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# Exploring multidimensional operationalizations of precarious employment in Swedish register data – a typological approach and a summative score approach

Jonsson, J [1] ; Matilla-Santander, N; Kreshpaj, B; Orellana, C; Johansson, G; Burström, B; Alderling, M; Peckham, T; Kjellberg, K; Selander, J; Östergren, P-O; Bodin, T [1] Unit of Occupational Medicine, Institute of Environmental Medicine, Karolínska Institutet, Solnavägen 4, 11365 Stockholm, Sweden



## ABSTRACT (ENGLISH)

Objectives This study aimed to explore multidimensional operationalizations of precarious employment (PE) in Swedish register data using two approaches: (i) a typological approach and (ii) a dimensional, summative scale approach. It also examined the distribution of sociodemographic and occupational characteristics of precarious employees in Sweden. Method Register data was retrieved on individuals and their employers in the Swedish workforce. Five items corresponding to three dimensions of PE were operationalized: contractual relationship insecurity, contractual temporariness, multiple jobs/sectors, income level, and lack of unionization. First, latent class analysis was applied and a typology of six employment types emerged. Second, a summative scale was constructed by scoring all PE-items. Results Three types of PE were found using the typological approach, which were characterized by direct employment, solo self-employment and multiple job holding, respectively. The summative scale score ranged between -10 and +2 (average: -1.8). Particularly poor scores were seen for solo self-employed, multiple job holders/multiple sectors, and low income. Female gender, young age, low education and foreign origin were prone to precariousness. PE was more frequent among certain economic sectors and occupations. Conclusions Using an existing register of labor market data, two operationalizations of PE were constructed and rendered promising for exposure assessment. Hence, the operationalizations could be of interest for countries with similar data structure. Both approaches highlighted precarious combinations of employment conditions and pointed towards the existence of a wide continuum of precariousness on the labor market. Etiological studies and research assessing trends over time are needed to validate these findings.

## FULL TEXT

### Headnote

This paper presents items of precarious employment (PE) operationalised as a summative scale and an employment typology using register-based labour market data. Three PE types, as well as a wide range of summative scale scores indicating precariousness, were found. Sociodemographic characteristics often found overrepresented in PE were confirmed, and new perspectives on some of these are given.

Key terms: employment condition; employment quality; epidemiology; nonstandard employment; occupational health; precarious employment; register data; summative score approach; typological approach

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Conclusions Using an existing register of labor market data, two operationalizations of PE were constructed and rendered promising for exposure assessment. Hence, the operationalizations could be of interest for countries with similar data structure. Both approaches highlighted precarious combinations of employment conditions and pointed towards the existence of a wide continuum of precariousness on the labor market. Etiological studies and research assessing trends over time are needed to validate these findings.
Key terms employment condition; nonstandard employment; employment quality; epidemiology; occupational health.
Precarious employment (PE) is recognized as a multidimensional construct encompassing several aspects of employment conditions, including lack of protective regulation, short/uncertain employment duration, lack of fringe benefits and poor wages (1-6). Yet, no internationally accepted definition transcending historical and socio-political contexts currently exists (5, 6). In addition, unidimensional measures such as type of employment [eg, (7-9)] are still widely applied to operationalize PE in epidemiological research. However, unidimensional indicators do not fully capture the extent of precariousness, limiting our ability to monitor the prevalence, distribution and health effects of PE (10). In order to move towards a more comprehensive operationalization, several efforts have been dedicated to developing multidimensional PE measures. This has been done using both typological measurement approaches, where employment sharing certain features are grouped together (11-14), and dimensional approaches, through scales (4, 15) and indices (16), in which PE is represented on a continuum from low to high.
Despite significant interest in this area, several limitations are present in prior studies using multidimensional PE measures. For one, the self-employed are often not included, despite the fact that these workers lack many of the rights and protections of regular employees. Solo self-employed can be considered particularly vulnerable in regards of income and job insecurity, as well as in terms of economic pressures and downturns (17, 18). Further, many previous operationalizations have relied primarily on survey data, such as Europe-wide surveys like the European Working Conditions Survey (EWCS) (11, 12, 14) and the European Labor Force Survey (EU-LFS) (18), as well as country-specific surveys from, for example, Canada (16, 19), the US (13), Spain (4, 20), and Sweden (15, 21). Drawing conclusions from survey samples involves risk of bias. Under- and overcoverage in sampling frames, high proxy rates (22), and non-response rates (22, 23) have been reported for the EU-LFS (22) and the EWCS (23). Also, there have been reports of decreasing response rates and other sources of bias in national surveys within Sweden (24-26).
Alternatively, Sweden and other Nordic countries have comprehensive register structures containing several linkable population-based registers with detailed data on employees (including the self-employed) and employers. Register-based operationalizations of PE would circumvent some of the challenges of surveybased research and could also provide a more precise picture of the sociodemographic and occupational characteristics over-represented in PE conditions. Further, studies that researchers struggle with could be enabled, such as surveillance of the PE population and longitudinal studies of various social and health effects of PE, particularly if both a typological and dimensional approach could be explored and applied in epidemiological research.

## Objectives

The objective of this study was to explore multidimensional operationalizations of PE in Swedish register data using two approaches (i) a typological approach and (ii) a dimensional, summative scale approach. We also aimed to examine the distribution of sociodemographic and occupational characteristics of precarious employees in Sweden.

## Method

### Data and data collection

Register data was collected from the Longitudinal Integrated Database for Health Insurance and Labour Market Studies (LISA) for the year 2014. LISA is held by Statistics Sweden and covers the population of Sweden from the age of 15 onwards; it is updated annually and includes both individual- and employer-level data (27).

Individual-level data was retrieved on age (18-24; 25-34; 35-44; 45-54; 55-65 years), gender (female; male), highest completed education (primary school; secondary school; tertiary education <2 years; tertiary education >3 years), country of birth (Sweden; born in a Nordic country; born in EU-28; born outside EU-28), occupation, income (annual salary from employer; annual income from other work-related sources), income from unemployment insurance and study compensation (yes; no). Data was further collected on individuals' employers, including reference employer (largest source of income in November) and primary, secondary and tertiary employers (largest to third largest source of income during the year), economic sector (grouped in 10 and 15 categories), number of employees in the company (1; 2-5; 6-10; 11-50; 51-100; >100) and ownership sector (private; public). Reference employer was also retrieved for year 2012 and 2013. Individuals were linked across years with the use of an (anonymized) identification number replacing the unique Swedish personal identification number.

### Study population

In 2014, LISA included 6 728 752 individuals. Individuals were included in the study if they were alive and residing in Sweden at the end of the year, had at least one employer, a registered work-related income, and were 18-65 years of age. Individuals with missing values in any of the items required for the PE operationalizations were excluded. The final study population was 4 349 322 (supplementary material www.sjweh.fi/show_abstract.php?abstract_id=3928, figure S1).

### Procedure

Conceptual framework of PE. Operationalization of PE was based on a review by Kreshpaj et al (6) who identified three dimensions and nine themes of PE: (i) employment insecurity, including items of contractual relationship insecurity (contract with employer or with other party, eg, agency or self-employed), contractual temporariness (permanent or fixed-term contract), underemployment (full-time or part-time contract) and multiple jobs and/or multiple jobs in multiple economic sectors; (ii) income inadequacy, including income level (low hourly wage, monthly income or annual income); and (iii) lack of rights and protection, including lack of unionization (representation at the work place), lack of social security (social support/benefits), lack of regulatory support (labor policies) and lack of work place rights (actual and/or power to exercise work place rights).

Operationalization of PE. A total of five items representing all three dimensions were found to be operationalizable (table 1). Income level was operationalized in two steps. First, the total estimated annual salary (before taxes) was estimated by summing up work-related income sources, ie, salary, income from business, work-related social insurance benefits (parental benefits, sickness benefits and related sources) and unemployment benefits. In order to estimate the full annual salary (100%), the social insurance and unemployment benefits were multiplied by 1.25 as these are paid out in approximately 80% of the monthly salary (28, 29). This estimation was done so that the emerging income level was not affected by temporary absences, such as parental leave, sickness absence or unemployment. Second, the estimated annual salary was categorized based on the median salary of the population meeting the inclusion criteria of 2014 (325 400 Swedish krona): <60%, 60-79%, 80-119%, 120-199% and >200% of the median. The <60% cut-off was chosen in order to account for individuals living at risk of poverty (30).

Further, union coverage was operationalized as the approximate likelihood of being covered by a collective bargaining agreement (CBA) at the company level. Likelihood of coverage was calculated as the probability of certain groups being covered by occupational pension, using data from the Swedish Social Insurance Inspectorate (31). CBA coverage was estimated by multiplying the probabilities reported for company size, ownership sector and economic sector (15 categories), stratified by gender. Public sector employees were considered 100% covered by CBA, and solo self-employed were considered 0% covered. See details in supplementary table S1.

Constructing an employment typology. Latent class analysis (LCA) was applied in order to extract clusters -

employment types - from the data. First, the LCA was run on an exploratory dataset containing half of the sample. The initially best cluster solutions were chosen based on plotting Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Thereafter, test statistics for relative fit and measures of classification diagnostics were compared. The former included AIC, BIC, and sample-size adjusted BIC (SABIC). The latter included entropy and average posterior probabilities. Furthermore, conditional item probabilities (ie, the likelihood of endorsing items given a specific class membership) and latent class homogeneity and separation (observed versus expected probability ratio) were inspected in order to find the most informative solution. Second, a cross-validation was conducted on the calibration data set (ie, the other half of the sample). Finally, the chosen cluster solution was run for the full dataset. See supplementary table S2 for details on the exploratory and confirmatory solutions.

A six-cluster solution was chosen as the best fit. According to AIC, BIC and SABIC, a seven-cluster solution was the best, while the entropy and average posterior probabilities were slightly better for four- and five-cluster solutions. However, importantly, when comparing the unique high conditional item probabilities, a six-cluster solution resulted in more distinct clusters. Conditional item probabilities for the six-cluster solution are shown in table S3. Labels were assigned to each cluster by inspecting conditional item probabilities and confirmed by assessing the distribution of sociodemographic characteristics across employment types.

Constructing a summative scale. Levels of PE items were scored based on their relative deviation from the "standard" level on an ordinal scale (where applicable). Standard levels - ie, direct employment, stable employment, one job, median salary and >90% CBA coverage - were scored as 0, while lower and higher scores were given for deviations from the standard levels (-2 to +2). See scoring of PE items in table 2.

For low earners, holding multiple jobs and frequently changing employer could reflect a weak position on the labor market, whereas the reverse could be true for high earners whose skills are in high demand. For these workers, such as successful freelancers/consultants, multiple jobs could allow for skill acquisition, receiving additional credentials or moving into a new occupation (32), off-setting detrimental impacts of short job tenure or being self-employed. Hence, to reduce misclassification, positive scores were introduced for those in the highest income categories. All items received the same weight, consistent with previous studies constructing scales of PE (11, 16).

Further statistical analysis

LCA modelling was conducted for the sample excluding students in order to detect the potential effects of this group. Descriptive tables and figures were created for the total population and stratified per employment type (using modal assignment, ie, most likely cluster). In order to compare the resulting typology and summative scale, both measures were described in terms of characteristics considered especially relevant for PE, including gender, age, level of education, country of birth, occupation (where applicable) and economic sector (2, 11, 14). Finally, the proportion of each employment type falling below the 25th percentile of the summative score for the total population was calculated to identify the most precarious population. LCA modelling was conducted in Mplus version 8.4 (33), and data management and descriptive statistics were performed with SAS, version 9.4 (SAS Institute, Cary, NC, USA).

Ethical considerations

The Regional Ethics Committee of Stockholm approved this study (2016/2325-31).

Results

Employment typology

Of the six emerging employment types, three were considered non-precarious and three were considered precarious, as reflected by their labels. The non-precarious employment types were labelled (i) "standard employment relationship" (SER-type; 60%), characterized by large proportions of direct and stable employment, one employer, median income and high CBA coverage; (ii) "business owners" (2%) that were non-solo selfemployed with one job, stable employment, medianto-high income and moderate CBA coverage; and (iii) proficrnns (10%) mainly in direct employment, either stable or unstable, in multiple jobs/multiple sectors, with high income. The three precarious employment types were labelled (i) "PE relationship" (PER-type; 22%), characterized by large proportions of direct- and agency-employment, unstable employment, multiple jobs/multiple sectors, and poor income; (ii) "precarious self-employment" (5%) with large proportions of solo self-employment, one job, poor income

and low CBA coverage; and (iii) "precarious multiple job holders" (2%), being in combined employment (employment and self-employment), with multiple jobs in multiple sectors, poor-to-median income and low CBA coverage. Further rationale for the labels is provided in table S4. Descriptive statistics for the PE items by employment type are presented in table 3. Excluding students did not affect the interpretation of the typology (data not shown).

Summative scale

The overall summative score ranged between -10 and +2 with an average of -1.8. In particular, agency employment (-4.2), solo self-employment (-5.3), unstable employment (-4.1), multiple jobs in multiple sectors (-4.1), income <60% of the median (-5.1) and CBA coverage <70% (-4.8) were associated with poor scores (see table 3). Approximately 25% of the total population scored 0. The SER-type had the highest score with an average of -0.3, while the business owners and proficians had scores of -1.9 and -2.0, respectively. The PERtype, precarious self-employed and precarious multiple job holders had the lowest scores with averages of -4.7, -4.9, and -6.1, respectively. See the score distribution in figure 1.

The 25th percentile of the summative score for the total population was -4. Only 0.4% of the SER type, and 5.3% and 11.8% of the business owners and proficians, respectively, had scores below -4. Meanwhile 81.5%, 80.4% and 95.7% of the PER-type, precarious self-employed and precarious multiple job holders, respectively, were captured by the lowest quartile (data not shown).

Sociodemographic and occupational characteristics

Sociodemographic characteristics are presented in table 4. Compared with the SER-type, the PER-type had a greater proportion of women (53% versus 50%), 18-24 year-olds (34% versus 4%) and individuals working within sectors of accommodation and food services (9% versus 2%) and professional, scientific and technical activities (16% versus 9%). Additionally, the PER-type had comparatively less individuals with tertiary education >3 years (18% versus 28%) and individuals born in Sweden (79% versus 86%). The most common occupational groups of the PER-type included food preparation assistants (49%), agriculture laborers (46%) and sales and services workers (35%), in contrast with occupations of armed forces (85-86%) and banking, financial and insurance managers (84%) for the SER-type. See Figure S2a-b. The average summative scale scores within occupations were substantially lower for the PER-type, compared to the SER-type, for every occupation displayed.

The precarious self-employment type was characterized by high proportions of males (67% versus 50% in the SER-type), 55-64 year-olds (29% versus 22%) and individuals with elementary education (17% versus 9%), as well as comparatively more individuals from the arts, entertainment and recreation (15% versus 3%) and construction sectors (15% versus 6%). This employment type also had less individuals born in Sweden (79% versus 86%).

The precarious multiple job holders had a large proportion of males (62%, compared with 50% of the SER-type), while age was similarly distributed among the employment types. In addition, there was a slightly larger proportion of <2 year tertiary education (19% versus 15%), and a slightly smaller proportion of >3 year tertiary education (24% versus 28%). Work was mainly carried out in the private ownership sector (98% versus 59%), within sectors of professional, scientific and technical activities (22% versus 9%) and agriculture (9% versus 1%).

In accordance with the precarious employment types, the lowest average summative scores were found among women (-1.9), 18-24 year-olds (-4.2), individuals with primary school education (-2.4), foreign-born outside the EU-28 (-2.4), students (-4.8), private ownership sector workers (-2.2), as well as within certain economic sectors, especially agriculture (-4.3), accommodation and food service (-4.3), and arts and entertainment (-3.5).

Discussion

Key results

Typological approach. In summary, we found three types of PE using a typological measurement approach: one in employment (22%) (PER), one in solo self-employment (5%), and one holding multiple jobs in combinationemployment (2%). The size of the PER-type (as well as all precarious types taken together) and the SER-type were in the range of other estimates (11, 34, 35).

The employment types characterized by self-employment and multiple job holding represent a novel aspect of this study. A study by Peckham et al (13) conducted in the US and a study by Gevaert et al (14) using data from the

EWCS applied the construct of employment quality and identified two and four types of self-employed, respectively, in their typological measurement approaches. In both the US and European analyses, insecure selfemployed types emerged, although these are not entirely comparable to types of precarious self-employment and multiple job holders reported here. This is in part because the employment quality concept extends the concept of PE as well as the fact that neither the US nor European analyses accounted for combined employment. Both our study and the European one, however, indicate that the number of employees of self-employed is an important indicator in distinguishing between different forms of self-employment. Our study also suggests that combined employment is a useful indicator.

Summative scale approach. The average of the summative scale score was -1.8, with approximately 25% of the total population scoring 0. In this approach, 0 represents standard employment conditions in all dimensions with the possibility of receiving 1-2 additional points for incomes >120% of the median. The negative overall average score was therefore expected. Others have developed PE scales, the most notable being the Employment Precariousness Scale (4) and the Employment Precarity Index (16). The index identified precarious conditions by the upper quartile, while studies applying the Employment Precariousness Scale successfully implemented the use of tertiles, quartiles and quintiles in relation to health outcomes and social consequences (36-38). Suitable cut-offs to determine PE for the present scale will have to be determined in future studies, but the lowest quartile captures the majority of the precarious employment types identified in our data.

Sociodemographic and occupational characteristics of precarious employees

Previous studies have indicated that workers with PE arrangements are predominantly female and young (2, 17, 37). In the current study, women had a slightly poorer average summative score than men and were in slight majority in the PER-type. Young individuals were more clearly overrepresented in the PER-type and by low scores. By including the self-employed in our analysis, we provide a nuanced picture of PE in the Swedish context. Importantly, we show that many men and older age groups experience PE, but that the character of precariousness might differ between genders and age. Women and young might be overrepresented in terms of more "traditional" precariousness, ie, more often characterized by direct, but unstable, employment in certain economic sectors and occupations. Meanwhile men and older ages might be overrepresented in precarious selfemployment and precarious multiple job holding. The previous has been supported by Gevaert et al (14).

