically considered lower levels of evidence given a greater likelihood for risk of bias (56). It should also be noted that the two studies with the lowest quality ratings were excluded from the meta-analysis due to insufficient information. For an overview of the quality scoring see supplementary table S3.

Discussion

This is the first review that has focused exclusively on suicide risk in this diverse and high-pressure industry. Overall, transport workers had a significantly higher risk for suicide than the general and employed populations. This finding was robust across sensitivity analyses, including removing studies where transport workers were classified in groups that may have included other laborers such as construction, which is its own high-risk industry (21). It appears that this association is driven by those working in the maritime industry (eg, deck and engine crew). Despite non-significant subgroup comparisons, the risk for suicide appears more pronounced among men and 'all persons' groups working in transport. Although women had a higher estimate, this did not reach significance and there were relatively fewer included studies that provided information on suicide among women in the transport industry. Globally, suicides occur more frequently among men than women (2). The transport industry is considered a male-dominated workforce (57). Other male-dominated industries such as agriculture (37) or laborers/construction (21) have also demonstrated higher risks for suicide. It is important then to consider the impact of gender and masculine norms with regards to suicide and related behaviors in the workplace. Previous research has identified the role of masculine self-reliance and stoicism as being relevant to suicide, stigma, and helpseeking (58). These qualities have been directly linked to suicide among men working in agriculture (59). Furthermore, within a workplace context,

elements of masculinity (eg, dominance, anti-weakness positioning) have also been implicated in co-creating toxic workplace cultures that favor competition and hierarchy and often lead to adverse outcomes for workers (of all genders) such as bullying/harassment, burnout, poor work-life balance, and reduced worker well-being, which has implications for the function and health of work teams and organizations [eg, (60, 61)].

These 'masculinity contest cultures' within organizations may also influence workers to take unnecessary risks to achieve role objectives and may help explain why certain work-related stressors impact suicide in men and women differently (60). For example, there are relatively high suicide rates among women in highly hierarchical professional occupations such as healthcare, as compared to men (62). In turn, men may have higher suicide rates than women when experiencing job insecurity or unemployment, where men are unable to prove subjective 'worth' and achieve social status as a 'man' (60). Regarding transport specifically, despite many regulations and safety practices implemented at national and organizational levels, systemic pressures to take risks such as working through fatigue, using substances, and travelling at higher speeds are well documented (63). Furthermore, organizational safety requirements and fitness for work parameters, such as preventing pilots from flying if they experience mental health difficulties, may serve to further inhibit helpseeking and contribute to 'anti-weakness' high stress workplace cultures. Given high rates of suicide among men working in the transport industry, and the possible impact of masculine norms and organizational values, it is essential that suicide prevention strategies and mental health promotion interventions developed for men in this industry are sensitive to, and directly accommodate, the role of masculinity and socialization of gender on helpseeking and perceived acceptability of services (64, 65). This may be especially important in the wake of the COVID-19 pandemic and associated increase in occupational and financial pressures for these workers (66).

In addition to the impact of gender and workplace stressors such as job insecurity (4), there are other organizational and individual factors that may contribute to suicide risk within the transport industry. It was not possible in the current meta-analysis to determine what impact known risk factors such as socioeconomic, relationship problems, substance use, or mental health variables had in contributing to suicide risk in transport workers. For instance, transit/driving professionals often experience a range of traumatic workplace incidents and accidents, including community suicides whereby individuals may crash into/walk in front of heavy vehicles or 'person under train' related events (67). Consequently, a burgeoning field of research examines mental health conditions experienced by transport workers, including acute or post-traumatic stress, and subsequent impacts on their work performance [eg, (67)]. However, a detailed exploration of how these experiences and associated mental health conditions may relate to the experience of suicidal thoughts and behaviors in these workers is lacking.

In the current review, those working in the maritime industry had an elevated risk for suicide, whereas estimates for the aviation and transit/driving sector did not reach significance. This may be a result of different levels of economic and educational attainment across industries. Indeed, certain transport workers such as commercial pilots obtain higher occupational skill levels compared to a ship's deck crew, and previous research has shown that those working in professions with lower skill levels (including maritime and transit/driving professions) have a higher risk of suicide (21). Furthermore, merchant seafaring is a highly hazardous and isolating profession (68), associated with considerable loneliness, mental health problems, fatigue, and job strain (69-71). Importantly, loneliness combined with other factors such as self-worth, acquired capability, and perceived burden-someness are central elements in the interpersonal theory of suicide (72).

Implications and directions for future research

Unfortunately, in recent reviews of workplace suicide prevention (73) and men's mental health promotion interventions (74), there were no programs specifically tailored to the transport industry. Given the elevated risk of suicide among transport workers, there is a strong need for developing, implementing, and evaluating tailored multilevel workplace suicide prevention interventions that are cognizant of interrelated workplace stressors and encourage cultural change with regards to suicide related stigma, help-seeking, and other related barriers such as less healthy aspects of masculine norms. While masculine norms are not inherently harmful, it is important that workplace suicide prevention and mental health promotion interventions in male-dominated occupations are

perceived of as authentic and relatable, reframe help-seeking as a strength, and support adaptive coping and emotion regulation strategies not based on suppression (64, 65).