As expected, foreign-born individuals showed lower summative scores as compared to native Swedes, and were overrepresented in the PER and precarious selfemployment types. The precariousness of foreign-born, recent immigrants and racialized workers has been reported by others (17), pointing towards an ethnicization of the precarious work force. In Sweden, foreignborn are more often self-employed, which reportedly is due to the lack of employment options, while Swedishborn more often combine employment with self-employment (34). The latter is evident when comparing the proportion of Swedish-born among precarious multiple job holders and precarious self-employed. Finally, low education was found to be prevalent among the precarious, especially for the PER and precarious self-employment types, in accordance with previous reports (2, 14, 17).

Economic sectors and occupations with low summative scale scores found in this study is partly confirmed by a Eurofund report constructing employment types and scores of employment quality (11). The report found low scores for agriculture grouped together with mining and quarrying (although the latter received high scores in this study), transportation and storage, and wholesale and retail. In our study, elementary occupations (eg, food preparation assistants), skilled agricultural workers, and service and sales workers received low scores. These occupations were also prevalent within the precarious employment types identified by Eurofund, as well as other studies using Canadian data (17).

Consistency of employment types and summative scale score

Cross-checking the summative scores and the employment types by comparing the proportion of each type falling under the lowest quartile of the total score, confirms that the lowest quartile captures the majority of all precarious types. Further, sociodemographic groups known to be associated with employment precariousness were overrepresented in the precarious employment types - especially the PER-type - and generally received lower

scores. This indicates that the employment types and the scores are consistent and that both capture PE.

Strengths and weaknesses of the two approaches

Both methods find strength in that they are based on a solid theoretical and empirical foundation and thus easily interpreted, despite the underlying multidimensionality. The typological approach has an additional strength in that it provides a nuanced picture of how multiple employment conditions cluster together. In that sense, the typological approach provides an opportunity to identify various types of PE and, thereby, expands our understanding of how PE can take expression. The summative score approach provides no insight as to which dimensions or items contribute to the final score. The scoring approach, however, provides a continuum of precariousness, which is an advantage when comparing and identifying degrees of PE. As employment types are not ordinal, they cannot be easily graded or ranked. The typological approach, on the other hand, gives an idea of the size of the workforce that can be considered precariously employed, which is not straightforward in the summative scale approach unless a cut-off score representing PE is decided upon. Another strength of the scoring approach, however, is that it is easily applicable and comparable across time, whereas the number and interpretation of emerging employment types could change among years. Hence, latent class approaches for longitudinal or repeated measures data could instead be applied if multiple years are to be analyzed (39).

A strength of this study is the use of register data, which, unlike survey data, provide objective measures of employment conditions across the entire Swedish work force (including self-employed workers). Further, register data provides opportunities to explore operationalizations of PE across time, sociodemographic and occupational correlates, and a range of register-based outcomes. There are, however, limitations to this study.

There is no formal validation of the typology or summative scale included. However, comparison of scores with employment types and vice versa, supports internal consistency. The sociodemographic and occupational characteristics, as well as the proportions of the precarious employment types falling within the lowest quartile of the summative scale score, supports that both approaches are identifying a similar population.

The register data used did not take informal workers into account. Reports, however, show that approxi- mately 3% of workers in Nordic countries were informal in 2009, which is among the lowest worldwide (34). Further, not all aspects of PE could be optimally operationalized due to the lack of available data. Our items of CBA coverage was based on the probability of receiving occupational pension from the employer, which probably overestimates CBA coverage slightly. Finally, the temporal resolution of one year introduces risk of misclassification in the temporariness and multiple job holding items. Despite these limitations, our study suggests that future research on PE should consider innovative uses of register data.

Generalizability

Our approach to operationalizing PE could be applied in countries with similar register structure. As political and macroeconomic changes affect the labor market, the emerging typology and score distribution could vary across years. Therefore, studies examining trends over time are needed. We consider both approaches to operationalizing PE to have substantial potential for uses in exposure assessment within epidemiological studies applying register-based outcome measures.

Concluding remarks

Using the typological approach to operationalize PE identified three types of precarious employment. These provided insight into how precariousness can take expression - in direct employment, solo self-employment or in combined employment (multiple job holding). The scoring approach pointed towards a wide continuum of precarious conditions on the labor market. Gender, age, education and foreign-born status were associated with PE. This was especially notable across age and gender, suggesting that stratified analyses may be appropriate in future studies. Both approaches are promising in terms of exposure assessment: the typological approach being most useful when the experience of different combinations of employment conditions is important; and the summative score approach being most useful when the degree of precariousness is of importance. Etiological studies and research assessing trends over time are needed in order to validate these operationalizations. Register-based operationalizations in countries with similar register structure are encouraged in order to increase international comparability.

## Sidebar

Refers to the following texts of the Journal: 2018;44(4):341-350 2019;45(5):429-443 2020;46(3):321-329 2020;46(3):235-247

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Additional material

Please note that there is additional material available belonging to this article on the Scandinavian Journal of Work, Environment &Health -website.

Correspondence to: Johanna Jonsson, Unit of Occupational Medicine, Institute of Environmental Medicine, Karolinska Institutet, Solnavägen 4, 11365 Stockholm, Sweden. [E-mail: johanna.jonsson@ki.se]

## Footnote

1 Unit of Occupational Medicine, Institute of Environmental Medicine, Karolínska Institutet, Stockholm, Sweden.

2 Center for Occupational and Environmental Medicine, Stockholm Region, Stockholm, Sweden.

3 Equity and Health Policy Research Group, Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden.

4 Centre for Epidemiology and Community Medicine, Stockholm Region, Stockholm, Sweden.

5 Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, USA.

6 Social Medicine and Global Health, Department of Clinical Sciences Malmö, Lund University, Malmö, Sweden.

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# Working conditions and health behavior as causes of educational inequalities in self-rated health: an inverse odds weighting approach

Schram, J L D; Groeniger, J Oude; Schuring, M; Proper, K I; van Oostrom, S H; Robroek, S J W; Burdorf, A



## ABSTRACT (ENGLISH)

The novel causal mediation approach 'inverse odds weighting' showed that working conditions and health behaviors accounted for more than half of the educational inequalities in self-rated health. Preventive interventions focusing on improving working conditions and health behavior among lower educational groups may contribute to reducing these educational inequalities in self-rated health. Objective Using a novel mediation method that presents unbiased results even in the presence of exposuremediator interactions, this study estimated the extent to which working conditions and health behaviors contribute to educational inequalities in self-rated health in the workforce. Methods Respondents of the longitudinal Survey of Health, Ageing, and Retirement in Europe (SHARE) in 16 countries were selected, aged 50-64 years, in paid employment at baseline and with information on education and self-rated health (N=15 028). Education, health behaviors [including body mass index (BMI)] and working conditions were measured at baseline and self-rated health at baseline and two-year follow-up. Causal mediation analysis with inverse odds weighting was used to estimate the total effect of education on self-rated health, decomposed into a natural direct

effect (NDE) and natural indirect effect (NIE). Results Lower educated workers were more likely to perceive their health as poor than higher educated workers [relative risk (RR) 1.48, 95% confidence interval (CI) 1.37-1.60]. They were also more likely to have unfavorable working conditions and unhealthy behaviors, except for alcohol consumption. When all working conditions were included, the remaining NDE was RR 1.30 (95% CI 1.15-1.44). When BMI and health behaviors were included, the remaining NDE was RR 1.40 (95% CI 1.27-1.54). Working conditions explained 38% and health behaviors and BMI explained 16% of educational inequalities in health. Including all mediators explained 64% of educational inequalities in self-rated health. Conclusions Working conditions and health behaviors explain over half of the educational inequalities in selfrated health. To reduce health inequalities, improving working conditions seems to be more important than introducing health promotion programs in the workforce.

## FULL TEXT

### Headnote

The novel causal mediation approach 'inverse odds weighting' showed that working conditions and health behaviors accounted for more than half of the educational inequalities in self-rated health. Preventive interventions focusing on improving working conditions and health behavior among lower educational groups may contribute to reducing these educational inequalities in self-rated health.

Key terms: causal mediation; educational inequality; health behavior; inverse odds weighting; longitudinal analysis; mediation analysis; self-rated health; socioeconomic inequality; working condition

Objective Using a novel mediation method that presents unbiased results even in the presence of exposuremediator interactions, this study estimated the extent to which working conditions and health behaviors contribute to educational inequalities in self-rated health in the workforce. Methods Respondents of the longitudinal Survey of Health, Ageing, and Retirement in Europe (SHARE) in 16 countries were selected, aged 50-64 years, in paid employment at baseline and with information on education and self-rated health (N=15 028). Education, health behaviors [including body mass index (BMI)] and working conditions were measured at baseline and self-rated health at baseline and two-year follow-up. Causal mediation analysis with inverse odds weighting was used to estimate the total effect of education on self-rated health, decomposed into a natural direct effect (NDE) and natural indirect effect (NIE). Results Lower educated workers were more likely to perceive their health as poor than higher educated workers [relative risk (RR) 1.48, 95% confidence interval (CI) 1.37-1.60]. They were also more likely to have unfavorable working conditions and unhealthy behaviors, except for alcohol consumption. When all working conditions were included, the remaining NDE was RR 1.30 (95% CI 1.15-1.44). When BMI and health behaviors were included, the remaining NDE was RR 1.40 (95% CI 1.27-1.54). Working conditions explained 38% and health behaviors and BMI explained 16% of educational inequalities in health. Including all mediators explained 64% of educational inequalities in self-rated health. Conclusions Working conditions and health behaviors explain over half of the educational inequalities in selfrated health. To reduce health inequalities, improving working conditions seems to be more important than introducing health promotion programs in the workforce.

Key terms causal mediation; longitudinal analysis; mediation analysis; socioeconomic inequality.

Reducing educational inequalities in health is one of the main challenges for public health (1, 2). Various studies have identified potential determinants of educational inequalities in morbidity and mortality by examining mediating factors that explain the association between education and health (1, 3, 4). Many explanations have been presented, ranging from behavioral risk factors and subjective economic status to material and occupational factors (1, 5-7). People with a low educational level have a poorer self-rated health than those with a high educational level. In the European Union, 56% of people with low education were in very good or good self-rated health, compared to 80% of the high educated in 2018 (8). Poor working conditions and unhealthy behaviors are more prevalent in lower compared to higher socioeconomic groups (9-11) and are associated with poor health (12-14). Previous studies have estimated that these factors may explain approximately two thirds of the association between socioeconomic position and self-rated health (13). A recent review summarized that work factors explained about one third of

socioeconomic inequalities in self-rated health and health behavior about one fifth (6).

To determine to what extent risk factors contribute to educational inequalities in health, studies have mainly used traditional approaches to mediation analysis, primarily the so-called 'difference method' (15-17). This method assesses mediation by estimating the reduction in the excess (health) risk of lower educational groups compared to the highest educational group after conditioning on the mediator(s). This approach, however, is only valid in linear models under the assumption that there is no interaction between the exposure and mediator on the outcome (18, 19). Several studies have shown that this crucial assumption is often violated (18), also in studies on socioeconomic inequalities in health (15, 20, 21).

Counterfactual or causal mediation analysis bypass the need to rely on this assumption but are still rarely utilized in observational studies (22). This may be related to a lack of flexibility of current causal mediation methods, such as limitations to include multiple mediators (23). Recently, Tchetgen introduced the inverse odds weighting (IOW) approach to estimate natural direct and indirect effects (NDE and NIE), which accommodates effect decomposition with multiple mediators (regardless of their scale), even in the presence of exposure-mediator interactions and nonlinearities (24). Because it is likely that the effect of an unhealthy lifestyle and working conditions on health is different for low compared to high educated persons (3, 25, 26), this study utilizes the IOW approach to estimate to what extent educational inequalities in self-rated health are mediated by working conditions and health behavior.

## Methods

### Data

The study population consisted of participants of the Survey of Health, Ageing, and Retirement in Europe (SHARE),a longitudinal study that collects health, social, and economic data on the population aged >50 years every two years. It started in 2004 and 2005 in 11 European countries (Sweden, Denmark, the Netherlands, Belgium, Germany, Austria, Switzerland, France, Italy, Spain and Greece) (27). In 2006, the Czech Republic, Ireland and Poland joined and, in 2010, Estonia and Slovenia. The SHARE sampling design varied in the participating countries, ranging from random selection of households to multistage designs, due to various institutional settings. Details on data collection, comparability of data, and response levels are provided by the official SHARE documentation found at www.shareproject.org/data-documentation.html.

For this study, given different periods of enrolment in the SHARE study, respondents who participated in at least two consecutive waves were selected if they were aged 50-64 and employed at the first wave and had information on self-rated health in the subsequent wave. The upper age range was chosen to focus on age groups with substantial participation in paid employment. Five waves were used for the analysis and the total sample included 15 028 respondents. For a division per country and wave, see the supplementary material (www.sjweh.fi/show_abstract.php?abstract_id=3918) table S1. All data were self-reported.

### Self-rated health

The outcome of this study was self-rated health for which a single item question was used. Respondents could indicate whether their health was excellent, very good, good, fair or poor. Self-rated health was dichotomized into 'less than good' (poor or fair) and 'good ' (good, very good or excellent) (28).

### Educational level

Highest level of education was coded according to the 1997 International Standard Classification of Education (ISCED-97) and categorized into low (0-2: pre-primary, primary and lower secondary education), intermediate (3-4: upper secondary education/post-secondary nontertiary) and high (5-6: tertiary education).

### Body mass index (BMI) and health behaviors

BMI was calculated by dividing body weight in kilogram by the square of body height in meters. BMI was categorized into normal weight (<25 kg/m2), overweight (>25-<30 kg/m2), and obese (>30 kg/m2). Smoking status was measured with two questions and categorized into three categories: non-, former, and current smoker (27). Alcohol consumption was based on the number of days per week participants drank alcohol during the last three months (in wave 1 during the last six months): <1 day, 1-2 days (reference category), 3-4 days, 5 days per week (29). In our analyses, BMI is included in health behaviors.

Working conditions

Three variables were included for working conditions: physical job demands, job control, and job rewards. All working conditions were assessed by items derived from the Job Content Questionnaire on the demand-control model (30) and the effort-reward imbalance model questionnaire (31). Physical job demands were measured using a single question: "My job is physically demanding". Individuals who indicated strongly agree or agree were considered to have a physically demanding job. Job control and rewards were included in this study as underlying dimensions of the job demand-control model and effort-reward imbalance since previous research has shown that these factors are more prevalent among workers with a low compared to high educational level, while high job demands are more prevalent among workers with a high educational level (10). Moreover, previous research also showed that low rewards and low job control are the main drivers in the association between job demand-control or effort-reward imbalance and exit from paid employment (32). Job control was measured by using the sum score of two items: (i) "I have very little freedom to decide how I do my work" and (ii) "I have an opportunity to develop new skills". Questions were recoded to ensure that higher values indicate higher physical job demands and lack of job control. Rewards were measured by using the sum score of five items addressing support, recognition, salary/earnings, job promotion prospects, and job security. All items were measured on a 4-point scale ranging from 1=strongly agree to 4=strongly disagree. Questions were recoded to ensure that higher values indicate a lack of rewards.

Following Dragano et al (33), we used the upper country-specific tertile of the scale distribution for lack of rewards and lack of job control. As previous analyses showed that the measures of job control and rewards varied across countries, tertiles were calculated for each country separately (34).

Covariates

Cohabitation was used to categorize individuals into living with a spouse or partner and living alone. Sex was a dichotomous covariate, while age was a categorical variable, divided into three categories 50-54, 55-59 and 60-64 years. Self-rated health at baseline, country and wave were also covariates.

Statistical analysis

Education, health behaviors and working conditions were measured at the first available wave, while selfrated health was measured at baseline and the consecutive wave at two-year follow-up. Since the study population is >50 years, we can reasonably assume that educational attainment has preceded working conditions and health behavior, even though they were measured at the same wave. Missing variables (ranging 0- 3.48%, table 1) were imputed using multiple imputation by chained equations (M=20) (35). Descriptive statistics were used to describe the prevalence of the health behaviors and working conditions in each educational category.

Due to significant interactions between education, job control and job rewards, causal mediation analysis was used to estimate the NDE, NIE, and total effect (TE). The TE of education on self-rated health (comparing low versus high educated and low versus mid educated) was decomposed into the effect occurring through the mediators of interests (NIE) - ie, working conditions and health behaviors - and the effect occurring through other pathways (NDE) (figure 1). The NIE estimates the expected change in self-rated health among low educated persons, if, potentially counter to the fact, the mediators were changed from the level of the low educated to the level of the high educated, with educational level being fixed at low education. The NDE expresses the expected change in educational inequalities in self-rated health if, potentially counter to fact, the individual would change from being low to high educated, but the mediators of interest were kept at the level they would have taken for the high educated (ie, the referent level) (19).

In order to identify the NIE and NDE, four assumptions have to be made: no unmeasured confounding between (i) the exposure and the mediator, (ii) the mediator and the outcome and (iii) the exposure and outcome. Furthermore, (iv) there are no confounders of the mediator-outcome relationship that are itself affected by the exposure (36). The NDE, NIE, and TE were calculated using the IOW approach. In this approach the mediator itself is not entered into the regression model for the outcome but is only used in the construction of a weight. By applying this weight in the outcome model, the exposure and mediator are effectively independent and the indirect pathway involving the

mediator is deactivated (16).

Following Tchetgen Tchetgen (24) and Nguyen et al (16), the mediation analysis consisted of five steps. First, a multinomial logistic model was fitted regressing the exposure (education) on the mediators and covariates. Second, an IOW weight was computed by taking the inverse of the predicted odds from step 1 for each observation. The reference group's weight, either mid or high educated, was set at 1. Third, the NDE was estimated using generalized linear models with a Poisson distribution and log-link function regressing the outcome on exposure and covariates, weighted by the previously calculated IOW weight. Poisson models were used instead of logistic regression models because for common outcomes the odds ratio is non-collapsible, which underestimates mediation effects (16). Fourth, the TE was estimated using a generalized linear model with a Poisson distribution and log-link function regressing the outcome on exposure and covariates (without including the weights). Fifth, the NIE was calculated by subtracting the NDE from the TE. The effect estimates were bootstrapped (1000 repetitions) to derive confidence intervals (CI) for the NDE, NIE and TE.

The steps for the IOW regression were followed for each mediator separately (tables 2 and 3) and all mediators combined (table 4). Self-rated health at baseline, country, age, sex, cohabitation and wave dummies were included as covariates. Finally, a measure of the "proportion mediated" (PM) on the risk ratio (RR) scale was calculated using the equation provided by VanderWeele (37, 38).