However, the transport industry largely relies on and works within the logistics chain (ie, movement and storage of freight at all stages until reaching the consumer), which is a highly complex environment comprising multifaceted industries and stakeholders interwoven across a (time) sensitive supply chain. Failure in one link of the supply chain has a significant impact on others and can ultimately cease all operations. Therefore, a challenge unique to the transport industry is that any initiative (such as a suicide prevention gatekeeper training or workplace mental health and well-being interventions) that requires workers to come offline from the supply chain will have negative consequences for the stoppage of movement within the chain and may inadvertently contribute to workplace stress. Additionally, safety regulations for fatigue translate to specific operational and required rest hours which further impacts upon opportunities for employees to participate in programs outside of work hours. These occupational barriers have implications for how motivated organizations and workers may be for engaging in such programs, resulting in issues with feasibility and sustainability. In the maritime industry there may be more opportunity for interventions while at sea versus the highly stressful and time sensitive periods at port or during river passage, or during rest hours (70). Various recommendations have been made regarding 'whole of ship' training around physical and mental health and well-being, promoting resilience, and creating more supportive and equal work environments in the maritime industry (75). However, the pressures of globalized supply chain deliverables, rotating crew, and the trend toward hiring international workers at low wages and with lower standards of employment are important systemic barriers that require industry level consideration (75-78). Future research regarding suicide prevention strategies is required to determine ways to address co-occurring and interconnected contributing risk factors, and also the manner in which such initiatives can be delivered and tailored to the unique challenges of the transport sector. Industry and stakeholder involvement in the co-design of programs may be one important avenue.

Methodological considerations

Several important considerations relate to the current findings. Across studies and samples, there were inconsistencies in how occupation/working status was defined with slight variations in conceptualization across occupational classification systems. Studies that had overly broad occupation definitions were excluded, which may mean that some transport workers were missed. Furthermore, there were differences in when occupation was assigned (ie, at the beginning of the data collection period or upon death) which may also influence the results. This, in addition to diversity across the transport samples by sector and across studies by design, may explain some of the high heterogeneity observed in this meta-analysis. There are also inherent challenges to suicide surveillance that may have impacted current findings. For example, difficulties with classifying suicide cases (79) or limited capacity for comprehensive record linkage to facilitate adequate control of known risk factors (80). Indeed, an inability to adequately control for confounders, besides age and gender, was a routinely cited limitation in the included articles. We combined general working age populations and the employed population as a reference group in the overall meta-analysis; however, subgroup analyses were performed which did not show any difference between models in which the comparator was the general or the employed population. This indicates that there was no 'healthy worker' effect whereby it might be expected that the general population which includes people unable to work due to illness, mental health, and physical or intellectual abilities may have an elevated risk for suicide or poor outcomes whereas the working population may be protected from such (81). A lack of a healthy worker effect was also directly acknowledged across several included articles (19, 45, 46). While our review was intended to be as comprehensive as possible on this complex and understudied topic within the diverse and highly stressful transport industry, we note that several studies were published prior to 2005. Subgroup analyses by year of publication were non-significant, however, it appears that the overall risk of suicide in transport workers may be influenced by these older studies. There have been considerable changes to society, workplace safety practices, globalization, staffing, and technology in recent years which may have had a substantial impact on the transport industry and ultimately risk for suicide. Finally, with a reliance on non-randomized and observational designs, it is difficult to assess certainty of evidence such as through GRADE assessments (82).

Strengths and limitations

The review followed the most up to date PRISMA guidelines. Furthermore, by focusing on transport workers specifically, we were able to conduct subgroup analyses across multiple transport industries in addition to other sample and study characteristics. Nevertheless, there are certain limitations that should be noted. The review was limited to English-language publications, which may have resulted in some missing articles. Indeed, the included articles were all from high-income countries which means it is likely that our review may have missed studies from low- and middle-income countries (LMIC) and was unable to provide solid conclusions relating to suicide among transport workers from LMIC. This is important, firstly, as most suicides around the world occur in LMIC (2), and secondly, the transport industry (especially merchant seafaring) is a relatively international occupation with the potential for unique stressors in migrant or foreign workers from LMIC or those working under 'flags of convenience' (ie, ships registered to countries without residency requirements) (75, 77).

Another important limitation is the quality assessment tool that was used in the current study. There is a lack of consensus regarding high quality, validated quality assessment/risk of bias tools for descriptive and observational studies, so we relied upon a generic measure in the present study. While the quality assessment was conducted independently and several included studies were rated as high quality, it is acknowledged that descriptive and observational designs are more susceptible to risk of bias and findings should be interpreted in light of this (56). The sensitivity analysis removing low quality studies produced a slightly stronger effect for risk of suicide in transport workers. Subgroup analyses by study design also revealed there was a significant difference whereby cohort and case-control studies demonstrated a significant risk of suicide in transport workers whereas case series and ecological studies were not significant.