Proportion mediated = RRNDE (RRNIE -1) / (RRTe -1)

All analyses were conducted in Stata V15.1 (Stata Corp, College Station, TX, USA).

Sensitivity analysis

We conducted sensitivity analyses to check the robustness of our results. First, analyses were repeated not accounting for self-rated health at baseline (supplementary tables S2, S3, and S4). Second, we repeated the mediation analysis using the traditional difference method (supplementary table S5). Third, the analyses including health behaviors and working conditions as mediators were also separately conducted by European region (supplementary tables S6 and S7), since previous research has shown that educational inequalities in health behavior differs substantially across European regions (eg, north-south gradients for smoking among women) (39).

Results

There was a higher prevalence of less than good health with lower education (table 1). Overweight and obesity were more prevalent among lower educated persons, whereas alcohol use was more common among highly educated persons. Non- and former smokers were more prevalent among higher educated persons. Lower educated persons had poorer working conditions. Physically demanding work and low job control had a stronger social gradient than low job rewards.

Table 2 presents the educational inequalities in selfrated health and impact from health behaviors. Low educated persons reported 1.17-fold (95% CI 1.09-1.25) and 1.48-fold (95% CI 1.37-1.60) higher occurrence of poor self-rated health compared to respectively intermediate and highly educated persons. If low educated persons were to have the BMI or health behaviors of high educated persons, educational inequalities would be still be 1.47-1.49. Table 3 shows the educational inequalities and the impact of unfavorable working conditions. If low educated persons were to have the same physical demanding jobs as high educated, educational inequalities would be reduced to 1.37 (95% CI 1.23-1.51). A similar reduction is shown for lack of job control, while a lack of rewards does not show a reduction in educational inequalities.

If low educated persons were to adopt all health behaviors of high educated persons, educational inequalities in self-rated health would reduce from 1.48 (95% CI 1.37-1.60) to 1.40 (95% CI 1.27-1.54) (table 4). If low educated persons were to have the same working conditions as high educated persons, educational inequalities would reduce from 1.48 to 1.30 (95% CI 1.15-1.44). Furthermore, the estimated reduction in educational inequalities in self-rated health by working conditions was up to 38%, while health behavior explained 16% of the inequalities. Including both working conditions and health behaviors, these factors together explained up to 64% of the educational inequalities in self-rated health.

Sensitivity analysis

Not adjusting for self-rated health at baseline (supplementary tables S2, S3 and S4), working conditions explained 31% (low versus high education: TE 1.82 to NDE 1.57) to 35% (low versus middle education: TE 1.31 to NDE 1.20) of the educational inequalities in selfrated health, while health behavior explained 27% (low versus high education: TE 1.82 to NDE 1.60; low versus middle education: TE 1.31 to NDE 1.22). Together these factors explained 53-54% of the educational inequalities. In the traditional difference method, the estimated mediation effects of low versus high education were similar for working conditions and for health behavior to the results from the IOW approach, while the combined effect differed substantially from the IOW approach (PM 50% versus 64%) (supplementary table S5). Results from separate analyses per European region (supplementary tables S6 and S7), showed that health behaviors contributed more to educational inequalities in the Northern countries compared to the Southern countries (NIE 1.20 and 1.01, respectively), whereas working conditions contributed more in Southern countries than in Northern countries (NIE 1.32 and 0.98, respectively). Supplementary table S8 showed that educational gradients in health behaviors were more pronounced in Northern Europe than in Southern Europe and educational gradients in poor working conditions were greater in Southern Europe than in Northern Europe.

## Discussion

This study showed that unhealthy behaviors and poor working conditions contribute strongly to educational inequalities in older employees' self-rated health. While the separate mediators accounted for a small part of the educational inequalities, combined these mediators accounted for 71% of the educational inequalities in selfrated health comparing low to intermediate educated persons and 64% comparing low to high educated persons.

A systematic review of studies assessing mediators between education and self-rated health suggests that material factors, a wider category including working conditions, contribute more to socioeconomic inequalities than behavioral factors (40). A recent review showed that working conditions explained about one third of the socioeconomic inequalities in self-rated health in the working population, while health behavior accounted for about one fifth (6). Although the range and detail of working conditions in our study is limited and the studies differ in years of follow-up, our results seem to align with this review for working conditions, whereas the contribution of health behavior was slightly smaller in our results. The association between poor working conditions and self-rated health at follow-up remained, even when adjusting for self-rated health at baseline (supplementary table S7). Our results align to previous research when accounting for self-rated health at baseline in the sensitivity analyses, which showed a larger contribution of working conditions to educational inequalities in self-rated health, while the contribution of health behavior decreased.

The majority of research on the contribution of working conditions and health behavior to health inequalities has focused on workers in general with limited longitudinal evidence (6). Specific studies focusing on the older population are scarce and focused on either health behavior (41) or working conditions (42). In a German study, using the German SHARE data, behavioral factors explained 19% of the association between low education and self-rated health (41). In an American study, control at work was important for socioeconomic inequalities in self-rated health, while physical demands were not (42). Our study adds to this by analyzing the influence of working conditions and health behavior simultaneously in a longitudinal dataset, showing that working conditions are of more importance than health behaviors in explaining health inequalities among older workers.

To our knowledge, this paper is the first to use causal mediation analysis to assess the relative contribution of working conditions and health behaviors to educational inequalities in self-rated health within the older working population. The traditional difference method is often employed to assess mediation, but it only gives correct direct and indirect effects under very stringent assumptions (24). The advantage of the IOW method is that it can provide direct and indirect effect estimates, even in the presence of nonlinearities and interactions (24). Because the mediator itself is never entered in the outcome model, but only indirectly through the creation of the weights, exposure-mediation interactions do not have to be specified and fewer modelling assumptions are required (43). As shown in the sensitivity analysis, the results of the analyses comparing persons with a low to those with a high educational level in the IOW approach were in line with the traditional method, although in the traditional method the proportion mediated for the low versus middle educated group is underestimated compared to the IOW approach.

Which method is most appropriate to use will vary from study to study and relies on evaluating the pros and cons of the different approaches. In our study, IOW was most appropriate due to exposure-mediator interactions found in our dataset.

Our results suggest that working conditions are more important than health behaviors in explaining educational inequalities in self-rated health among older workers in Europe. Regional differences are profound. Sensitivity analyses showed that, in northern countries, educational inequalities in health were more strongly affected by health behavior, while in southern Europe working conditions were more important. This implies that policies and interventions to reduce educational inequalities in health are more promising when they are targeted towards reducing unhealthy behaviors in lower educational groups in northern Europe and targeted towards reducing poor working conditions in lower educational groups in southern Europe.

In our study, a large longitudinal dataset with comparable procedures in data collection and study design across countries was used to test the contribution of working conditions and health behavior to educational inequalities in self-rated health. However, the study has some limitations. First, people with good self-rated health were more likely to participate in the study, as in next waves of SHARE, participants were more likely to be in good health (44). This self-selection process may differ across educational levels, and, thus educational inequalities may have been affected. Second, working conditions or health behaviors at earlier life stages were not accounted for, and these may have affected the educational inequalities in self-rated health due to the combined and cumulative effect of risk factors over the life course (45). Third, interpretation of NIE estimates as causal depends on several unmeasured confounding assumptions underlying causal mediation analysis. Although we adjusted for self-rated health at baseline, results could still be biased due to other unmeasured confounders, such as childhood or adolescent health. Fourth, all data were self-reported. Persons reporting poor self-rated health may also tend to report poor working conditions and poor health behavior, leading to reporting bias. Future studies using not just self-reported indicators are needed to conduct similar analyses. Furthermore, the working conditions reported were limited and relatively crude in comparison to surveys that specifically focus on working conditions. Cross-sectional studies have found a larger contribution of working conditions to educational inequalities in self-rated health when including biomechanical and chemical exposures (6). For self-rated health, research has shown it is strongly predictive for objective health measures, such as mortality (46).

Concluding remarks

Our findings show that both strenuous working conditions and, to a smaller extent, unhealthy behaviors contribute to educational inequalities in older employees' self-rated health. This expands the knowledge basis for prevention strategies aiming to reduce socioeconomic inequalities in health.

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Data sharing statement

The SHARE data are publicly available at www.shareproject.org/data-access/user-registration.html. The authors of this manuscript are not authorized to provide data directly to any users.

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**Sidebar**

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1 Department of Public Health, Erasmus Medical Centre Rotterdam, The Netherlands.

2 Department of Public Administration and Sociology, Erasmus University, Rotterdam, The Netherlands.

3 Centre for Nutrition, Prevention and Health Services, National Institute for Public Health and the Environment

(RIVM), Bilthoven, The Netherlands.

Correspondence to: Suzan J W Robroek, Department of Public Health, Erasmus Medical Centre, Rotterdam 3000 CA, The Netherlands. [E-mail: s.robroek@erasmusmc.nl]

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# How qualitative studies can strengthen occupational health research

Boot, C R L [1] ; Bosma, A R [1] Affiliation: Amsterdam UMC, VU University, Amsterdam Public Health Research Institute, Department of Public and Occupational Health, Amsterdam, The Netherlands



## ABSTRACT (ENGLISH)

The Scandinavian Journal of Work, Environment and Health (SJWEH) has a strong reputation in publishing high quality studies using quantitative research methods in the field of occupational health. Studies using qualitative research methods, however, are rarely published in the Journal. Here, Boot and Bosma explain how qualitative studies can contribute to the field of occupational health research and to SJWEH's aim to promote high quality and impactful research in the field of occupational and environmental health and safety and increase knowledge through scientific publications.

## FULL TEXT

### Headnote

Key terms: editorial; occupational health research; qualitative research; qualitative study; quantitative research

The Scandinavian Journal of Work, Environment and Health (SJWEH) has a strong reputation in publishing high quality studies using quantitative research methods in the field of occupational health. Studies using qualitative research methods, however, are rarely published in the Journal. In this editorial, we explain how qualitative studies can contribute to the field of occupational health research and to SJWEH's aim to promote high quality and impactful research in the field of occupational and environmental health and safety and increase knowledge through scientific publications.

SJWEH has its origin in occupational medicine, toxicology and epidemiology, providing answers to questions about causal mechanisms between workplace exposures and health (1). The impact of these causes in the environment on health can be quantified in occupational epidemiological studies. Addressing environmental causes to improve health requires collective action of the (work) environment. Over the years, the field of occupational health - as well as the Journal - has broadened its focus to capture the complex relationship between the larger work environment and health in general (2). The multitude of etiologies of current occupational and environmental health problems requires more complex interventions (3). Studying the impact of human behavior and its interaction with the environment became more important (4). Insights from social sciences are indispensable to understanding human behavior, for example, studying the eating habits of shift workers (5). With this broader focus, research designs other than quantitative ones have emerged, such as qualitative research designs. With its interpretative and inductive approach, qualitative research is aimed at understanding people's experiences, behaviors and interactions by interpreting a subjective and constructed reality, while quantitative research is aimed at investigating and explaining phenomena, assuming an objective reality (6-10). Qualitative research can provide insights about new phenomena, experiences or processes. Furthermore, qualitative research is valuable when the aim is to describe the larger social context in relation to the topic of interest (6). For example, qualitative research could aid in better understanding how workers with, eg, cancer or chronic conditions are successful in staying at or returning to work (11-15). Experience and interpretation of symptoms and limitations can provide information on a wide range of barriers and facilitators of working with chronic conditions that are difficult to capture in quantitative data. Such data can only be retrieved from an in-depth analysis of processes and context.

To better understand the potential of qualitative research, it is helpful to reflect on its historical development, which Pertti Alasuutari comprehensively described (16). Qualitative research developed from an interpretative approach that has its roots in philosophy, anthropology and history and goes back to the nineteenth century (6). Sociologists were the first to systematically apply an interpretative approach for the purpose of scientific research (16). Until then, positivism was the dominant paradigm in science, including in sociology (16, 17). Positivism is a philosophical theory

positing that knowledge is derived from empiricism by taking a reductionist approach (17). In a reductionist approach, (social) reality is reduced to causal chains of predefined variables that are fit into models.
Max Weber (1864-1920) was one of the key pioneers of sociology who criticized positivism in sociology (16). His research focused on norms and values. He proposed an interpretative understanding of actions rather than taking a reductionist or deterministic approach. This is what is now referred to as qualitative research. An interpretative approach is useful to generate new theory.
From the above, it may seem as if the positivism paradigm is used in quantitative research only, but that is not true. Although the inductive approach is most often used in qualitative research, qualitative designs can also be applied to test existing theory by applying a more deductive than inductive approach to verify or falsify theory.
Different study designs can provide complimentary perspectives. Qualitative research is the best choice when the context and its complex interactions with human behavior play an essential role in the studied phenomenon, for example, to understand the nature of relationships between events in their social or economic context or to explore different experiences (eg, 10-13). Qualitative research designs are needed to capture elements that cannot (yet) be captured in numbers but are essential to a better understanding. A mixed-methods design, in which quantitative and qualitative research methods inform and complement each other, has the potential to combine the best of both worlds (eg, 14,18).
For SJWEH, high external validity - generalizability to other contexts - is an important indicator of quality and a strong determinant of acceptance for publication. As qualitative studies aim for a rich description of a specific context, generalization is not an aim of high quality qualitative research. For qualitative studies, external validity depends on transferability to another context. Elements of transferability are the description of the context for the purpose of transferability, a maximum variation in the sample, and comparison with literature (19). In essence, transferability relates to how the knowledge generated in qualitative studies contributes to a better understanding of how the (work) environment affects health. This may comprise new insights into needs or experiences of workers who are facing new problems (eg, 11), perceived barriers related to a complex process (eg, 12), or a better understanding of why a workplace intervention was not as successful as expected (eg, 15).
So how to compose a high quality manuscript of a qualitative study? Not surprisingly, many criteria for high quality studies are similar for both types of research designs, although the operationalization differs. The consolidated criteria for reporting qualitative research (COREQ) 32-item checklist was developed as a qualitative counterpart of the CONSORT statement for quantitative studies (20). The COREQ32 checklist aims to improve the quality of reporting of qualitative studies, and strives for greater recognition of qualitative research to be considered as equal to quantitative research (20). The checklist consists of 32 criteria relating to (i) research team and reflexivity; (ii) study design; and (iii) analysis and findings. Adhering to this guideline is strongly recommended as it will likely increase the methodological quality of a manuscript.
Following are five recommendations for a qualitative study to be published in the Journal.
1. In qualitative designs, researchers are much more involved with the participants. A reflection on how the involvement of the researchers, based on their personal characteristics might have influenced the results should be included in the manuscript.
2. In the introduction, a case should be made for why qualitative research was the most appropriate route to answer the research question. For example, explain why it is important that we know experiences of professionals about return to work of cancer patients (11). Describe how this will contribute to what is already known.
3. In the methods section, the theoretical framework, setting and recruitment of participants and analyses should be carefully described. It is important to keep in mind that most readers of SJWEH will likely have more experience with quantitative than qualitative research designs. Checks and balance ensuring a high quality procedure should be included, for example: a dual coding procedure in which two researchers have coded transcripts independently to prevent bias; a clear description of how the codes were categorized into themes, or a member check to ensure the participants supported the summary of the interviews in which they took part.
4. In the discussion section, a case should be made for how the findings of the study can be transferred to other

contexts and how they generally improve the understanding of phenomena in the field of occupational health research.

5. Apply the COREQ32 checklist to your qualitative study (20).

We warmly invite you to submit your high quality manuscripts with a qualitative research design to SJWEH!

## Sidebar

Cécile RL Boot, PhD 12 Astrid R Bosma, MSc1

1 Amsterdam UMC, VU University, Amsterdam Public Health Research Institute, Department of Public and Occupational Health, Amsterdam, The Netherlands.

2 Radboud University, Behavioural Science Institute, Nijmegen, The Netherlands.

[E-mail: crl.boot@amsterdamumc.nl]

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## DETAILS

| | |
|---|---|
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# Breast cancer among Danish women occupationally exposed to diesel exhaust and polycyclic aromatic hydrocarbons, 1964–2016


Pedersen, Julie Elbæk, MSc [1] ; Strandberg-Larsen, Katrine, PhD [2] ; Andersson, Michael, PhD [3] ; Hansen, Johnni, PhD [1] [1] Danish Cancer Society Research Center, Copenhagen, Denmark. [2] Department of Public Health, University of Copenhagen, Copenhagen, Denmark. [3] Department of Oncology, Rigshospitalet, Copenhagen, Denmark.




## ABSTRACT (ENGLISH)


Objective The aim of this study was to explore the association between occupational exposure to diesel exhaust and polycyclic aromatic hydrocarbons (PAH), respectively, and breast cancer subtypes. Methods The study included 38 375 women <70 years with incident breast cancer, identified in the Danish Cancer Registry, and 5 breast cancer-free controls per case who were randomly selected from the Danish Civil Registration System and matched on year of birth. Full employment history was obtained for all study subjects from a nationwide pension fund, and exposure to diesel exhaust and PAH was assessed using a job exposure matrix. Conditional logistic regression was used for estimation of odds ratios (OR) with adjustment for reproductive factors and socioeconomic status. Results No noteworthy associations were observed for overall breast cancer in women exposed to diesel exhaust. However, diesel exhaust modestly elevated the risk of estrogen receptor negative breast tumors before age 50 [OR 1.26, 95% confidence interval (CI) 1.09-1.46]. Duration- and dose-response relationships were further observed for this subtype in this age group. No notable risk patterns were generally observed for PAH exposure. Conclusion Occupational exposure to diesel exhaust may increase the risk of early-onset estrogen receptor negative breast tumors in women. Future studies exploring this association are warranted.

# FULL TEXT


## Headnote

Objective The aim of this study was to explore the association between occupational exposure to diesel exhaust and polycyclic aromatic hydrocarbons (PAH), respectively, and breast cancer subtypes.

Methods The study included 38 375 women <70 years with incident breast cancer, identified in the Danish Cancer Registry, and 5 breast cancer-free controls per case who were randomly selected from the Danish Civil Registration System and matched on year of birth. Full employment history was obtained for all study subjects from a nationwide pension fund, and exposure to diesel exhaust and PAH was assessed using a job exposure matrix. Conditional logistic regression was used for estimation of odds ratios (OR) with adjustment for reproductive factors and socioeconomic status.