There was high heterogeneity observed in the metaanalysis which may be the result of including different reference groups, classifications of occupations and suicides, and country/regions. Finally, there were relatively few studies identified that examined suicide in the commercial aviation sector. This may reflect systemic factors described earlier (eg, fitness for work assessments) which may indicate suicides occur less frequently in these workers or it could be due to a lack of research attention. Instead, we identified, and subsequently excluded studies that involved plane-assisted suicides using light aircraft, hobby pilots, or general aviation.

Concluding remarks

This review provides a comprehensive investigation of suicide risk among transport workers specifically. Overall, transport workers had a significantly higher risk for suicide than the general and employed populations. Based on subgroup analyses, it appears that the observed risk for suicide among transport workers relative to the general and employed populations is driven by the association for those working in maritime occupations. These findings highlight an important need for tailored suicide prevention and mental health promotion initiatives that are sensitive to organizational practices and culture in this unique, high-pressure and male-dominated industry.

Acknowledgements

We acknowledge Jason Spedding for his assistance with the initial data searches.

Data availability

Data can be obtained from the authors on request.

Disclosure of competing interests

The authors declare no potential competing interests in relation to the current manuscript.

Sidebar

Mathieu S, Ross V, Wardhani R, Brough P, Wishart D, Chan XW, Kölves K. Suicide among transport industry workers: A systematic review and meta-analysis. Scand J Work Environ Health. 2022;48(8):598-610. doi:10.5271/sjweh.4059

Correspondence to: Dr Sharna Mathieu, Australian Institute for Suicide Research and Prevention, Psychology Building (M24), Griffith University Messines Ridge Road, Mount Gravatt, Queensland, 4122, Brisbane, Australia. [E-mail: s.mathieu@griffith.edu.au]

Received for publication: 6 April 2022

References

References

1. Turecki G, Brent DA, Gunnell D, O'Connor RC, Oquendo MA, Pirkis J et al. Suicide and suicide risk. Nat Rev Dis Primers 2019 Oct;5(1):74. https://doi.org/10.1038/s41572019-0121-0.
2. World Health Organization. Suicide worldwide in 2019: global health estimates. Geneva: World Health Organization; 2021.
3. Milner A, Witt K, LaMontagne AD, Niedhammer I. Psychosocial job stressors and suicidality: a metaanalysis and systematic review. Occup Environ Med 2018 Apr;75(4):245-53. https://doi.org/10.1136/ oemed-2017-104531.
4. Woo JM, Postolache TT. The impact of work environment on mood disorders and suicide: evidence and implications. Int J Disabil Hum Dev 2008;7(2): 185-200. https://doi. org/10.1515/IJDHD.2008.7.2.185.
5. Milner A, Witt K, Maheen H, LaMontagne AD. Access to means of suicide, occupation and the risk of suicide: a national study over 12 years of coronial data. BMC Psychiatry 2017 Apr;17(1):125. https://doi.org/10.1186/ s12888-017-1288-0.
6. Ross V, Mathieu SL, Witt K, Kõlves K. Preventing Suicide in the Workplace. In: Wall T, Cooper CL, Brough P, editors. The SAGE Handbook of Organizational Wellbeing. London: SAGE; 2021. p. 266-81.
7. Arellana J, Márquez L, Cantillo V. COVID-19 outbreak in Colombia: An analysis of its impacts on transport systems. Journal of Advanced Transportation. 2020;2020. https://doi. org/10.1155/2020/8867316.
8. Sobieralski JB. COVID-19 and airline employment: insights from historical uncertainty shocks to the industry. Transp Res Interdiscip Perspect 2020 May;5:100123. https://doi. org/10.1016/j.trip.2020.100123.
9. Stannard S. COVID-19 in the maritime setting: the challenges, regulations and the international response. Int Marit Health 2020;71(2):85-90. https://doi.org/10.5603/ IMH.2020.0016.
10. Villa R, Monzón A. Mobility restrictions and e-commerce: holistic balance in madrid centre during COVID-19 lockdown. Economies. 2021;9(2):57. https://doi. org/10.3390/economies9020057.
11. Carotenuto A, Molino I, Fasanaro AM, Amenta F. Psychological stress in seafarers: a review. Int Marit Health 2012;63(4):188-94.
12. Pellegrino P, Marqueze EC. Aspects of work and sleep associated with work ability in regular aviation pilots. Rev Saude Publica 2019 Jan;53:16. https://doi.org/10.11606/ S1518-8787.2019053000345.
13. Montoro L, Useche S, Alonso F, Cendales B. Work environment, stress, and driving anger: A structural equation model for predicting traffic sanctions of public transport drivers. Int J Environ Res Public Health 2018 Mar;15(3):497. https://doi.org/rn.3390/ijerph15030497.
14. Useche SA, Gómez V, Cendales B, Alonso F. Working conditions, job strain, and traffic safety among three groups of public transport drivers. Saf Health Work 2018 Dec;9(4):454-61. https://doi.org/10.1016/j. shaw.2018.01.003.
15. Crizzle AM, Bigelow P, Adams D, Gooderham S, Myers AM, Thiffault P. Health and wellness of long-haul truck and bus drivers: A systematic literature review and directions for future research. J Transp Health 2017;7:90-109. https://doi. org/10.1016/j.jth.2017.05.359.
16. van Vreden C, Xia T, Collie A, Pritchard E, Newnam S, Lubman DI et al. The physical and mental health of Australian truck drivers: a national cross-sectional study. BMC Public Health 2022 Mar;22(1):464. https://doi. org/10.1186/s12889-022-12850-5.
17. Xia T, Iles R, Newnam S, Lubman DI, Collie A. Workrelated injury and disease in Australian road transport workers: a retrospective population based cohort study. J Transp Health 2019;12:34-41. https://doi.org/10.1016/j. jth.2018.11.002.
18. Andersen K, Hawgood J, Klieve H, Kõlves K, De Leo D. Suicide in selected occupations in Queensland: evidence from the State suicide register. Aust N Z J Psychiatry 2010 Mar;44(3):243-9. https://doi. org/10.3109/00048670903487142.
19. Guseva Canu I, Bovio N, Mediouni Z, Bochud M, Wild P; Swiss National Cohort (SNC). Suicide mortality follow-up of the Swiss National Cohort (1990-2014): sex-specific risk estimates by occupational socio-economic group in