Results No noteworthy associations were observed for overall breast cancer in women exposed to diesel exhaust. However, diesel exhaust modestly elevated the risk of estrogen receptor negative breast tumors before age 50 [OR 1.26, 95% confidence interval (CI) 1.09-1.46]. Duration- and dose-response relationships were further observed for this subtype in this age group. No notable risk patterns were generally observed for PAH exposure.

Conclusion Occupational exposure to diesel exhaust may increase the risk of early-onset estrogen receptor negative breast tumors in women. Future studies exploring this association are warranted.



Key terms breast cancer subtype; Denmark; exposure; female worker; full job history; JEM; job exposure matrix; occupational exposure; occupational risk factor; PAH.


Breast cancer has the highest incidence rate of all cancers in women and it has been increasing over the last half of the 20th century (1). Further, breast cancer is a heterogeneous disease, and the various subtypes are often characterized by the presence or absence of particular biomarkers, ie, hormonal and growth receptors (2, 3). Acknowledged breast cancer risk factors include early age at menarche, late age at menopause, advanced age at childbearing and nulliparity, use of oral contraceptives, and hormone replacement therapy (HTR) (4). In addition, some lifestyle factors such as obesity, alcohol consumption, and physical inactivity as well as greater breast density and genetics are also shown to increase the risk (5, 6). Most risk factors have been observed to be positively associated with different breast cancer subtypes in both young and older women (3, 4). Nonetheless, the etiology of breast cancer is not completely understood and acknowledged risk factors cannot explain all of the increase in incidence rates (7). More recently, increasing levels of hormone-mimicking chemicals in the environment, including diesel exhaust and polycyclic aromatic hydrocarbons (PAH), have been suggested to play a role in breast cancer development (8) (9). Compared with the general population, certain types of workers especially encounter higher levels of these air pollutants from various workrelated sources. Diesel exhaust consists of a mixture of chemical components, including gases (eg, carbon monoxide and nitrogen oxides), particulates comprising metals, sulfates, organic and inorganic carbon, and aromatic hydrocarbons such as benzene and PAH (8). Further, PAH also originate from other sources of incomplete combustion of organic material (9).

The International Agency for Research on Cancer (IARC) has classifed both diesel exhaust and specific PAH as carcinogenic to humans (group 1), but this classification was primarily based on lung cancer (8) (9). Moreover, chemical components of diesel exhaust, including PAH, are lipophilic, have estrogenic properties, and are stored in mammary tissue. Thus, it is plausible that these agents may as well be linked to carcinogenesis in breast cells (10). In addition, the effect of carcinogenic exposures on breast cancer risk among women have been suggested to be higher during particular windows of susceptibility early in life, ie, prior to and during pregnancy (11). Further, the effect may also be higher in nulliparous women as breast tissue in these women is less differentiated (12, 13) and thereby perceived as more vulnerable (14).

Nevertheless, only a limited number of incidence studies have examined the effect of these occupational exposures on the risk of breast cancer among women (15-22). Moreover, breast cancer risk in possibly susceptible subgroups and the risk of hormonal subtypes have not been evaluated in different age groups of women in previous explorations.

Through the use of lifetime information on employment history and a job exposure matrix (JEM), we conducted a nationwide registry-based case-control study exploring the association between occupational exposure to diesel exhaust and PAH, respectively, and the risk of subtypes of breast cancer in different groups of Danish women.

Methods

Case and control selection

Cases were initially identified in the national Danish Cancer Registry. Since 1943, this registry has systematically registered all cancers in Denmark and holds individual-based information on the date of diagnosis and details of pathological characteristics. Until 1978, the International Classification of Disease revision 7 (ICD-7) was used to categorize breast cancer. From 1978 to 2003, a converted version of ICD-10 was used and subsequently revision 10 (ICD-10) (23). Employment information was available from 1964 (see next section), and cases with full employment history, ie, women who were born after 1946 and thereby 18 years old in 1964, were included in the study. As a result, cases were <70 years old when diagnosed in the study period ending in 2016.

The Danish Breast Cancer Group (DBCG) database was founded in 1975 and has obtained comprehensive information on diagnostics, treatment and control since 1978 (24). We retrieved additional information on subtypes of breast cancer from DBCG covering the period 1978-2015, which included data on estrogen receptor (ER) status.

Demographic information on all residents in Denmark has been registered systematically in the Danish Civil Registration System since 1968 (25). Five controls matched on year of birth were chosen for each case at random using this registry (the incidence-density sampling approach). Controls were required to be alive and free of breast cancer at the date of diagnosis, and controls as well as cases were required to be born in Denmark in order to ensure complete information on work history. The Danish Cancer Registry, DBCG, and the Danish Civil Registration System all entail a unique 10-digit personal identification number (PIN), which serves as a unique key to all public administration of Danish residents, including healthcare, and all relevant information in these registries was linked using this PIN. As the study was registrybased, no ethical approval was required.

Occupational history

The Danish Supplementary Pension Fund Register (ATP) was established in 1964 and has held compulsory membership for all wage earners working >9 hours/ week. All jobs are registered with information on the unique PIN of the employee, date of start and end of each employment, company name, and a unique 8-digit company number for tax purposes. All information is kept even if a company closes or employees emigrate or die (26). Statistics Denmark has classified companies into a five-digit branch/industry code (in Danish: Danmarks Statistisk Erhvervsgrupperingskode, DSE) (27) according to an extended version of the International Standard Industrial Classification of all Economic Activities (ISIC) (26, 28). The PIN was also used to link the occupational history from ATP, and registration in this registry, which was an indicator of labor force participation, was a prerequisite for being eligible for the study.

Exposure assessment

To translate the industrial employments into exposure to diesel exhaust and PAH, respectively, a Danish JEM (NOCCA-DANJEM) was used, which includes metrics of the probability of job-specific exposure (P) and mean intensity level of exposure (L) for each relevant agent of exposure and occupational group. Further, this information is available for four periods of time (1945-1959, 1960-1974, 1975-1984 and 1985-1995).

The JEM is based on the Nordic Occupational Can- cer Study job exposure matrix (NOCCA-JEM) (29), and as exposed jobs in the NOCCA-JEM are founded on the Nordic Classification of Occupations (NYK), the construction of the NOCCA-DANJEM had involved a development of a crosswalk between Nordic NYK and Danish DSE codes, which was conducted by a Danish occupational expert. As specific DSE77 codes corresponded to several NYK codes with various exposure estimates, the development of this crossroad had involved an expert evaluation of the average exposure in these Danish industries representing various jobs in which both men and women are employed.

In order to improve specificity, we categorized employment with a probability of exposure <20% and women employed less than one year as unexposed. As the JEM did not entail measurements of exposure after 1995,

metrics of exposure probability and level for this period were assumed to reflect those in the most recent era (1985-1995).

Covariates

In the supplementary material (www.sjweh.fi/show_ abstract.php?abstract_id=3923), figure S1 provides a directed acyclic graph (DAG) with an overview of the presumed causal interplay of risk factors for breast cancer, and obtainment of information on potential confounders was partly based on this. As a result, we included information from the Danish Civil Registration System on job title reflecting socioeconomic status (SES) and reproductive factors were included. Information on last known job title was self-reported and was initially attained from annual tax returns or official change of address forms. We grouped this information according to SES using the Danish Institute of Social Sciences' definition: group 1 (highest status) included academics, group 2 included middle education, group 3 included shorter education, group 4 included skilled workers, and group 5 included unskilled workers (30). Further, group 6 consisted of women with missing information on job title, which comprised a relatively large proportion of especially the younger women included in the study (approximately 30%). Information on reproductive factors, including parity (0, 1-2, >3 children) and the exact age at first live birth (<25, 25-29, 30-34 and >35 years), was available. In addition, possible confounding by work-related physical activity was assessed using the NOCCA-DANJEM and categorized according to "ever" versus "never" having worked in a job with "heavy or rather heavy physical work".

Statistical analysis

We used conditional logistic regression for matched data sets to estimate odds ratios (OR) with corresponding 95% confidence intervals (CI), and all analyses were thereby conditioned on the matching variable, ie, year of birth. The full adjusted models further included age at first live birth, parity and work-related physical activity. Due to the relatively large proportion of women who had missing data on SES, we conducted a subsequent full case analysis including women with no missing data on this variable, which yielded analogous results (only results for the overall findings are shown). All analyses were stratified according to the women's age at the index date (<50, >50 years old), approximating menopausal status.

We used different dimensions of exposure, including duration of exposure as well as cumulative exposure. Duration of exposure was calculated by summing the years of employment in all exposed calendar periods across all industries (1-9, 10-20, >20 years). Further, cumulative exposure was the product of the proportion exposed, intensity level and years worked in each exposed time period, which was summed over all exposed jobs in a woman's occupational history. The categorization of cumulative exposure was based on the percentiles among the controls (>0-25, >25-50, >50-75, >75). Trend tests were conducted to explore durationand dose-response relationships by using ordinal scores.

Analyses exploring the impact of lag time (the years between initial exposure and the index date) on the main results (>1-9, 10-20 and >20 years) as well as timing of exposure among parous women (before versus after first live birth) were conducted as well. In addition, the same analyses were conducted with a further stratification by ER status. We also conducted a stratified analysis exploring the effect of parous status on the risk of overall breast cancer in the two age groups. Lastly, as the population of women in the study were <70 years of age, the lag time for women exposed late in their work life would have been too short for potential breast tumors to develop. Hence, we conducted a sensitivity analysis excluding women exposed after age 50.

All analyses were performed with Stata statistical software v 14.2 (StataCorp, College Station, TX, USA).

Results

A consequence of restricting the study population to women aged <70 years in 2016 was the relatively high proportion of breast cancer cases diagnosed before age 50. The distribution of known major breast cancer risk factors in both age groups was consistent with current knowledge, ie, cases were generally more likely than controls to have a higher SES, lower parity, and higher age at first full-term birth, although a slightly higher proportion had never been employed in work with heavy physical requirements (table 1). Regarding ER status, a relatively larger proportion of cases in both age groups were diagnosed with ER+ tumors and thus the distribution of hormonal

cancer subtypes followed an expected pattern as well. Approximately 7% and 6% of the study population of women had been occupationally exposed to diesel exhaust and PAH, respectively, from working in industries entailing these exposures. Women exposed to diesel exhaust had most often been employed in construction as well as different transportation industries entailing this exposure whereas women exposed to PAH most often had been employed in industries involving work with metal and machinery (see supplementary table 1 for a complete overview of the proportion of exposed women employed in industries with diesel exhaust and PAH, respectively).

Adjustment for the selected potential confounders did not affect our results, which showed no striking elevation in the risk of breast cancer before or after age 50 years in women exposed to diesel exhaust and PAH (table 2). Cumulative exposure to diesel exhaust tended to increase the risk before age 50 in a dose-responselike pattern. However, analyses by other dimensions of exposure as well as exposure time windows did not indicate any convincing positive associations for diesel exhaust and PAH in both age groups (table 3). Parous status was shown to affect the association between diesel exhaust and overall breast cancer after age 50 years as only exposed nulliparous women in this age group had an increased risk (OR 1.61, 95% CI 1.13-2.31) (table 4).

When conducting a further stratification by hormonal subtype of breast cancer, diesel exhaust was primarily



associated with a modest increased risk of ER- tumors before age 50 (OR 1.26, 95% CI 1.09-1.46). Before age 50, longer duration of exposure to diesel exhaust was also positively associated with the risk of ER- tumors and cumulative exposure was indicated to increase the risk of both ER- and ER+ breast cancers in a dose-response-like manner, but this observation was most pronounced for ER- tumors. In addition, women exposed >20 years prior to the index date had the highest risk of ER- tumors (OR 1.49, 95% CI 1.19-1.88). Exposure to diesel exhaust after first live birth also increased the risk of ER- breast cancer before age 50 (OR 1.39, 95% CI 1.09-1.76). After age 50, no convincing associations between diesel exhaust and hormonal subtypes of breast cancer were observed (table 5). Subsequent adjustment for PAH exposure did not alter these findings (data not shown). No substantial risk patterns were generally observed for PAH exposure and hormonal subtypes in both age groups (supplementary table S2), and adjustment for diesel exhaust did not affect these findings either (data not shown). Excluding women exposed after age 50 did not affect the risk estimates.

## Discussion

The present study showed no marked elevated risk of overall breast cancer diagnosed before or after age 50 following occupational exposure to diesel exhaust and PAH, respectively. However, diesel exhaust modestly elevated the risk of early-onset (before age 50) ER-tumors, and duration- and dose-response relationships were also observed for this particular subtype in this age group as well as a positive association with longer latency. Diesel exhaust exposure after first live birth increased the risk of early-onset ER- tumors. After age 50, diesel exhaust was associated with an increased risk of overall breast cancer among nulliparous women. No other notable positive risk patterns were observed for diesel exhaust exposure after age 50 as well as for PAH exposure in both age groups.

Previous similar studies exploring the association between diesel exposure and breast cancer incidence in women are somewhat inconsistent. A Swedish cohort study using a similar JEM for the exposure assessment reported an increased risk of post-menopausal breast cancer with longer duration (HR 1.69, 95% CI 1.01-2.82) and higher cumulative exposure (HR 1.61, 95% CI 0.93-2.79) (17). Using the same cohort, a subsequent study with improved exposure estimates also detected an increased risk of post-menopausal breast cancer among women with diesel exhaust exposure (22). These findings do not resemble those observed in this present study, which only indicated an increased risk of early-onset ER- tumors. The Swedish study population was somewhat smaller compared to ours and a different categorization of employment was used, which may in part explain the inconsistency in results. An Australian case-control study used occupational experts to assess exposure to diesel exhaust and reported a modest increased risk of pre-menopausal breast cancer (OR 1.29, 95% CI 0.77-2.18), but no risk elevations were observed for post-menopausal breast cancer (20). A Finish case-control study also using a JEM for the exposure assessment similarly detected an increased risk of pre-menopausal breast cancer in women with medium/ high level of exposure to diesel exhaust (SIR 1.48, 95% CI 0.48-4.61) (15) while no association between occupational

exposure to diesel exhaust and overall breast cancer was detected in a Swedish cohort study (18). These last reports in part support our results as we did not detect an overall increased risk of breast cancer before or after age 50 and, moreover, only observed an indication of an increased risk of early-onset breast cancer with cumulative exposure. However, when stratifying by ER status, we observed a somewhat consistent pattern of an increased risk of ER- tumors before age 50. As these previous studies did not stratify by ER status in women with pre-menopausal breast cancer, a potential increased risk of early-onset ER- tumors may have been overlooked.

Our somewhat consistent findings of an increased risk of ER- tumors before age 50 among women exposed to diesel exhaust may be biologically plausible; diesel exhaust is classified as carcinogenic to humans (8) and chemical components are lipophilic, have estrogenic properties, and are stored in mammary tissue where they may cause carcinogenesis (10). Further, it has been theorized that ER- tumors may be more sensitive to hormonal imbalance and that they are therefore more strongly affected by acknowledged risk factors (31). Hence, it is possible that diesel exhaust may affect the risk of this subtype more strongly as well. Moreover, young women exposed to diesel exhaust may have an increased breast cancer risk as they experience several time windows of heightened biological susceptibility to carcinogenic exposures, ie, the time prior to first full-term pregnancy, where breast cells are less differentiated, and during pregnancy, where hormones and growth factors mediate maximal development of breast tissue (32). However, only exposure to diesel exhaust after first live birth was observed to increase the risk of early-onset ER- tumors in our study, which implies that the time after pregnancy may also constitute a window of susceptibility to carcinogenic exposures increasing the risk of this breast cancer subtype. However, this observation cannot be confirmed by previous studies as similar examinations have not been undertaken. Since the period following birth has not been highlighted as critical in a recent review on influences of environmental chemicals on breast cancer risk (11), our observation may as well be due to chance or uncontrolled confounding and therefore needs to be studied further.

In this present study, nulliparous women exposed to diesel exhaust were observed to have an increased risk after age 50, which supports the hypotheses that undifferentiated breast cell structures in these women are more susceptible to carcinogenic exposures (12-14). To the authors' knowledge, no prior incidence studies have addressed the risk of breast cancer among nulliparous women with occupational diesel exhaust exposure as well. However, a previous study on breast cancer risk with occupational exposure to benzene, which is one of the chemical components in diesel exhaust, reported an elevated risk among nulliparous women (OR 1.94, 95% CI 0.9-4.1) (33) and thus partly supports our finding. However, this result needs to be confirmed in future studies.

Our explorations of a potential effect of PAH exposure on breast cancer risk did not yield any convincing positive findings. This is generally not supported by previous incidence studies indicating an increased breast cancer risk among women with occupational PAH exposure (16, 17, 19, 21). When using a JEM for the exposure assessment, all workers employed within the same industry are assigned the same exposure, despite the fact that there may well be exposure variance due to factors such as job, job tasks and protective equipment. In addition, we used a JEM that was not gender-specific, which may also be considered a limitation as women and men in the same industry may be exposed differently due to different jobs and job tasks. Consequently, non-differential exposure misclassification may have been an issue and led to an attenuation of risk estimates. However, as we considered women in exposed jobs with a probability of <20% to be unexposed, exposure misclassification may have been reduced. In addition, the JEM entailed specific dimensions such as specific time periods, probability and intensity, which are features that have been shown to increase validity and reduce the attenuation of risk estimates (34). As several prior studies detecting an increased breast cancer risk with PAH exposure also used a JEM with no gender-specific dimensions to assess exposure to PAH (17, 19, 21), additional methodological issues may as well have contributed to the discrepancy in results. Other limitations in our study involve that the oldest generation of women included in the study that held jobs in a very young age, ie, <18 years, might have been misclassified with respect to exposure as these jobs would not have been registered in the ATP register. Further, the classification of employment in the various versions of the NOCCA-JEM was based on different classifications of employment. Hence, the crosswalk between the original NOCCA-JEM and the Danish version was somewhat imperfect and may

have increased the exposure misclassification slightly.
Moreover, we did not have information on exposure after 1995 and, therefore, metrics of probability and level of exposure in this period may have been slightly imprecise as they were based on metrics in the most recent era in the JEM (1985-1995). As the ATP register has high validity (26), other misclassification errors regarding industrial classification were not considered to have weakened our results. The Danish Cancer Registry and DBCG also have high validity and almost complete coverage in the study period (23) (24), and therefore we do not consider misclassification of breast cancer status to be an issue either.
More importantly, it was not possible to account for potential confounding due to certain lifestyle factors such as obesity, alcohol consumption, physical inactivity, use of oral contraceptives and hormone replacement therapy (4). As several of these factors are associated with socioeconomic group, we may have indirectly accounted for these potential effects by controlling for the variable SES in our full case analyses, which did not change our risk estimates. These analyses may still be considered somewhat limited since our SES variable was based on self-reported job title and a relatively high percentage of the women in our study had missing information on this variable. However, as most of these lifestyle factors present a modest risk of breast cancer (35) and adjustment for these variables in most previous studies in this research area had marginal or no effect on the diesel exhaust and PAH exposure risk estimates (16, 17, 20, 21), lack of this information in our study are not presumed to be a critical limitation. Nonetheless, as our overall risk estimates are considered somewhat modest, they may still be explained by unknown confounding or chance. We choose not to make adjustment for multiple comparisons, as it has been argued that this strategy will lead to fewer errors of interpretation (36). Instead, positive associations were discussed according to biological plausibility and compared with the existing literature.
The exposures under study are also found in the general environment, however, normally to a lower extent than in some sectors of the working environment. Not being able to account for individual level exposure outside work is generally considered to be a limitation in occupational studies, including this one.
The strengths of this study include the large nationwide population-based case-control design, which allowed us to evaluate the risk of a high number of incident breast cancer cases, including specific subtypes, with life-time occupational exposures. Moreover, a uniqueness of the study was its unusual high number of breast cancer cases in relatively young women allowing us to explore rare subtypes by different age groups. Using reliable registry data on occupational history and a validated JEM with objective workplace exposure measurements and features such as probability and intensity scores in different time periods, which refined the exposure assessment, were also considered major strengths. Especially information on lifetime occupational history on Danish women with historical high workforce participation rates (37) allowed us not only to examine breast cancer, by ever having worked in an exposed job, but also by various exposure measures.

## Concluding remarks

This study shows no notable association between occupational diesel exhaust and overall breast cancer risk, and the same applies to PAH exposure. However, our results show a pattern indicating that diesel exhaust may increase the risk of ER- tumors in women before 50 years. Future studies on this issue that differentiate between subtypes of breast cancer in different age groups and explore the effect of reproductive status and exposure time windows are needed.

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## Conflicts of interest

The authors declare no conflicts of interest.

## Sidebar

Pedersen JE, Strandberg-Larsen K, Andersson M, Hansen J. Breast cancer among Danish women occupationally exposed to diesel exhaust and polycyclic aromatic hydrocarbons, 1964-2016. Scand J Work Environ Health. 2021:47(2):154-162. doi:10.5271/sjweh.3923

Correspondence to: Julie Elbæk Pedersen, Danish Cancer Society Research Center, Strandboulevarden 49, 2100

Copenhagen Ø, Denmark. [E-mail: juliep@cancer.dk]
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## DETAILS

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|---|---|
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# The effects of bright light treatment on subjective and objective sleepiness during three consecutive night shifts among hospital nurses – a counter-balanced placebo-controlled crossover study

Bjorvatn, Bjørn, PhD [1] ; Pallesen, Ståle, PhD [2] ; Waage, Siri, PhD [1] ; Thun, Eirunn, PhD [3] ; Blytt, Kjersti M, PhD [4 1] 1 Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway. [2] 2 Norwegian Competence Center for Sleep Disorders, Haukeland University Hospital, Bergen, Norway. [3] 3 Department of Psychosocial Science, University of Bergen, Bergen, Norway [4] 4 Department of Health and Caring Sciences, Western Norway University of Applied Sciences, Bergen, Norway



## ABSTRACT (ENGLISH)

Objectives The objective was to investigate effects of timed bright light treatment on subjective and objective measures of sleepiness during three consecutive night shifts among hospital nurses. Methods Thirty-five nurses were exposed to bright light (10,000 lux) and red dim light (100 lux) during three consecutive night shifts in a counter-balanced crossover trial lasting nine days, which included three days before and three days after the three night shifts. Light exposure for 30 minutes was scheduled between 02:00-03:00 hours on night 1, and thereafter delayed by one hour per night in order to delay the circadian rhythm. Subjective sleepiness was measured daily (heavy eyelids, reduced performance) and every second hour while awake (Karo-línska Sleepiness Scale, KSS). Objective sleepiness (Psychomotor Vigilance Task, PVT) was measured at 05:00 hours during each night shift. Beyond nocturnal light exposure on the night shifts, no behavioral restrictions or recommendations were given at or off work. Results Bright light treatment significantly reduced heavy eyelids during night shifts. However, results on KSS and PVT were unaffected by bright light. There were no differences in subjective sleepiness during the three days following the night shifts. Conclusions This bright light treatment protocol did not convincingly reduce sleepiness among nurses during three consecutive night shifts. Nor did bright light impede the readaptation back to a day-oriented rhythm following the night shift period. Too few consecutive night shifts, inappropriate timing of light, and possible use of other countermeasures are among the explanations for the limited effects of bright light in the present study.

## FULL TEXT

### Headnote

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Conclusions This bright light treatment protocol did not convincingly reduce sleepiness among nurses during three consecutive night shifts. Nor did bright light impede the readaptation back to a day-oriented rhythm following the night shift period. Too few consecutive night shifts, inappropriate timing of light, and possible use of other countermeasures are among the explanations for the limited effects of bright light in the present study.

Key terms field study; Karolinska Sleepiness Scale; night work; Psychomotor Vigilance Task; RCT.

Night work is associated with increased sleepiness and reduced performance while at work (1, 2). One reason for this is that the circadian rhythm is not adapted to night work. Several studies indicate that the circadian rhythm may not adapt even following more than one week of consecutive night work (2-4), and a review suggests that very few night workers in general obtain biological adaptation to night work (5). Several countermeasures targeting sleepiness during night work have been suggested, ie, bright light, melatonin, napping while at work, caffeine, exercise, and modafinil (6, 7). Some of these countermeasures phase shift the circadian rhythm (ie, bright light). Others appear to reduce sleepiness at work without phase shifting (ie, napping), probably by reducing the homeostatic sleep drive (8), whereas other countermeasures, like modafinil, have direct alerting effects (9). In addition to its phase shifting ability, bright light may reduce sleepiness through an acute alerting effect (10) and works as such through more than one mechanism. Several carefully executed laboratory studies show that timed exposure to bright light will facilitate adaptation of the circadian rhythm (3, 11, 12). However, adaptation to night work may lead to problems when the worker wants to adapt back to a normal day-night rhythm during time off or if the work schedule also includes day work. Thus, use of bright light may be most appropriate when shift workers have several consecutive night shifts (2, 6). The effect of light depends on the timing of exposure relative to the nadir of the endogenous rhythm of the person's biological clock, which is usually 1-2 hours before the habitual time of natural awakening (13). When bright light is administered at the wrong circadian phase (eg, after nadir), adaptation to night work is impeded (13, 14).

Even though it seems evident that timed bright light will facilitate circadian adaptation to night work, and thereby improve alertness and recovery (2, 6), several issues remain unsolved. Most previous studies have been well-controlled laboratory-based experiments. In real-life settings, timing of bright light treatment may conflict with work tasks, and environmental light may counteract the effects of bright light treatment, eg, by making people less sensitive to light (15) or by occurring at unfavorable times (14). Furthermore, night workers may use caffeine and other countermeasures, which likely explain why findings in field studies in general are less convincing than those of laboratory studies (16). Still, for treatment with bright light to be of any practical use to night workers, the constraints of real-life settings must be accepted.

Another issue relates to the number of consecutive night shifts necessary for recommending bright light as a countermeasure. Bright light treatment may be appropriate in work schedules with many consecutive night shifts. For schedules with one or a few consecutive night shifts, circadian adaptation may not be desirable (6), consequently bright light for adaptation to night work is therefore not recommended. Also, it is likely that the environment (eg, working indoors or outdoors) and type of work may be of importance. Understandably, bright light may be more effective in sedentary night work settings than during night work where the workers are more active (eg, moving, interacting, solving complex tasks).

To address some of these issues, the present study investigated the effects of bright light in a field study among nurses in a Norwegian hospital working rotas that included three consecutive night shifts. The nurses were assessed

with both subjective (validated sleepiness scales) and objective (reaction time tests) measures of sleepiness. Data were collected for three days before, during the three consecutive nights, and also for three days after the night work period. The nurses were exposed to bright light (about 10,000 lux) or dim red light (about 100 lux) in a counter-balanced crossover design. We hypothesized that bright light would reduce sleepiness during the night shifts. However, we also hypothesized that these positive effects during night work would lead to more sleepiness when the nurses returned to a day-oriented rhythm.

Methods

Participants

Nurses were recruited from different departments at Haukeland University Hospital in Bergen, Norway. Figure 1 shows a flow chart of the recruitment process. The nurses first answered a brief inclusion form, in which the following criteria had to be met: (i) a work schedule which included three consecutive night shifts; (ii) not pregnant; (iii) responding at least "occasionally" to the question "How often are you sleepy during night work?" ("never"; "seldom"; "occasionally"; "often"; "always").

Procedure

Before the study was initiated, a paper-based questionnaire was administered enquiring about demographic data - including age, sex, marital status, children living at home - and questions to identify shift work disorder (17) based on the minimal criteria from the International Classification of Sleep Disorders, version 3 (18).

The participants were exposed to light in a counterbalanced placebo-controlled crossover study. Randomization was done manually, and cluster randomization was used in cases where two or more nurses at the same hospital unit participated at the same time. A researcher who was not involved in the project marked the light boxes with a letter signalizing each condition, packed the boxes for delivery to the units, and kept the blinding key until the data were analyzed. Both conditions lasted nine days, that is, three days before the night shifts, three consecutive night shifts, and three days after the night shifts. During the three night shifts in both conditions, nurses were instructed to sit in front of a light box measuring 45 cm wide, 20 cm high and 22 cm deep (Tynset Elektronikk, Norway) at 30 cm distance for 30 minutes per night shift. If the participants for some reason (for instance heavy workload) were prohibited from sitting down for 30 consecutive minutes, we advised them to split the light period in two (15 minutes ·2). Time for light exposure was scheduled between 02:00-03:00 hours the first night, 03:00-04:00 hours the second night, and 04:00-05:00 the third night. Even though we did not know the exact circadian phase of the participating nurses, the bright light exposure was timed in order to phase delay the endogenous rhythm. We gradually delayed the exposure times from night to night to maximize the phase delaying effects on the circadian rhythm (14).

Light in the experimental condition amounted to ~10,000 lux (full-spectrum white light, 4000 Kelvin). In the control condition, red dim light (~100 lux) from identical light boxes was administered. We did not instruct the nurses to follow any other specific behavioral recom- mendations, either at work or during time off work. Thus, caffeine intake and other possible countermeasures could be used ad libitum. The study (both conditions) took place during the period from October to April, when sunlight is reduced in the morning and evening in Norway. A washout period of at least three weeks was scheduled between the two conditions. Following each night shift, the nurses were asked to record how long time they sat in front of the light box (0, <15, 15-29, or >30 minutes).

Karolinška Sleepiness Scale (KSS). KSS comprises a single item assessing subjective sleepiness on a scale from 1 (very alert) to 9 (very sleepy, fighting sleep, effort to stay awake) (20). The scale was completed every second hour while awake during days 4-9, that is, during the three night shifts and the three days after the night shift period.

At the end of the study periods (after day 9), the nurses were asked to rate how their overall functioning had been the last six days (the three night shifts + the three following days), compared to similar work periods, on a single-item seven-point scale (1=very much better; 2=much better; 3=better; 4=as usual; 5=worse; 6=much worse; 7=very much worse).

Reaction time test. We used the 5-minute version of the PC-Psychomotor Vigilance Task (PC-PVT) to measure the participants' reaction time (21). The participants were instructed to take the test at 05:00 hours every night shift. If the participants for some reason were prohibited from conducting the test at 05:00 hours, we encouraged them to

take the test as close to this time as possible. The participants were given the following information: "a red number will be presented on the screen. Every time you see it, click as fast as you can using the mouse, with your dominant hand." As recommended when using the PC-PVT software, we used a USB mouse called Razer, which supports 1000 Hz polling. The outcome measures from the PVT were mean reaction time and number of lapses (reaction time >500 ms) (22).

Measures

Accumulated Time with Sleepiness (ATS) Scale. The ATS Scale is designed to provide an integrated rating representing sleepiness over longer periods, ie, accumulated sleepiness (0-100%) during a work shift or during a whole day when off from work (19). In the present study, we used only two of the ATS items: "Did you experience any of the following while you were awake: (i) heavy eyelids and (ii) reduced performance?". ATS ratings were recorded every day before going to bed during the whole study period (days 1-9).

Other daily measures. The nurses also provided an answer to the question "How good was your day overall, in terms of mood, energy and drive on a nine-point scale (1=very good; 3=good; 5=neither good nor bad; 7=bad; 9=very bad)?". Furthermore, caffeine intake was recorded in terms of number of cups/glasses consumed. Similar to ATS, both these measures were recorded every day before going to bed during the whole study period of nine days.

Ethics

We obtained written informed consent from all nurses before study initiation. The nurses were compensated with a gift card of approximately €100 for participation. The Norwegian Regional Committee for Medical and Health Research Ethics (REK sør-øst/No 2016/636) approved the study, which was registered at ClinicalTrials.gov, identifier NCT02978053.

Statistics

Data were analyzed using SPSS statistics 25 (IBM, Armonk, NY, USA). Data on ATS, quality of day, caffeine intake and reaction times were analyzed with twoway ANOVA (general linear model, GLM) using condition (red versus bright light) and day as factors. Separate ANOVA were performed for the three days before the night shifts, the three night shifts, and for the three days following the night shifts. The KSS data during the night work period were analyzed with a three-way ANOVA (GLM) with condition (red versus bright light), night (1-3) and hour of the night (KSS measured at 22:00, 24:00, 02:00, 04:00 and 06:00 hours) as factors. The KSS data during the three days following the night shifts were analyzed with a two-way ANOVA (GLM) using condition (red versus bright light) and day (mean KSS values while awake from 10:00-20:00 hours during days 7-9) as factors. When ANOVA indicated significant effects, post hoc comparisons were performed with paired t-tests. For the two ATS items (heavy eyelids and reduced performance), we also performed paired t-tests between the last day before the night shifts and the first night shift in the placebo condition. Overall functioning the last six days of the study period was analyzed with a paired t-test (red versus bright light). P-values were corrected for lack of compound symmetry using the epsilon correction according to the Huyhn-Feldt procedure. Due to some missing data, the number of observations varied somewhat in the different statistical analyses. The alpha level was set at 0.05.

Results

In total, 35 nurses completed both light conditions. The mean age of the nurses was 35.4 (standard deviation 11.2) years; 80.0% were females, 48.6% and 51.4% were married/cohabiting or single, respectively, and 31.4% reported having children living at home. In total, 60.0% fulfilled the criteria for shift work disorder (table 1). The nurses were fairly compliant with the light instructions. Among the 33 nurses who reported exposure time in the bright light condition, 85.7% (night 1), 80.0% (night 2), and 82.9% (night 3) reported >30 minutes, respectively. Corresponding numbers in the red dim light condition were 74.3%, 74.3%, and 71.4%, respectively. None of nurses in either condition reported 0 minutes of exposure.

Table 1 shows the results of the two-way ANOVA for scores on heavy eyelids, reduced performance, quality of day, and caffeine intake. Before the night shift period, there were no significant differences between the red and bright light conditions (table 1, figure 2). Scores on heavy eyelids (6.3% versus 17.8%, P<0.0005) and reduced performance (7.4% versus 16.0%, P<0.05) both increased from the last day before the night shifts to the first night

shift in the placebo condition. During the three night shifts, there was a significantly lower score in the bright light condition for heavy eyelids on the first two night shifts (days 4 and 5), as shown in figure 2. There were no significant differences depending on light condition for "reduced performance", "quality of day" or "caffeine intake". However, we found a significant effect of day for both quality of day (worse quality over time) and caffeine intake (reduced intake over time) independent of condition (table 1, figure 2). After the night shift period, there were no differences between the two light conditions, but a significant effect of day, with a reduction in heavy eyelids, improved performance, better quality of day, and an increase in caffeine intake, over time (table 1, figure 2).

Figure 3 shows the scores on the KSS. Not surprisingly, there was a significant effect of hour of the night [$F(4,116)=60.15$, $P<0.001$] as well as an interaction between night and hour of the night [$F(8,232)=3.90$, $P=0.001$], indicating that KSS values increased from 22:00 to 06:00 hours and decreased from night shift to night shift (figure 3A). There was however no indication of an effect of light condition [$F(1,29)=0.05$]. When averaging KSS scores over each night shift (mean KSS 22:00-06:00 hours) and over hours awake each following day (mean KSS 10:00-20:00 hours), we found no indication of an effect of light condition (table 1, figure 3B).

There was no difference in the responses to the question in which the nurses rated their functioning the last six days of the study period (the three night shifts + the three following days) as compared to similar work periods. In both conditions (red light: 3.74 and bright light: 3.84, $t=0.68$, $P=0.500$) the score indicated a rating close to "as usual".

Table 1 shows the results of the two-way ANOVA for mean and number of lapses on the PVT (reaction time test) during the three night shifts. There were no significant differences between conditions or across nights (table 1, figure 4).

Discussion

Bright light treatment reduced the percentage of time with heavy eyelids while working nights. Besides this finding, there were no indications that bright light reduced sleepiness, neither on subjective (ie, KSS) nor objective (reaction time tests) measures. Thus, our first hypothesis that bright light would reduce sleepiness during the night shifts was only partly confirmed. This lack of clear effect was surprising, since bright light both phase shifts the circadian rhythm and additionally has an acute alerting effect (10, 14). We discuss possible explanations for the limited effects below. Our second hypothesis - that bright light treatment would lead to more sleepiness following the night work period when the nurses returned to a day-oriented rhythm - was not supported, likely due to lack of clear effects of bright light during the night work period. A problematic readaptation back to a day-oriented rhythm could only be expected if bright light facilitated adaptation to night work in the first place.