workingage population. Soc Psychiatry Psychiatr Epidemiol 2019 Dec;54(12):1483-95. https://doi.org/10.1007/s00127-01901728-4.
20. Milner A, Page K, LaMontagne AD. Suicide among male road and rail drivers in Australia: a retrospective mortality study. Road &Transport Research: A Journal of Australian and New Zealand Research and Practice. 2015;24(2):26.
21. Milner A, Spittal MJ, Pirkis J, LaMontagne AD. Suicide by occupation: systematic review and meta-analysis. Br J Psychiatry 2013 Dec;203(6):409-16. https://doi. org/10.1192/bjp.bp.113.128405.
22. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021 Mar;372:n71. https://doi.org/10.1136/bmj.n71.
23. United States Executive Office of the President Office of Management and Budget. Standard Occupational Classification Manual. United States of America: 2018.
24. Kõlves K, Sisask M, Rocket I. Observational studies in suicide research. In: Kõlves K, Sisask M, Varnik P, Varnik A, De Leo D, editors. Advancing Suicide Research. Boston, MA: Hogrefe Publishing; 2021.
25. Farrah K, Young K, Tunis MC, Zhao L. Risk of bias tools in systematic reviews of health interventions: an analysis of PROSPERO-registered protocols. Syst Rev 2019 Nov;8(1):280. https://doi.org/10.1186/s13643-019-1172-8.
26. Reardon T, Harvey K, Baranowska M, O'Brien D, Smith L, Creswell C. What do parents perceive are the barriers and facilitators to accessing psychological treatment for mental health problems in children and adolescents? A systematic review of qualitative and quantitative studies. Eur Child Adolesc Psychiatry 2017 Jun;26(6):623-47. https://doi. org/10.1007/s00787-016-0930-6.
27. Kmet LM, Cook LS, Lee RC. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Edmonton, Alberta: Alberta Heritage Foundation for Medical Research; 2004.
28. Too LS, Spittal MJ. Suicide Clusters Among Top 10 HighRisk Occupations: A Study From 2001 to 2016 in Australia. J Nerv Ment Dis 2020 Dec;208(12):942-6. https://doi. org/10.1097/NMD.0000000000001234.
29. Schmid M, Michaud L, Bovio N, Guseva Canu I; Swiss National Cohort (SNC). Prevalence of somatic and psychiatric morbidity across occupations in Switzerland and its correlation with suicide mortality: results from the Swiss National Cohort (1990-2014). BMC Psychiatry 2020 Jun;20(1):324. https://doi.org/10.1186/s12888-020-027337.
30. Wild P, Bovio N, Guseva Canu I; Swiss National Cohort. Part-time work and other occupational risk factors for suicide among working women in the Swiss National Cohort. Int Arch Occup Environ Health 2021 Jul;94(5):98190. https://doi.org/10.1007/s00420-020-01629-z.
31. Meltzer H, Griffiths C, Brock A, Rooney C, Jenkins R. Patterns of suicide by occupation in England and Wales: 2001-2005. Br J Psychiatry 2008 Jul;193(1):73-6. https:// doi.org/10.1192/bjp.bp.107.040550.
32. Roberts SE, Jaremin B, Lloyd K. High-risk occupations for suicide. Psychol Med 2013 Jun;43(6):1231-40. https://doi. org/10.1017/S0033291712002024.
33. Alexopoulos EC, Kavalidou K, Messolora F. Suicide mortality across broad occupational groups in Greece: a descriptive study. Saf Health Work 2016 Mar;7(1):1-5. https://doi.org/10.1016/j.shaw.2015.09.004.
34. Koh D, Guanco-Chua S, Ong CN. A study of the mortality patterns of taxi drivers in Singapore. Ann Acad Med Singap 1988 Oct;17(4):579-82.
35. Mustard CA, Bielecky A, Etches J, Wilkins R, Tjepkema M, Amick BC et al. Suicide mortality by occupation in Canada, 1991-2001. Can J Psychiatry 2010 Jun;55(6):369-76. https://doi.org/10.n77/070674371005500606.
36. Yamauchi T, Sasaki T, Yoshikawa T, Matsumoto S, Takahashi M. Incidence of overwork-related mental disorders and suicide in Japan. Occup Med (Lond) 2018 Aug;68(6):370-7. https://doi.org/10.1093/occmed/kqy080.
37. Klingelschmidt J, Milner A, Khireddine-Medouni I, Witt K, Alexopoulos EC, Toivanen S et al. Suicide among agricultural, forestry, and fishery workers: a systematic literature review and meta-analysis. Scand J Work Environ Health 2018 Jan;44(1):3-15. https://doi.org/10.5271/ sjweh.3682.
38. Greenland S, O'Rourke K. Chapter 33 Meta-Analysis. In: Rothman KJ, Greenland S, Lash TL, editors. Modern