There are several possible explanations for why bright light did not clearly reduce sleepiness during the night shifts. First, it is shown that the phase shifting and alerting effects of bright light depend on its timing, intensity, duration, wavelength, as well as individual variability and light exposure history (10, 15, 23). We timed bright light in order to phase delay the circadian rhythm (11, 16, 24). However, we did not estimate the nurses' exact circadian phase (nadir of the core body temperature rhythm or melatonin rhythm). In earlier studies among night workers at oil platforms, we individually timed bright light after interviewing each participant (16, 24). Thus, the present protocol is somewhat different from our earlier field studies. A more precise timing of bright light would presumably have improved sleepiness to a greater degree in the present study. However, for bright light treatment to be feasible in different work settings, in the present study we wanted to investigate a novel method which would be easy to implement in a real life work setting, without demanding knoi of sleep and circadian rhythms. Regarding light intensity (10,000 lux), duration (30 minutes per day), and wavelength (bright white light), we used the same type of light apparatus shown to be effective in other studies (16, 24). However, we cannot rule out that different intensity, duration and wavelength would matter. Regarding individual variability, we included only nurses who complained of sleepiness at least occasionally during night work. We consider this inclusion criterion a strength, as it is less likely that nurses will benefit from treatment if they do not struggle with sleepiness during night work. A second explanation of the modest findings in the present study relates to the work setting. Bright light may be less effective for reducing sleepiness among night workers who are active (move, interact with people, perform complex work tasks). Hospital nurses are likely to be quite active at work. In more sedentary work settings, eg, in which workers

interact less with people and do not perform active or complex work sleepiness may be more pronounced, and bright light may therefore also be more effective. A third explanation may be that the participating nurses were not restricted from using other countermeasures, such as caffeine. However, we did not find differences in caffeine intake (around 3-3.5 cups per night) between the red and bright light condition. Furthermore, no restrictions or recommendations were given for how the nurses should act during time off from work. This lack of restrictions at and off work is likely to explain why bright light is more effective in laboratory studies where such restrictions are common (16). For instance, it is shown that being exposed to daylight on the way home from work in the morning will impede adaptation to night work (2). Nurses who stay in shift work assumingly cope better with night work than those who quit; hence, another explanation may be that the participants could have represented healthy shift workers (25), where the therapeutic potential of light therapy would have been expected to be limited. However, as all nurses in the present study admitted to sleepiness during night work and since 60% suffered from shift work disorder, this explanation of the limited findings does not seem very likely.

In line with several previous studies (20, 26-28), we found that subjective sleepiness, independent of light condition, increased throughout the night shift, with highest values at 06:00 hours. Furthermore, subjective sleepiness improved on nights 2 and 3 compared to night 1, also similar to what has been reported by previous studies (24, 28, 29). This may suggest some adaptation to night work following consecutive night shifts. However, our data did not show that PVT performance improved with consecutive night shifts. This is in line with a recent laboratory study (12) but in contrast to some other studies (30, 31).

Many nurses struggle with sleepiness during night work (32, 33). The purpose of the present study was to investigate whether a relatively easily implemented bright light treatment protocol would be effective in reducing sleepiness while at work. If bright light would have a positive effect, the significance could be great. Bright light causes no or only mild and temporary sideeffects (34), and increased alertness while at work may have positive effects on patient care and safety, and possibly also on the health and safety of the night worker. Considering the number of nurses working all around the world, the individual, societal and economic impact of positive effects of such treatment will likely be of immense importance. However, based on our findings, we cannot conclude that the present protocol improved sleepiness more than the control condition. We recommend refining the protocol and studying whether differences in the methods (eg, timing, duration, light history, light composition, individual tailoring) may improve the end results. However, the present results question whether bright light treatment as a single intervention should be recommended among nurses working a maximum of three consecutive night shifts. Furthermore, one may question whether it is advisable to adjust the circadian rhythm in night work lasting only three days. Shift work is associated with a number of negative health effects, eg, cardiovascular disorders and cancer (1). However, whether adjustment of the circadian rhythm by eg, bright light increases or decreases the risk of these long-term health consequences is unclear. More research on this topic is clearly warranted.

Strengths and limitations

As mentioned, we did not instruct the nurses to fol- low any other specific recommendations at or off work regarding light exposure during commute home, sleep timing after night shifts, light exposure during daytime etc. This may be considered both a strength and a limitation. It can be regarded a strength because the data become more generalizable but a limitation since control over these parameters, eg, by adding scheduled sleep after shifts (29, 31) will likely improve the effects of bright light. The majority (80%) of participants in the present study were females. Our findings may therefore not generalize to male-dominated work settings. However, in the healthcare sector most people are females, as supported by a recent European survey which found a significant female preponderance (78%) of night workers (35). Our study is therefore likely to be generalizable to the nursing profession in other European countries. One limitation was that some measures (KSS and reaction time tests) were not measured before the night shift period, but only during the night shifts (reaction time tests) or during the night shifts and the following three days (KSS). Another limitation was the large drop-out rate during the study. The nurses withdrew for many different reasons, eg, pregnancy, job change, illness. Considering the cross-over design with several weeks in-between the conditions, this was expected. Other interfering factors not controlled for in the present study were

lightening conditions in the hospital and the individual nurse's chronotype, both of which may have impacted the results.

In conclusion, this bright light treatment protocol showed no convincing effects on reducing sleepiness among nurses working three consecutive night shifts. Furthermore, bright light did not impact readaptation back to a day-oriented rhythm following the night shift period.

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Conflict of interest

The authors declare no conflict of interest.

**Sidebar**

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Correspondence to: Bjørn Bjorvatn, Department of Global Public Health and Primary Care, University of Bergen, Kalfarveien 31, N-5018 Bergen, Norway. [E-mail: bjorn.bjorvatn@uib.no]

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## DETAILS

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# Dust exposure and the impact on hospital readmission of farming and wood industry workers for asthma and chronic obstructive pulmonary disease (COPD)


Vested, Anne, PhD [1] ; Kolstad, Henrik A [1] ; Basinas, Ioannis, PhD [2] ; Burdorf, Alex [3] ; Elholm, Grethe [4] ; Heederik, Dick, PhD; Jacobsen, Gitte H; Kromhout, Hans, PhD; Omland, Øyvind, PhD; Schaumburg, Inger, PhD; Sigsgaard, Torben, PhD; Vestergaard, Jesper M; Wouters, Inge M; Schlünssen, Vivi, PhD [1] Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. [2] Centre for Human Exposure Science, Institute of Occupational Medicine, Edinburgh, United Kingdom. [3] Department of Public Health, Rotterdam, Erasmus Medical Center Rotterdam, The Netherlands. [4] Department of Public Health, Section for Environment, Occupation and Health, Danish Ramazzini Centre, Aarhus University, Aarhus, Denmark.




## ABSTRACT (ENGLISH)


Objectives It is still not well established how occupational air pollutants affect the prognosis of asthma or chronic obstructive pulmonary disease (COPD). This study uses nationwide Danish registers and quantitative dust industry exposure matrices (IEM) for the farming and wood industries to estimate whether previous year dust exposure level impacts hospital readmissions for workers diagnosed with asthma or COPD. Methods We identified all individuals with a first diagnosis of either asthma (769 individuals) or COPD (342 individuals) between 1997 and 2007 and followed them until the next hospital admission for asthma or COPD, emigration, death or 31 December 2007. We included only individuals who worked in either the wood or farm-ing industries at least one year during follow-up. We used logistic regression analysis to investigate associations between dust exposure level in the previous year and hospital readmission, adjusting for sex, age, time since first diagnosis, socioeconomic status, and labor force participation. Results Asthma readmissions for individuals with low and high dust exposure were increased [adjusted rate ratio (RRadj) 2.52, 95% confidence interval (CI) 1.45-4.40] and RRadj 2.64 (95% CI 1.52-4.60), respectively. For COPD readmission, the risk estimates were RRadj 1.36 (95% CI 0.57-3.23) for low and RRadj 1.20 (95% CI

0.49-2.95) for high exposure level in the previous year. For asthma readmission, stratified analyses by type of dust exposure during follow-up showed increased risks for both wood dust [RRadj 2.67 (95% CI 1.35-5.26) high exposure level] and farming dust [RRadj 3.59 (95% CI 1.11-11.59) high exposure level]. No clear associations were seen for COPD readmissions. Conclusions This study indicates that exposure to wood or farm dust in the previous year increases the risk of hospital readmission for individuals with asthma but not for those with COPD.

## FULL TEXT

### Headnote

Objectives It is still not well established how occupational air pollutants affect the prognosis of asthma or chronic obstructive pulmonary disease (COPD). This study uses nationwide Danish registers and quantitative dust industry exposure matrices (IEM) for the farming and wood industries to estimate whether previous year dust exposure level impacts hospital readmissions for workers diagnosed with asthma or COPD.

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Results Asthma readmissions for individuals with low and high dust exposure were increased [adjusted rate ratio (RRadj) 2.52, 95% confidence interval (CI) 1.45-4.40] and RRadj 2.64 (95% CI 1.52-4.60), respectively. For COPD readmission, the risk estimates were RRadj 1.36 (95% CI 0.57-3.23) for low and RRadj 1.20 (95% CI 0.49-2.95) for high exposure level in the previous year. For asthma readmission, stratified analyses by type of dust exposure during follow-up showed increased risks for both wood dust [RRadj 2.67 (95% CI 1.35-5.26) high exposure level] and farming dust [RRadj 3.59 (95% CI 1.11-11.59) high exposure level]. No clear associations were seen for COPD readmissions.

Conclusions This study indicates that exposure to wood or farm dust in the previous year increases the risk of hospital readmission for individuals with asthma but not for those with COPD.

Key terms air pollutant; farmer; industry exposure matrix; lung disease; woodworker.

Asthma and chronic obstructive lung disease (COPD) are prevalent obstructive lung diseases contributing substantially to morbidity and mortality worldwide (1). Organic dust exposure, most importantly from the farming and wood industries, is a suggested risk fac-tor for both asthma and COPD (2, 3). However, how organic dust exposure affects individuals with asthma or COPD is not well established. We hypothesize that recent exposure to wood or farming dust is a risk factor for rehospitalization among individuals with asthma or COPD. We investigated this hypothesis in a longitudinal study using nationwide Danish administrative health and industry registers and quantitative dust industry exposure matrices (IEM) where hospital readmissions for asthma and COPD cases among ever farming and wood workers during follow-up were identified.

We aimed to investigate the association between previous year exposure to wood or farm dust and readmission for asthma or COPD.

Methods

We recently published a study on the association between farming and wood dust exposure and COPD incidence using a population of Danish workers who worked in the farming or wood industries 1964-2007 and were born 1933-1977 (4). Using this population, we identified all individuals with a first hospital diagnosis of either asthma or COPD between 1997-2007 in the Danish National Patient Register (4) who were blue-collar workers in either the wood or farming industries after their initial asthma or COPD diagnosis. Employment data came from the Supplementary Pension Fund register, which provides annual information on employment (industry code) according to the Danish Industrial Classification of Economic Activities. Overall, 769 workers diagnosed with asthma (3777 person-years) and 342 with COPD (1369 person-years) were included.

The population was followed from the year after their first asthma or COPD hospital diagnosis (including emergency room and department visits) until the year of first hospital readmission for asthma or COPD, respectively, with censoring for death, emigration, loss to follow-up, 65 years of age, retirement or end of follow-up on 31 December 2007.

COPD was defined according to the International Classification of Diseases, 10th revision (ICD-10) as emphysema (J43, J43.0, J43.1, J43.2, J43.8, J43.9) or other chronic obstructive pulmonary disease (J44, J44.0, J44.1 J44.8, J44.9). Asthma was defined by ICD-10 codes for asthma (J45, J45.0, J45.1, J45.8, J45.9) or status asthmaticus (J46, J46.9).

We established wood and farming industry-specific time-dependent IEM for inhalable dust exposure levels as described earlier (4). Briefly, arithmetic mean exposure levels were estimated from the WOODEX exposure database (5) and personal measurements from Danish farmers (6) both based on the inhalable dust fraction. The wood industry IEM included quantitative dust estimates for six industries: (i) sawmilling/planing of wood, (ii) manufacture of veneer boards/wood-based boards, (iii) manufacture of builders carpentry/joinery, (iv) manufacture of wooden packaging, (v) furniture industry, and (vi) carpenter and joiner business/construction. The farming IEM included estimates for crop-, cattle-, pig-, poultry-, mixed-, and fur-animal farming.

Each person-year of employment within the wood or farming industries during follow-up was assigned an exposure level based on the IEM, and follow-up years were further divided into three exposure groups [no (reference), low (>0-0.7 mg/m3) and high (>0.7 mg/m3)] according to the median exposure level. The majority of the reference group worked in other industries and a minority was unemployed (table 1).

Associations between previous year dust exposure and hospital readmission for asthma or COPD were investigated with logistic regression analyses with person-years as the unit of analysis providing rate ratios (RR). We additionally performed stratified analyses for farming and wood workers separately excluding those with mixed exposure. All independent variables were lagged one year. Age (10-year categories), sex, time since first diagnosis (in years), socioeconomic status (SES), and labor force participation (yes/no) were included as covariates. Labor force participation was defined as a period, minimally 25% of the year, with no public benefit payment. We performed all analyses using STATA 13.0 (Stata Corp, College Station, TX, USA) on Statistics Denmark.

Results

The study population spent 51% (asthma cases) and 57% (COPD cases), respectively, of their follow-up time in wood or farming related industries. The mean number of follow-up years was 3.9 (range 1-10) for asthma patients and 3.4 (range 1-10) for COPD patients. At baseline, the mean age was 39 [standard deviation (SD) 10] and 49 (SD 9) years for asthma and COPD patients, respectively. Most were men, had a basic level work, and a stable labor force participation. The majority of the follow-up years were in the high dust exposure groups. Workers who were not exposed at the start of follow-up were more likely to have a lower degree of labor force participation and basic level work (table 1).

In the main analysis, asthma readmissions were associated with previous year dust exposure, adjusted rate ratios (RRadj) 2.52 [95% confidence interval (CI) 1.45-4.40] for low and RRadj 2.64 (95% CI 1.52-4.60) for high exposure level compared to no exposure in the previous year (table 2). RRadj for COPD readmission were 1.36 (95% CI 0.57-3.23) for low and 1.20 (95% CI 0.49-2.95) for high exposure level in the previous year, compared to non-exposed in the previous year. For asthma readmissions, analyses stratified by type of dust exposure provided similar estimates as the main analysis for wood dust: RRadj 2.38 (95% CI 1.23-4.60) and 2.67 (95% CI 1.35-5.26) for low and high exposure level previous year, respectively. For those exposed to farming dust only, the RRadj were even higher: 4.03 (95% CI 1.20-13.52) and 3.59 (95% CI 1.11-11.59) (table 2). No clear association was seen for COPD readmissions, either for wood or farming dust. The small percentage (1.5% and 4%, respectively) of the asthma and COPD populations exposed to both wood and farming dust during follow-up were excluded in the stratified analysis.

Discussion

In this analysis, being exposed to wood and farming dust in the previous year more than doubled the risk of hospital

readmission for asthma patients but not COPD patients. Analyses stratified by wood and farming dust exposure showed even higher risk estimates for farming-dust-exposed workers.

Studies suggest that hospital readmissions for asthma and COPD are related to the level of ambient air pollution (7). However, we are not aware of studies investigating how occupational dust exposure impacts hospital readmissions for workers with asthma or COPD. A 40% increased risk of COPD (but not asthma) exacerbations has previously been reported among COPD patients living within a radius of 500 m of a livestock farm (8). People with asthma more often report uncontrolled asthma in jobs with airborne exposures compared to jobs without (9), and ongoing occupational exposure has been associated with a poorer prognosis for individuals with asthma caused by occupational agents (10). Barely any knowledge on the impact of occupational exposures on COPD prognosis is available. However, a study from the US suggests a history of occupational exposures to be associated with a worse prognosis in patients with COPD (11).

In the current study, we focused on the impact of previous year exposure to wood or farming dust on hospital readmissions for asthma and COPD patients. For asthma, we realize that acute exacerbations, leading to hospital readmission, can be related to short-term peak exposure, however, we hypothesized that not only peak exposures but also dust exposure in the preceding months affects the prognosis, possibly due to low grade inflammation caused by ongoing exposure.

Even though the organic components in wood dust (mainly celluloses, hemicelluloses, lignin and low molecular weight organic and inorganic compounds) and farm dust (mainly organic material from plants, fodder, animals, microorganisms, and soil) are probably highly different, quite similar results were seen for the two types of dust.

A strength of this study is the use of comprehensive Danish employment and health registers combined with quantitative estimates of wood and farming dust exposure in a register-based cohort study with minimal risk of recall bias. A limitation is missing smoking information. However, for a subgroup of the cohort from which the wood and farming workers with asthma and COPD of the current study are identified, we observed no association between wood or farming dust and smoking (4). Therefore, we do not anticipate smoking to confound our findings. The observed null finding regarding COPD readmissions is likely explained by the healthy worker survivor effect, which was evident also in our recent publication on wood or farming dust exposure and risk of COPD (4). We assume severity of COPD has a large impact on work ability and that this may underestimate the effect of dust exposure, further supporting the healthy worker survivor effect.

Another limitation is that job task information cannot be accounted for in IEM. However, the farming and wood industry are well-defined entities where the probability of exposure is high and substantial variability in exposure within different farming and wood industries are well documented.

In conclusion, this study indicates that previous year exposure to wood or farming dust increases the risk of hospital readmission for individuals with asthma but not for individuals with COPD. In future studies more detailed information on severity of asthma and COPD are warranted.