Epidemiology Third Edition. Philadelphia, PA: Lippincott Williams &Wilkins; 2008. p. 652-82.
39. The Cochrane Collaboration. Review Manager (RevMan). 5.4: ed2020.
40. Witt K, Milner A, Spittal M. Systematic Reviews and MetaAnalyses in Suicide Prevention Research. In: Kõlves K, Sisask M, Varnik P, Varnik A, De Leo D, editors. Advancing Suicide Research. Boston, MA: Hogrefe Publishing; 2021.
41. Carter T, John A, Williams JG, Roberts SE. Suicide, fatal injuries and drowning among the crews of United Kingdom and Bermuda registered cruise and passenger ships from 1976 to 2018. Int Marit Health 2020;71(1):12-9. https://doi. org/10.5603/IMH.2020.0006.
42. Politano PM, Walton RO. Analysis of ntsb aircraft-assisted pilot suicides: 1982-2014. Suicide Life Threat Behav 2016 Apr;46(2):234-8. https://doi.org/10.1111/sltb.12187.
43. Ballard TJ, Lagorio S, De Santis M, De Angelis G, Santaquilani M, Caldora M et al. A retrospective cohort mortality study of Italian commercial airline cockpit crew and cabin attendants, 1965-96. Int J Occup Environ Health 2002 Apr-Jun;8(2):87-96. https://doi.org/10.1179/ oeh.2002.8.2.87.
44. Brandt LP, Kirk NU, Jensen OC, Hansen HL. Mortality among Danish merchant seamen from 1970 to 1985. Am J Ind Med 1994 Jun;25(6):867-76. https://doi.org/10.1002/ ajim.4700250610.
45. Hansen HL, Jensen J. Female seafarers adopt the high risk lifestyle of male seafarers. Occup Environ Med 1998 Jan;55(1):49-51. https://doi.org/10.1136/oem.55.1.49.
46. Rafnsson V, Gunnarsdóttir H. Risk of fatal accidents occurring other than at sea among Icelandic seamen. BMJ 1993 May;306(6889):1379-81. https://doi.org/10.1136/ bmj.306.6889.1379.
47. Guidotti TL. Mortality of urban transit workers: indications of an excess of deaths by suicide using gas. Occup Med (Lond) 1992 Aug;42(3):125-8.
48. Kposowa AJ. Suicide mortality in the United States: differentials by industrial and occupational groups. Am J Ind Med 1999 Dec;36(6):645-52. https://doi. org/10.1002/(SICI)1097-0274(199912)36:6<645:AIDAJIM7>3.0.CO;2-T.
49. Labovitz S, Hagedorn R. An analysis of suicide rates among occupational categories. Sociol Inq 1971 ;41 (1): 67-72. https://doi.org/10.1111/j.1475-682X.1971.tb01201.x.
50. Wada K, Eguchi H, Prieto-Merino D, Smith DR. Occupational differences in suicide mortality among Japanese men of working age. J Affect Disord 2016 Jan;190:316-21. https://doi.org/10.1016/jjad.2015.10.032.
51. Agerbo E, Gunnell D, Bonde JP, Mortensen PB, Nordentoft M. Suicide and occupation: the impact of socio-economic, demographic and psychiatric differences. Psychol Med 2007 Aug;37(8):1131-40. https://doi.org/10.1017/ S0033291707000487.
52. Stack S. Occupation and suicide. Soc Sci Q 2001;82(2):38496. https://doi.org/10.1111/0038-4941.00030.
53. Windsor-Shellard B, Gunnell D. Occupation-specific suicide risk in England: 2011-2015. Br J Psychiatry 2019 Apr;215(4):1-6. https://doi.org/10.1192/bjp.2019.69.
54. Stallones L, Doenges T, Dik BJ, Valley MA. Occupation and suicide: Colorado, 2004-2006. Am J Ind Med 2013 Nov;56(11):1290-5.
55. Pirkis J, Nicholas A, Gunnell D. The case for case-control studies in the field of suicide prevention. Epidemiol Psychiatr Sci 2019 Oct;29:e62. https://doi.org/10.1017/ S2045796019000581.
56. Murad MH, Asi N, Alsawas M, Alahdab F. New evidence pyramid. Evid Based Med 2016 Aug;21(4):125-7. https:// doi.org/10.1136/ebmed-2016-110401.
57. Turnbull P. Promoting the employment of women in the transport sector: Obstacles and policy options: International Labour Organization (ILO); 2013.
58. Pirkis J, Spittal MJ, Keogh L, Mousaferiadis T, Currier D. Masculinity and suicidal thinking. Soc Psychiatry Psychiatr Epidemiol 2017 Mar;52(3):319-27. https://doi.org/10.1007/ s00127-016-1324-2.
59. Kunde L, Kõlves K, Kelly B, Reddy P, de Leo D. "The Masks We Wear": A qualitative study of suicide in Australian farmers. J Rural Health 2018 Jun;34(3):254-62. https://doi.org/10.1111/jrh.12290.
60. Berdahl JL, Cooper M, Glick P, Livingston RW, Williams JC. Work as a masculinity contest. J Soc Issues 2018;74:422. https://doi.org/10.1111/josi.12289.

61. Brough P, Kinman G, McDowall A, Chan XC. '#Me too' for work-life balance. British Psychological Society Work-life Balance Bulletin. 2021;5:4-8.
62. Milner AJ, Spittal MS, Pirkis J, LaMontagne AD. Does gender explain the relationship between occupation and suicide? Findings from a meta-analytic study. Community Ment Health J 2016 Jul;52(5):568-73. https://doi.org/10.1007/s10597-015-9889-x.
63. Newnam S, Goode N. Do not blame the driver: a systems analysis of the causes of road freight crashes. Accid Anal Prev 2015 Mar;76:141-51. https://doi.org/10.1016/j. aap.2015.01.016.
64. Seaton CL, Bottorff JL, Oliffe JL, Medhurst K, DeLeenheer D. Mental health promotion in male-dominated workplaces: perspectives of male employees and workplace representatives. Psychol Men Masc 2019;20(4):541. https:// doi.org/10.1037/men0000182.
65. Struszczyk S, Galdas PM, Tiffin PA. Men and suicide prevention: a scoping review. J Ment Health 2019 Feb;28(1):80-8. https://doi.org/10.1080/09638237.2017.13 70638.
66. Khan AR, Ratele K, Arendse N. Men, suicide, and Covid-19: critical masculinity analyses and interventions. Postdigital Science and Education. 2020;2(3):651-6. https:// doi.org/10.1007/s42438-020-00152-1.
67. Carey MG, Regehr C, Wagner SL, White M, Alden LE, Buys N et al. The prevalence of PTSD, major depression and anxiety symptoms among high-risk public transportation workers. Int Arch Occup Environ Health 2021 Jul;94(5):867-75. https://doi.org/10.1007/s00420020-01631-5.
68. Roberts SE, Nielsen D, Kotłowski A, Jaremin B. Fatal accidents and injuries among merchant seafarers worldwide. Occup Med (Lond) 2014 Jun;64(4):259-66. https://doi. org/10.1093/occmed/kqu017.
69. Iversen RT. The mental health of seafarers. Int Marit Health 2012;63(2):78-89.
70. Oldenburg M, Jensen HJ. Stress and strain among merchant seafarers differs across the three voyage episodes of port stay, river passage and sea passage. PLoS One 2019 Jun;14(6):e0217904. https://doi.org/10.1371/journal.pone.0217904.
71. Oldenburg M, Jensen HJ, Latza U, Baur X. Seafaring stressors aboard merchant and passenger ships. Int J Public Health 2009;54(2):96-105. https://doi.org/10.1007/s00038009-7067-z.
72. Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite SR, Selby EA, Joiner TE Jr. The interpersonal theory of suicide. Psychol Rev 2010 Apr;117(2):575-600. https://doi. org/10.1037/a0018697.
73. Milner A, Page K, Spencer-Thomas S, Lamotagne AD. Workplace suicide prevention: a systematic review of published and unpublished activities. Health Promot Int 2015 Mar;30(1):29-37. https://doi.org/10.1093/heapro/dau085.
74. Seaton CL, Bottorff JL, Jones-Bricker M, Oliffe JL, DeLeenheer D, Medhurst K. Men's mental health promotion interventions: A scoping review. Am J Men Health 2017 Nov;11(6):1823-37. https://doi.org/10.1177/1557988317728353.
75. Rozanov V. Mental health problems and suicide in the younger generation - implications for prevention in the Navy and merchant fleet. Int Marit Health 2020;71(1):3441. https://doi.org/10.5603/IMH.2020.0009.
76. McVeigh J, MacLachlan M, Vallieres F, Hyland P, Stilz R, Cox H et al. Identifying predictors of stress and job satisfaction in a sample of merchant seafarers using structural equation modeling. Front Psychol 2019 Feb;10:70. https://doi.org/10.3389/fpsyg.2019.00070.
77. McVeigh J, MacLachlan M. A silver wave? Filipino shipmates' experience of merchant seafaring. Mar Policy 2019;99:283-97. https://doi.org/10.1016/j. marpol.2018.10.012.
78. McVeigh J, MacLachlan M, Coyle C, Kavanagh B. Perceptions of well-being, resilience and stress amongst a sample of merchant seafarers and superintendents. Marit Stud 2019;18(2):139-58. https://doi.org/10.1007/s40152018-0129-1.
79. Silverman MM, De Leo D. Why there is a need for an international nomenclature and classification system for suicide. Crisis 2016 Mar;37(2):83-7. https://doi. org/10.1027/0227-5910/a000419.
80. Erlangsen A, Qin P, Mittendorffer-Rutz E. Data Linkage and Studies of Suicidal Behavior. In: Kõlves K, Sisask M, Varnik P, Varnik A, De Leo D, editors. Advancing Suicide Research. Boston, MA: Hogrefe Publishing; 2021. p.