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## Sidebar

Vested A, Kolstad HA, Basinas I, Burdorf A, Elholm G, Heederik D, Jacobsen GH, Kromhout H, Omland Ø, Schaumburg I, Sigsgaard T, Vestergaard JM, Wouters IM, Schlünssen V. Dust exposure and the impact on hospital readmission of farming and wood industry workers for asthma and chronic obstructive pulmonary disease (COPD). Scand J Work Environ Health. 2021;47(2):163-167. doi:10.5271/sjweh.3926

Correspondence to: Anne Vested, Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark. [E-mail: anneveed@rm.dk]

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## DETAILS

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# Non-standard employment and mortality in Belgian workers: A census-based investigation

Balogh, R [1] ; Gadeyne, S; Vanroelen, C [1] Department of Sociology, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium



## ABSTRACT (ENGLISH)

This paper shows that types of (non-standard) employment measured in 2001 were associated with different and gender-dependent mortality risks and patterns over the subsequent 13 years in Belgium. Especially male temporary agency and seasonal workers at baseline exhibited elevated all-cause and cause-specific mortality compared to permanent employees. Policy should particularly protect these groups, more specifically from accidents and occupational exposure. Objectives Evidence is growing that non-standard employment is associated with adverse health. However, little is known about the relationship between different non-standard employment arrangements and subsequent all-cause and cause-specific mortality. Using population-wide data, the present study investigated this link. Methods Data was derived from the 2001 Belgian census and a 13-year-long follow-up. The analyses comprised 1 454 033 healthy and disability-free employees aged 30-59 years at baseline. Cox regressions were fitted to analyze the mortality risks of those in non-standard employment forms (temporary agency, seasonal, fixed-term, causal work and employment program) compared to permanent employees. Results Several groups of workers in non-standard employment arrangements in 2001 exhibited a higher mortality risk relative to permanent employees during the follow-up after adjusting for socio-economic and workrelated factors. This was especially the case among men. The relative mortality disadvantage was particularly elevated for male temporary agency workers. External causes of death played an important role in this association. Conclusions A mortality gradient between the core and outer periphery of the Belgian labor market has been observed. This study also shows that the excess risk of death, previously attributed to non-permanent employment as a whole, hides inequalities between specific forms of non-standard work (eg, temporary agency, seasonal, fixed-term employment).

## FULL TEXT

### Headnote

This paper shows that types of (non-standard) employment measured in 2001 were associated with different and gender-dependent mortality risks and patterns over the subsequent 13 years in Belgium. Especially male temporary agency and seasonal workers at baseline exhibited elevated all-cause and cause-specific mortality compared to permanent employees. Policy should particularly protect these groups, more specifically from accidents and occupational exposure.

Key terms: accident; all-cause mortality; cancer; cause-specific mortality; fixed-term employment; precarious employment; seasonal work; suicide; temporary agency work; temporary work

Objectives Evidence is growing that non-standard employment is associated with adverse health. However, little is known about the relationship between different non-standard employment arrangements and subsequent all-cause and cause-specific mortality. Using population-wide data, the present study investigated this link.

Methods Data was derived from the 2001 Belgian census and a 13-year-long follow-up. The analyses comprised 1 454 033 healthy and disability-free employees aged 30-59 years at baseline. Cox regressions were fitted to analyze the mortality risks of those in non-standard employment forms (temporary agency, seasonal, fixed-term, causal work and employment program) compared to permanent employees.

Results Several groups of workers in non-standard employment arrangements in 2001 exhibited a higher mortality risk relative to permanent employees during the follow-up after adjusting for socio-economic and workrelated factors. This was especially the case among men. The relative mortality disadvantage was particularly elevated for male temporary agency workers. External causes of death played an important role in this association.

Conclusions A mortality gradient between the core and outer periphery of the Belgian labor market has been

observed. This study also shows that the excess risk of death, previously attributed to non-permanent employment as a whole, hides inequalities between specific forms of non-standard work (eg, temporary agency, seasonal, fixed-term employment).

Key terms accident; all-cause mortality; cancer; cause-specific mortality; fixed-term employment; precarious employment; seasonal work; suicide; temporary agency work; temporary work.

The flexibilization of labor markets, weakening of the standard employment relationship, and expansion of non-standard forms of work (1-3) have led public health researchers to scrutinize whether holding any kind of job is sufficient to reap the protective health benefits ascribed to being in work (4, 5). Consequently, it has been shown that temporary employment is linked to adverse health compared to more stable jobs (6-8), although a recent study focusing on the public sector found null-effects (9). A problem, however, with using 'temporary employment' as a unit of analysis, is that it often serves as an umbrella concept for various contractual arrangements (10), which merit separate investigation. Moreover, it is recommendable to look again at the long-term health effects of different non-standard employment arrangements. Analogous to research on the health effects of unemployment (11), empirical support for the long-term negative consequences - or 'scarring effects' (12) - of job insecurity is emerging (13). The 'scarring' hypothesis maintains that exposure to unemployment - or, in our case, non-standard forms of employment - at one point in a career could generate effects on individuals' health at later stages of their lives even if exposure to that labor market situation was only temporal (11, 12).

Whereas a large body of evidence has shown that the experience of unemployment spell(s) is linked to increased risk of death later on in life (14-16), only a handful of studies have focused on analyzing the relationship between temporary employment arrangements and mortality over a longer period of time (17-19). They concluded that temporary employment was linked to excess all-cause (17-19), cardiovascular and non-violent (18), as well as smoking- and alcohol-related, and external mortality (19), depending on gender, with followup periods of 10-16 years. However, some questions remain. First, these studies mostly compared temporary employees as a whole with permanent workers. Only in one study were involuntary and voluntary, and satisfied and unsatisfied temporary workers distinguished (17). No single study was able to distinguish between various non-permanent groups (eg, temporary agency, fixed-term workers), even though such forms of employment could have vastly different mortality implications. In general, the sample sizes of the existing studies were also limited, making cause-specific mortality analyses impossible (17), or reducing statistical power (18). One study (19) used a larger dataset, but as the sample consisted primarily of municipal employees, its findings could not be generalized to the entire employed population. By drawing on the Belgian census and linked mortality follow-up data, we were able to eliminate some of the limitations in existing studies. Thanks to the large number of observations and a lengthy follow-up - and, as a result, a sufficient number of events occurring - we studied cause-specific mortality in a more robust way. It also follows that we were not required to group specific types of non-standard employees together in one overarching category of temporary employment. Doing so enabled us to evaluate which non-standard jobs might be more or less disadvantageous in terms of mortality (over a more than 13-year follow-up period). This can inform more targeted policy measures directed to those employment forms that are most at risk. Moreover, our strong study design, considering the 'hard endpoint of mortality', further added to existing evidence on adverse health effects of non-permanent employment as suggested by research using self-reported health indicators as outcomes (6, 7, 9). Belgium has had a relatively low prevalence of temporary employment over the time period investigated, in comparison to other European countries (20), providing an insightful context in which to assess the implications of non-standard employment as we could evaluate whether contractual inequalities between the sizable core and smaller periphery of salaried employees (18, 21) translate into pronounced mortality differences.

## Methods

### Data

The data for the analyses was derived from the 2001 Belgian census, linked to 13 years and three months of mortality and emigration follow-up from the National Register and death certificates between 1 October 2001 and 31 December 2014. The census covered all individuals officially registered in Belgium at the time. The causes of death

were coded according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision.

The study population

Individuals aged 30-59 years on the day of the 2001 census claiming to hold a job were eligible to be included in the analyses. In order to reduce the effects of health selection (5), the analysis was restricted to individuals with good or very good self-rated health and without longstanding illness or disability in 2001. To focus on the waged workers, we excluded the self-employed for whom the type of employment undertaken was systematically missing (namely 'entrepreneurs without an employment contract', 'independent individuals working primarily for one person or company', 'those practicing another independent, liberal profession' and those 'helping a self-employed'), as well as any further workers who were employing workers as employers themselves. The final study population with complete information on all key variables included 1 454 033 individuals (810 981 men and 643 052 women), representing 18 828 450 person-years in total; 37 487 individuals were censored on their date of emigration.

Measures

Our main exposure variable was derived from the following question in the census, pertaining to the individual's main job: "In case you are a salaried employee, what kind of work do you undertake?". The options were (i) permanent, (ii) temporary agency (emploi d'intérimaire), (iii) seasonal and (iv) fixed-term work, as well as (v) employment program (programme de mise au travail), (vi) apprenticeship/internship, (vii) student job, and (viii) casual work (without formal contract) or other. Those in permanent employment were taken as the reference category. Due to their small numbers, individuals in apprenticeships and student jobs were excluded.

A set of variables was adjusted for in the fully adjusted models. Educational attainment was categorized according to the International Standard Classification of Education classification (22). Housing tenure was used as a proxy for long-term wealth (dichotomized as owner or non-owner). Individuals were further distinguished between those residing in an urban agglomeration or not (23), and according to whether they had a partner living in the same household. Migration background (Belgian or foreign nationality of origin) was also included as an adjustment variable. Besides socio-economic characteristics, we also accounted for work-related factors: the broader economic sector of the main job, total number of weekly working hours (in main and side job) in categories (24), type of work schedule in the main job (including shift work), and multiple job-holding. The effects of work schedules and working hours on health and mortality have been analyzed in their own right (24-26), and adjusting for these enables us to establish if they act as confounders with regards to the relation under study.

All-cause mortality and mortality from the following underlying major causes was considered: diseases of the circulatory system (ICD10 I00-I99), cancer (ICD10 C00-D48), and all external causes (ICD10 V01-Y98). These major groups of causes were often investigated in previous unemployment- and work-related mortality research (14, 16, 18, 19). As external causes were previously pointed out as a source of excess mortality among non-permanent employees (19), we also specified for the following external sub-causes: transport accidents (ICD10 V01-V99), suicide (ICD10 X60-X84), and falls (ICD10 W00-W19). For approximately 1.5% of the events (around 1.8% and 1.2% for events among men and among women, respectively), no underlying cause of death was known.

Statistical analyses

Cox proportional hazards models (27, 28) were fitted to analyze the association between non-standard employment and mortality, with age as the underlying timescale, additionally adjusting for age in 5-year categories at the beginning of the follow-up (29). The proportional hazards assumption was assessed using Schoenfeld residuals, and by plotting Kaplan-Meier curves against predicted survival curves (28, 30). Separate models were fitted by gender.

Sensitivity analysis

To further account for potential confounders, we conducted a propensity score matching (15, 31-34) as part of a sensitivity analysis. This entailed a set of binary matches (34), separately for men and women. These analyses were conducted on a wider subpopulation, which included those with poorer health and a long-standing condition. Scores were calculated and observations outside of the region of common support - individuals with a higher score than the maximum or a lower score than the minimum observed in the other group - were not included in the matched

samples (33). Indicators used to calculate the propensity scores included self-rated health and the presence of a disability, as well as all adjustment variables detailed above except the type of work schedule, as this was unlikely to influence take-up of a certain form of employment, being more intrinsically linked to a job. It is strongly recommended to use pre-treatment/pre-exposure variables for establishing the matched sample, however, some of the indicators (such as health) included in the matching could have already been impacted by exposure to certain forms of employment, likely to impact (and introduce bias to) our estimates (32). As a last step, we ran the Cox models (adjusting for all variables used for matching as well as work schedule) on the matched samples. It needs to be noted that as binary matches were conducted, the matched sample of permanent employees (the "control group") was likely to slightly differ in each case (34). The analyses were carried out using STATA 14.2 (StataCorp, College Station, TX, USA.) and R (35), using the MatchIt package in the latter (36).

## Results

### Description of the research population

As table 1 shows, permanent employees formed the biggest group and fixed-term workers made up the largest non-standard group among both genders. Whereas around a third of male permanent employees and almost half of female permanent employees had tertiary qualifications, this proportion was only 12-13% among seasonal workers and around 19% among casual workers. The levels of educational attainment among female fixed-term workers were nearly comparable to those undertaking permanent employment. The prevalence of migration background was higher among all nonstandard than permanent workers. Inequalities in housing tenure were also observed.

### Analysis of mortality risks

Table 2 presents the results for all-cause mortality, whereas the cause-specific results are displayed in tables 3 and 4 for men and women, respectively. In total, over 40 000 deaths occurred over the 2001-2014 period. The age-adjusted models revealed that among men, all but casual workers were predisposed to higher risk of allcause mortality than were permanent workers. The same held for cancer mortality. Holding a temporary agency or a fixed-term job or being employed in an employment program was a predictor for a raised risk of all-cause mortality among women.

Further adjustment shows that some of the associations can be explained by permanent and non-standard workers' differing socio-demographic and work-related characteristics. Among men, adjusting for educational attainment and housing tenure, and among women, accounting for the economic sector of main job and housing tenure reduced the point estimates to the largest extent. Additional adjustment for total weekly working hours, work schedule and multiple job-holding, however, did not attenuate the estimates of employment forms much (data not shown). As shown in the supplementary material (www.sjweh.fi/show_abstract. php?abstract_id=3931), tables S1 and S2, among men, working >40 hours a week, whereas among women, working less than the conventional full-time hours was linked to a reduced risk of all-cause mortality. Working shifts was linked to a higher risk of mortality from all causes, as well as from external causes and suicide among men, compared to working sliding hours.

Among men after adjustment, temporary agency, seasonal and fixed-term workers as well as those in employment programs in 2001 experienced excess risk of all-cause mortality in the subsequent 13 years compared to their permanently employed counterparts. We found an over twofold increased hazard ratio (HR) for all external causes [HR 2.07, 95% confidence interval (CI) 1.66-2.56], suicide (HR 2.17, 95% CI 1.61-2.91) and fall (HR 2.34, 95% CI 1.03-5.29) among male temporary agency workers, and an over five times higher risk of death due to transport accidents among male seasonal workers (HR 5.04, 95% CI 2.07-12.27). This is the highest adjusted HR exhibited in the study, although the CI is wide due to the small number of events. Male temporary agency (HR 1.38, 95% CI 1.13-1.68), seasonal (HR 1.64, 95% CI 1.02-2.65), fixed-term workers (HR 1.22, 95% CI 1.08-1.38) and those in employment programs (HR 1.21, 95% CI 1.00-1.46) experienced raised adjusted cancer mortality in comparison to permanent employees, and those employed within the framework of an employment program or holding a temporary agency contract were at heightened risk of death from circulatory diseases.

Among women, holding a temporary agency job, compared to being permanently employed, was a predictor for a higher risk of mortality from all causes (HR 1.28, 95% CI 1.09-1.51), circulatory diseases (HR 1.57, 95% CI 1.03-

2.38), all external causes (HR 1.92, 95% CI 1.30-2.83) and transport accidents (HR 2.52, 95% CI 1.22-5.17) after adjustment. All-cause mortality was also slightly increased among women undertaking fixed-term jobs (HR 1.14, 95% CI 1.04-1.24), but a break-down by causes did not show elevated point estimates.

Sensitivity analysis

Additional analyses on the matched samples (as presented in supplementary table S3) showed that for male seasonal workers, the association with all-cause and cancer mortality was no longer present in the matched sample. This, however, cannot be said about male temporary agency workers, where the HR of their employment situation remained to be elevated for all causes investigated, apart from falls, after adjustment. The slightly elevated all-cause mortality found for male fixed-term employees and men in employment programs was also not explained by known confounding factors. Among women, fixed-term employees had a slightly increased relative risk of all-cause mortality in comparison to permanent employees.

Discussion

Our study, which to our knowledge is the first one to assess associations between forms of non-standard employment and mortality using population-wide data, revealed considerable mortality inequalities within the salaried employee population in Belgium. Over the subsequent 13 years and three months of follow-up, certain non-standard workers were at increased risk of death compared to permanently employed workers. Our analyses add to existing evidence on the negative relationship between non-standard and temporary employment and health (6-9), and in particular to the handful of studies which looked at mortality outcomes (17-19) in the past. The considerable mortality inequalities we found indicate that exposure to certain forms of employment that deviate from permanent employment - however brief that may be - could be associated with a 'health scar' (11, 12). More broadly speaking, our investigation also links to unfolding discussions and growing evidence on the health implications of precarious employment (37).

An important contribution of this study lies in showing that the different forms of non-standard employment under examination were associated with different mortality risks and patterns. Particularly male temporary agency and seasonal workers were predisposed to elevated mortality relative to their permanent counterparts. This points to the heterogeneity between types of non-permanent workers when it comes to health and mortality, as observed - albeit differently - in prior research (17). Our results are also somewhat in line with a previous study, which demonstrated a health disadvantage for a group of non-permanent employees comprising seasonal and temporary agency workers compared to permanent workers - albeit not for fixedterm workers (21).

In the case of men in seasonal employment, however, accounting for socio-demographic and work-related characteristics often attenuated their mortality risks. Additional analyses on matched samples also underlined the role of confounding for this group of workers. Male temporary agency workers' relative mortality risks, on the other hand, remained quite consistently raised after full adjustment, as well as matching. They demonstrated a substantial mortality disadvantage, despite the legislative framework this form of work is subject to in Belgium (38). Our results overall underline that, from a health perspective, some non-permanent jobs (such as casual employment) might overall be less disadvantageous and leave its holders less vulnerable than others (like temporary agency work) (see 39). This study overall reveals the presence of a core and periphery (18, 21) within the Belgian labor force from a mortality perspective, although it also shows that this distinction may be limiting. Some non-permanent jobs might be more peripheral than others, indicating the need to move beyond a binary conceptualization of labor market segmentation. Temporary agency work, in particular, could cluster together with other adverse aspects of employment, putting workers at the lowest spectrum of employment quality (40), whereas some non-permanent jobs might be more advantageous in this regard. Workers in various work arrangements might also differ in their ability to obtain permanent employment later on, and in their likelihood to have transitioned out of or into unemployment before or after 2001.

A further insight our analysis has provided pertains to the specific causes of death. Excess mortality from external causes in temporary workers has been demonstrated in a prior study (19). Temporary agency workers were, after adjustment, and in comparison to, permanent employees, at an around twofold risk of dying from all external causes.

When delving into the sub-causes, we found similarly elevated fall mortality in male temporary agency workers with conventional regression adjustment, although the low number of events needs to be stressed. Workplace accidents resulting from unsafe working conditions, faster working tempo or insufficient job-specific knowledge among this group could be explaining factors in this association (5, 41, 42). Our results are in line with earlier findings (41) which indicated that temporary employment as a whole was particularly strongly associated with fatal work-related injuries (which covered some types of falls). Male temporary agency workers were also at a heightened relative risk of death by suicide. Transport accidents were causes of an excess risk of mortality in temporary agency and male seasonal workers. Further investigation should probe into the underlying mechanisms. Finally, contrary to earlier studies (18, 19), we found an elevated risk of both circulatory and cancer mortality (after adjustment) in some groups of non-permanent workers, compared to permanent employees, although some of this mortality disadvantage could be ascribed to confounding factors. Our data's population-wide coverage, and the possibility of differentiating between various sub-groups of nonstandard workers probably revealed some previously hidden mortality inequalities in this regard.