11528.
81. Buckley JP, Keil AP, McGrath LJ, Edwards JK. Evolving methods for inference in the presence of healthy worker survivor bias. Epidemiology 2015 Mar;26(2):204-12. https://doi.org/10.1097/EDE.0000000000000217.
82. Hilton Boon M, Thomson H, Shaw B, Akl EA, Lhachimi SK, López-Alcalde J et al.; GRADE Working Group. Challenges in applying the GRADE approach in public health guidelines and systematic reviews: a concept article from the GRADE Public Health Group. J Clin Epidemiol 2021 Jul;135:42-53. https://doi.org/10.1016/j.jclinepi.2021.01.001.

DETAILS

Subject:	Population; Observational studies; High pressure; Workers; Aviation; Driving ability; Occupations; Risk; COVID-19; Literature reviews; Marine transportation; Suicide; Subgroups; Males; Sensitivity analysis; Civil aviation; Mental health; Meta-analysis; Suicidal behavior; Coronaviruses; Systematic review; Suicides &suicide attempts; Transportation industry
Business indexing term:	Subject: Workers
Publication title:	Scandinavian Journal of Work, Environment &Health; Stockholm
Volume:	48
Issue:	8
Pages:	598-610
Publication year:	2022
Publication date:	2022
Section:	Review
Publisher:	Scandinavian Journal of Work, Environment &Health
Place of publication:	Stockholm
Country of publication:	Finland, Stockholm
Publication subject:	Occupational Health And Safety
ISSN:	03553140
e-ISSN:	1795990X
Source type:	Scholarly Journal
Language of publication:	English
Document type:	Evidence Based Healthcare, Journal Article

Gupta, N., Bjerregaard, S., Yang, L., Forsman, M., Rasmussen, C. L., Rasmussen, C. D. N., . . . Holtermann, A. (2022). Does occupational forward bending of the back increase long-term sickness absence risk? A 4-year prospective register-based study using device-measured compositional data analysis. Scandinavian Journal of Work, Environment & Health, 48(8), 651-661. doi:https://doi.org/10.5271/sjweh.4047

Objective Forward bending of the back is common in many jobs and a risk factor for sickness absence. However, this knowledge is based on self-reported forward bending that is generally imprecise. Thus, we aimed to investigate the dose-response relation between device-measured forward bending at work and prospective register-based risk of long-term sickness absence (LTSA). Methods At baseline, 944 workers (93% from blue-collar jobs) wore accelerometers on their upper back and thigh over 1-6 workdays to measure worktime with forward bending (>30° and >60°) and body positions. The first event of LTSA (>6 consecutive weeks) over a 4-year follow-up were retrieved from a national register. Compositional Cox proportional hazard analyses were used to model the association between worktime with forward bending of the back in an upright body position and LTSA adjusted for age, sex, body mass index (BMI), occupational lifting/ carrying, type of work, and, in an additional step, for leisure time physical activity (PA) on workdays. Results During a mean worktime of 457 minutes/day, the workers on average spent 40 and 10 minutes on forward bending >30° and >60° in the upright position, respectively. Five more minutes forward bending >30° and >60° at work were associated with a 4% 95% confidence interval (CI) 1.01-1.07] and 8% (95% CI 1.01-1.16) higher LTSA risk, respectively. Adjustment for leisure-time PA did not influence the results. Conclusion We found a dose-response association between device-measured forward bending of the back and prospective LTSA risk. This knowledge can be integrated into available feasible methods to measure forward bending of the back for improved workplace risk assessment and prevention.

Brendler-Lindqvist, M., Tondel, M., Helgesson, M., Nordqvist, T., & Svartengren, M. (2022). Overqualification at work and risk of hospitalization for psychiatric and somatic diseases among immigrants in sweden - a prospective register-based study. Scandinavian Journal of Work, Environment & Health, 48(8), 632-640. doi:https://doi.org/10.5271/sjweh.4055

Objectives This study aimed to (i) describe the prevalence of overqualification at work among immigrants in Sweden and (ii) analyze any association between overqualification and the risk of hospitalization for somatic and psychiatric disease among refugees and labor immigrants. Methods We performed a prospective register study in a cohort of 120 339 adults who immigrated to Sweden in 1991-2005 and were employed in 2006. Education-occupation status was defined as the combination of an individual's highest level of education and their occupation skill level. Individuals were followed from 2007 to 2016 with regard to hospitalization for a psychiatric, cardiovascular, respiratory or musculoskeletal disease or diabetes. Hazard ratios (HR) with 95% confidence intervals (CI) were calculated in a multivariate Cox regression analysis adjusted for age, gender, reason for residence and duration of residence. Results The overall prevalence of overqualification among immigrants with an academic education was 39%. Overqualified individuals had an increased risk of hospitalization for any disease (HR 1.33, 95% CI 1.21-1.46) compared to "job-matched with an academic education". However, the risk estimates were lower than that of "job-matched with no academic education" (HR 1.56, 1.46-1.68). The increased risk of hospitalization for a psychiatric disease of overqualified individuals did not differ from that of job-matched with no academic education. Conclusion Our study showed that being overqualified was associated with poorer health outcomes than jobmatched individuals with an academic education. Considering the high prevalence of overqualification in immigrants, this constitutes a concern, for both society and individuals.

Bonde, J. P. E., M.D., Sell, L., PhD., Jensen, J. H., PhD., Begtrup, L. M., PhD., Flachs, E. G., PhD., Jakobsson, K., PhD., . . . Tøttenborg, S. S., PhD. (2022). Occupational risk of COVID-19 across pandemic waves: A two-year national follow-up study of hospital admissions. Scandinavian Journal of Work, Environment & Health, 48(8), 672-677. doi:https://doi.org/10.5271/sjweh.4056

Objective Assuming that preventive measures to mitigate viral transmission of SARS-CoV-2 at the workplace may have been improved in the course of the COVID-19 pandemic, we examined the occupational risk of COVID-19 related hospital admission across the four pandemic waves in Denmark between week 8, 2020, and week 50, 2021. Methods The study included 4416 cases of COVID-19 related hospital admissions among 2.4 million Danish employees aged 20-69 with follow-up in 2020 through 2021. At-risk industrial sectors and a reference population were defined a priory by a job-exposure matrix on occupational risk for COVID-19. Incidence rate ratios (IRR) and potential effect modification by pandemic wave were computed with Poisson regression adjusted for demographic, social and health factors including completed COVID-19 vaccination. Results We observed an overall elevated relative risk in four of six at-risk industrial sectors, but the pandemic wave only modified the risk among healthcare employees, where the excess risk from a high initial level declined to background levels during the latest waves in models not adjusting for COVID-19 vaccination. In social care, education and transport, the elevated risk was not modified by pandemic wave. Conclusion Danish healthcare employees were to some extent protected against occupational transmission of SARS-CoV-2 during the two last pandemic waves even though the absolute risk conferred by occupation may not have been eliminated. Early vaccination of this group seems not to be the only explanation. The risk in other sectors remained elevated indicating a need to revisit preventive measures.

Badarin, K., M.Sc, Hemmingsson, T., PhD., Almroth, M., PhD., Falkstedt, D., PhD., Hillert, L., M.D., & Kjellberg, K., PhD. (2022). Does a change to an occupation with a lower physical workload reduce the risk of disability pension? A cohort study of employed men and women in sweden. Scandinavian Journal of Work, Environment & Health, 48(8), 662-671. doi:https://doi.org/10.5271/sjweh.4053.

Objective This study aimed to examine if a change to an occupation with a lower physical workload reduces the risk of all-cause disability pension (DP) and musculoskeletal DP (MDP). Methods The sample comprised 359 453 workers who were registered as living in Sweden in 2005 and aged 44-63 in 2010. Exposure to physical workload was measured from 2005-2010 by linking a mean value from a job exposure matrix to occupational codes. The mean values were then split into quartiles. All included participants had high exposure to physical workload (top quartile) from 2005-2007. A change in physical workload was measured as a change to (i) any lower quartile or (ii) medium-high or low quartiles from 2008-2010. DP cases were taken from register data from 2011-2016. Crude and multivariate Cox proportional-hazards regression models estimated sex-specific hazard ratios (HR) with 95% confidence intervals (CI). Results Compared to workers with consistently high physical workload, a change to any lower quartile of physical workload was associated with a decreased risk of all-cause DP (men: HR 0.59, 95% CI 0.46-0.77, women: HR 0.63, 95% CI 0.52-0.76) and MDP (men: HR 0.52, 95% CI 0.31-0.89, women: HR 0.61, 95% CI 0.44-0.84). Older workers had the largest decreased risk for MDP. Generally, changing from high to low physical workload was associated with a greater reduced risk of DP than changing from high to medium-high physical workload. Conclusion Changing to an occupation with lower exposure to physical workload was associated with reduced risks of DP and MDP among both sexes.

Cherrie, M., PhD., Rhodes, S., M.Sc, Wilkinson, J., PhD., Mueller, W., M.Sc, Nafilyan, V., PhD., Van Tongeren, M., PhD, & Pearce, N., PhD. (2022). Longitudinal changes in proportionate mortality due to COVID-19 by occupation in england and wales. Scandinavian Journal of Work, Environment & Health, 48(8), 611-620. doi:https://doi.org/10.5271/sjweh.4048