Our study also showcased strong gender differences. Female non-standard workers exhibited smaller HR overall than did their male counterparts and demonstrated less pronounced mortality patterns. This goes contrary to arguments that precarious employment could be more detrimental to women's than men's health (43), although our findings might be pertinent to the specific health outcome under study (44). There are indications that non-standard employment as a whole (including part-time employment) has a gendered distribution among households in Belgium (45). Female non-standard workers' unstable or low incomes could thus often be supplemented by their partner's (potentially more stable) wages, reflected in female temporary employee's lowers odds of being below the poverty line compared to their male counterparts (46). Overall, the less prominent position of employment in many women's lives may attenuate the mortality outcomes found in this study. Future research should strive to gain a broader household-perspective (45) when analyzing the health and mortality implications of non-standard employment.

Some limitations of our study need to be mentioned. Although the census provided information on all individuals in our subpopulation, it did so at one point in time. Individuals' broader employment trajectories, including the length of exposure to unemployment, which has been linked to subsequent mortality (14-16), could not be accounted for, nor did we have information on the length of time individuals spent in specific non-standard employment arrangements. There was also no information available in the census on individuals' lifestyle (eg, alcohol consumption or smoking) (18, 19), nor could we account for health status and other aspects prior to the census, a limitation for our sensitivity analyses. Restricting the analyses to healthy individuals with no long-standing illness or disability at the time of the census - and accounting for health status as part of our matching - meant however that we were able to reduce some of the potential health selection effects. Lastly, we could not fully construct a multidimensional index of precarious employment, and instead mostly relied on contractual instability, which, albeit widely used as a measure (47), has been shown to constitute only a partial proxy of employment precariousness (48). Nevertheless, we did additionally account for working hours, work schedule and multiple job-holding in our analyses.

Overall, our study's main strength stems from the register-based data we were able to draw on. The population-wide coverage and 13 years of mortality followup allowed us to evaluate cause-specific mortality, differentiate between various sub-groups and study longterm outcomes. This unique dataset enabled us to demonstrate considerable relative excess mortality for some groups of non-standard employees compared to permanent workers. Moreover, due to the large sample size, we were able to study mortality for employment forms separately for women and men, revealing substantial differences in patterns and extents of risks. In conclusion, we showed that taking non-permanent workers as one group conceals mortality inequalities within them. A dichotomous core-periphery understanding, therefore, might be less helpful in explaining mortality inequalities within the workforce. Further research on work-related health should therefore strive to study groups of workers in various contractual arrangements separately, while also accounting for spells of unemployment and changes between jobs with differing levels of precarity. This prerequisites access to adequate longitudinal data with information on trajectories and different aspects of working conditions. We also highlighted the need for studying the long-term health effects of

employment experiences, particularly among non-permanent workers. Monitoring the latter's health can be challenging from an occupational health and safety perspective (49), but is certainly warranted. All in all, policy-makers should pay more attention to non-standard employment as a potential work-related health determinant.

Concluding remarks

Our investigation shows that male workers in temporary agency contracts in 2001 in particular exhibited relative excess mortality compared to permanent workers during a more than 13-year follow-up period and that external causes of death played an important role in this association. This association persisted after accounting for differing characteristics between temporary agency and permanent workers.

Conflict of interest

The authors declare no conflicts of interest.

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## Sidebar

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1 Interface Demography, Vrije Universiteit Brussel, Brussels, Belgium.

2 Institute for Employment Research, University of Warwick, Coventry, UK.

3 Health Inequalities Research Group Employment Conditions Network (GREDS-EMCONET), Pompeu Fabra University, Barcelona, Spain.

Correspondence to: Rebeka Balogh, Department of Sociology, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium. [E-mail: Rebeka.Balogh@vub.be]

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# A longitudinal study of changes in interactional justice and subsequent short-term sickness absence among municipal employees

Koskenvuori, Mika, PhD [1] ; Pietiläinen, Olli, PhD [1] ; Elovainio, Marko, PhD [2] ; Rahkonen, Ossi, PhD [1] ; Salonsalmi, Aino, PhD [1] [1] Department of Public Health, University of Helsinki, Helsinki, Finland [2] Department of Psychology and Logopedics, University of Helsinki, Helsinki, Finland



## ABSTRACT (ENGLISH)

Objectives Level of perceived interactional justice has been shown to be associated with sickness absence, but less is known about the effects of changes in interactional justice. It is also unknown to what extent unmeasured, time-invariant differences contribute to the association. We investigated the association between interactional justice changes and subsequent short-term (1-3 days) sickness absences over a 12-year follow-up using between-and within-individual modeling among ageing municipal employees. Methods The data was derived from Helsinki Health Study cohort with baseline survey in 2000-2002 (N=8960, response rate 67%) and follow-up surveys in 2007 and 2012 (response rates 79% and 83%, respectively). At baseline, participants were 40-60-year-old employees of the City of Helsinki, Finland. Sickness absences from the employers registry were linked with the responses (78%). The analytic sample was 2109 and 2070 individuals for between-individual and 4433 individuals and 8425 observations for within-individual associations. Results Negative change in interactional justice was associated with an increased risk of short-term sickness absence in between-individual models after adjusting for age and gender. Adjustment for sickness absence history attenuated the association. In within-individual models, a negative change in perceived interactional justice was associated with an increased risk of short-term sickness absence spells [incidence rate ratios (IRR) 1.05 (95% confidence interval 1.01-1.09)]. This association was robust to adjustments for gender, age, health behaviors and sickness absence history. Conclusions Paying attention to management principles - especially managerial behavior and treatment of employees to avoid the deterioration of the level of interactional justice - may provide a way of reducing self-certified short-term sickness absence history.

## FULL TEXT

### Headnote

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changes and subsequent short-term (1-3 days) sickness absences over a 12-year follow-up using between-and within-individual modeling among ageing municipal employees.
Methods The data was derived from Helsinki Health Study cohort with baseline survey in 2000-2002 (N=8960, response rate 67%) and follow-up surveys in 2007 and 2012 (response rates 79% and 83%, respectively). At baseline, participants were 40-60-year-old employees of the City of Helsinki, Finland. Sickness absences from the employers registry were linked with the responses (78%). The analytic sample was 2109 and 2070 individuals for between-individual and 4433 individuals and 8425 observations for within-individual associations.
Results Negative change in interactional justice was associated with an increased risk of short-term sickness absence in between-individual models after adjusting for age and gender. Adjustment for sickness absence history attenuated the association. In within-individual models, a negative change in perceived interactional justice was associated with an increased risk of short-term sickness absence spells [incidence rate ratios (IRR) 1.05 (95% confidence interval 1.01-1.09)]. This association was robust to adjustments for gender, age, health behaviors and sickness absence history.
Conclusions Paying attention to management principles - especially managerial behavior and treatment of employees to avoid the deterioration of the level of interactional justice - may provide a way of reducing self-certified short-term sickness absence spells.
Key terms between-individual; change-effect; fixed effect; organizational justice; self-certified sickness absence; sickness absence spell; within-individual.
One established theoretical model explaining the association between work-related psychosocial factors and employee health is the organizational justice model of occupational strain (1). The model is based on the idea that, in addition to distributing resources and obligations within organizations, also the procedures and rules that guide decision-making in organizations matter. Studies of these rules and procedures have provided the basis for a new line of research examining decision-making and social relationships in working communities, ie, distributive, procedural and interactional justice that are the basic dimension of organizational justice. The idea behind the interactional justice dimension (2) suggests that people are not only sensitive to the actual decisions or the procedures leading to decisions, but also the way they are treated by those making the decisions. It has been argued that in todays increasingly social work life, the interactional dimension of organizational justice becomes increasingly important to employee wellbeing and health (3). Unfair treatment has been shown to evoke strong negative emotions, such as anger, anxiety and psychological distress (4), that in turn have direct physiological links to adverse health outcomes. Perceived injustice has been associated with vascular dysfunction (5), metabolic syndrome (6) and inflammatory markers (7). Indeed, the levels of various dimensions of organizational justice have repeatedly been shown to be associated with various health outcomes, including protection from sickness absence following a major life event (8), sickness absences among older employees (9) or among employees with mental disorders symptoms (10-11), disability pension (12) and retirement intentions (13). Specifically, the association between the interactional justice dimension and employee health have shown to be strong (3, 14).
In previous studies, the potential effects of organizational justice perceptions have been studied by calculating levels of perceived justice at two time points and comparing individuals with constantly low to those with increasing, decreasing or constantly high perceived organizational justice. The analyses have been conducted by comparing the effects between individuals reporting low organizational justice to the individuals reporting high organizational justice (so called between-individual analysis). This methodology has two problems: (i) the cut-off points for high and low groups may be artificial and the cut-off point may change over the years and ii) the between-individual analysis is unable to consider confounding by all time-invarying confounders (the unmeasured differences between the groups that explain the relationship between the organization justice and the outcome variable) (15). This effect can be mitigated by using the so called within-individual analysis, where each individual acts as a reference only to themselves, effectively removing the effects of unmeasured timeinvariant differences between the individuals. Other problems in previous studies include monomethod bias (measuring both exposure and outcome using the same measure) and short follow-ups. In this study, we used register-based sickness absences as our health

indicators and examined the association between the changes in interactional organizational justice and short-term sickness absence spells (SSAS) over 12-year follow-up and three measurement points. We used both between and within-individual modeling among ageing employees of the capital city of Finland, Helsinki, to find out possible association between changes in interactional justice and SSAS and compare two different modeling modalities. Sickness absences are often classified according to their length - to short- and long-term spells - or according to the certification method - to self- or medically certified. Reasons for short- and long-term absences are thus somewhat different. SSAS (1-3 days) are often self-certified and thus do not require a medical verification - therefore short absences may be less closely related to medically certified conditions. SSAS are more likely than medically certified sickness absence spells to reflect problems in working conditions, of which interactional justice is a significant component (12).We presumed that within-individual perceived association between organizational justice and SSAS is smaller when compared to between-individual perceived one, but that the association will be more robust with respect to a number of confounders.

Methods

Data

This study is part of the Helsinki Health Study examining the health and well-being of the ageing employees of the City of Helsinki (16). The City of Helsinki is the largest employer in Finland with approximately 40 000 employees, 72% of whom are women (17). The range of occupations is large and heterogeneous with over 100 occupational titles, covering both blue- and white-collar jobs. The data consisted of the Helsinki Health Study baseline (2000-2002) and two follow-up (2007, 2012) questionnaire surveys and the City of Helsinki personnel register data on sickness absence. All employees reaching 40, 45, 50, 55, and 60 years in 2000, 2001, and 2002 received the baseline survey. Altogether, 8960 employees responded to the baseline survey (response rate: 67%), 7332 to the first follow-up survey (response rate: 83%) and 6809 to the second (response rate: 79%). The follow-up questionnaires were only sent to the individuals who responded to the baseline questionnaire. As the baseline data were collected over three consecutive years, the period between baseline and follow-up surveys varies between 5-7 years. However, the first questionnaire in 2000 (N=3141) did not contain the questions about organizational justice, which limited the study population. The survey data were linked to the City of Helsinki personnel register data on sickness absence for those with written consent for such linkage (78%, N=5893). To be included in the study population in the between-individual analysis, a person must have responded to the baseline (2001-2002) and at least one follow-up (2007 or 2012) survey.

Individuals were excluded from the study from the moment they were no longer employed by the City of Helsinki. The largest reason for the attrition was retirement (N=1272 and 2210 in 2007 and 2012 respectively). In addition, those with missing values in any of the study variables were excluded from the betweenindividual analyses to assure the comparability of different models. However, they were not excluded from the within-individual analysis if they had any complete observations in any of the survey waves. No inputation was used for any data.

The final study population in the between-individual analysis comprised of 2109 and 2070 individuals for the baseline-2007 wave and 2007-2012 wave, respectively and 4433 individuals and a total of 8425 observations for the within-individual analysis. The gender split in the study reflects well the typical gender split in Finnish public sector (80% women).

The Ethics Committees of the Department of Public Health, University of Helsinki, and the health authorities of the City of Helsinki approved the study.

Measures

Interactionaljustice. The level of interactional justice was calculated using the four questions included into the Helsinki Health Study from the original six questions introduced by Moorman (18): (i) Our superior listens to the viewpoints of the employees in important subjects; (ii) Our superior is able to suppress personal bias; (iii) Our superior treats the employees with kindness and consideration; and (iv) I can trust our superior (Cron-bach's a = 0.89, 0.89 and 0.91 in baseline, 1st follow-up and 2nd follow-up, respectively). Each question had five different alternative answers from fully object (value 1) to fully agree (value 5). A sum score (4...20) was calculated from this

for each participant at each wave.
The interactional justice score was dichotomized at lowest tertile on the baseline. For the between-individual analysis the participants were split into four different categories according to the changes in the reported interactional justice: (i) stable high, (ii) stable low, (iii) change low-high and (iv) change high-low. The change was determined based on the results of two consecutive waves (baseline - >1st follow-up and 1st follow-up - >2nd follow-up).
For the within-individual analysis, the same dichot-omy for interactional justice was used to define each individual's perception of interactional justice at maximum of three time points (baseline, 2007 and 2012). Here the individuals were no longer grouped according to the change in perceived interactional justice, but the change was introduced at each time point by comparing the measured value of interactional justice with the mean value of interactional justice for each individual (see statistical methods). It should be noted that no universally agreed cut-off point exists for dichotomization, and a hybrid model would allow alternative methods for the treatment of interactional justice. However, in order to maintain the comparability between the models used in this study and with the previous works, a dichotomization approach was chosen.
Sickness absences
For Finnish municipal employees, SSAS are employee self-certified, 1-3-day absences. Longer absences require medical confirmation. The amount of SSAS for each individual was obtained from the employer's register, however, the causes of SSAS's were not available. The amount of SSAS were calculated for the three-year period following the first and second followup questionnaires or until the person was not any more employed by the City of Helsinki due to changing jobs or retirement. The average follow-up times were 2.7 and 2.6 years after the first and second follow-up questionnaires, respectively. The amount of SSAS during each three-year period following the measurement of interactional justice was used as a dependent (=outcome) variable in all the models.
Long-term sickness absences were not controlled as a separate covariate, but their duration as well as duration of other absences from work was deduced from the amount of working days to reduce the exposure time (see statistical methods).
Covariates
Gender and age were measured at baseline and used as covariates in all the models. Because no gender interactions (P>0.1) were found, men and women were analyzed together. As previous sickness absence is a significant predictor for the sickness absences (19), the amount of SSAS during the baseline survey (20002002) was added as a covariate. The rest of the covariates were measured simultaneously with the measurement of the perceived interactional justice in each wave (ie, the covariates were time variant). The treatment of the covariates was different for between- and withinindividual analyses (see statistical methods).
Being overweight and health behaviors were assessed via dichotomous variables: overweight (selfreported height / weight with cut-off at BMI >25 kg/ m2) and three variables representing health behaviors: alcohol use (problem drinker on CAGE questionnaire) (20), tobacco smoking (after individual responses for current smoking) and leisure-time physical activity [total of four questions on physical activity were converted to approximate metabolic equivalent (MET) index with cut-off at 14 MET hours] (21).
All the models in within-individual analysis were adjusted with additional random effect parameter for survey wave to take into account potential differences due to the measurement phase, workplace and sickness absence compensation. Table 1 describes the study population in detail.
Statistical methods
Due to the overdispersion of the data, negative binomial regression was used to calculate the incidence rate ratios (IRR) and their 95% confidence intervals (CI). Because the amount of working days during the study period varied among the study population, the absolute amount of SSAS was transformed to rate data (number of SSAS per working days) by adding the natural logarithm of the working days during the observation periods as an offset-parameter to the models. Therefore, the amount of working days represented the amount of exposure to SSAS for each individual. Three different models were used in both phases of modeling with varying covariates: model

1 = gender and age of the individuals at baseline, model
2 = model 1 + baseline SSAS, and model 3 = model 2 + weight and health behaviors. The analysis was done in two parts: between- and within-individual association.

Between-individual association

First the between-individual association between the change in interactional justice and SSAS was studied using generalized linear model. The reference category was interactional justice stable high to which the association between the change in interactional justice and risk for SSAS in other groups was compared.

Within-individual association

To further analyze the association between changes in individual's experience of interactional justice and SSAS and remove the effect of unobserved bias from the results, the association between the changes in interactional justice and SSAS was studied using withinindividual (or fixed-effects) regression analysis. Here the data from all three waves was pooled into a common pool of observations and used to derive withinindividual estimates for the association between the interactional justice and SSAS. The within-individual analysis automatically controls for all the obvious timeinvariant variables, such as gender and age at baseline, but also for all the other unmeasured time-invariant personal, demographic or environmental factors that may cause bias in the results (22). Disregarding the betweenassociation and focusing only on within-association is also an effective method to study if the effects of change in outcome variable are associated with changes in the explanatory variable (23).

The within-individual analysis is typically performed using a model with random effects. Random effects model assists in controlling the unobserved heterogeneity by splitting the unexplained variance into different levels of hierarchy (in this study temporal and individual levels) by introducing a residual (ie, error term) at each level. This splitting also allows the model to treat the lower-level entities unidentical thus maintaining for example the temporal hierarchy and giving the opportunity to make use of the longitudinal nature of the data (24).

However, conventional random effects model assumes that the residuals are uncorrelated with the observed covariates, which is typically an unrealistic assumption. If this assumption is violated, the model coefficients are biased. Another common way to introduce the individual specificity into a model is to use fixed-effects modeling. This can be achieved for example by introducing a dummy variable corresponding each individual to the model or typically more computationally efficiently by replacing the values of the covariates at each wave with the individual variances (deviation from each individual's mean score for each variable). However, it has been shown that conditional fixed effects do not truly control for the fixed covariates when used with negative binomial regression models (25).

To overcome the limitations of both models, an alternative solution, a so-called hybrid model, was selected as proposed by Allison (26) in the spirit of Mundlak (27) and previously used elsewhere (28-30). In the hybrid model, a random effects model is fitted with two variables for each time-varying regressor: individualspecific mean value and individual-specific variance to control for the between- and within-individual effects, respectively. This is done for all the models of hybridmodel modality by adding the individual specific mean and variance values as regressors. The hybrid model used gives the possibility to examine both within- and between-individual associations simultaneously and the credibility of hybrid model can be improved by comparing the associations for both dependent variables and covariates from traditional between-individual to associations decomposed from the hybrid model.

All the analyses were done using R (31) and the hybrid-model analysis used the glmmTMB-package (32).

Results

Table 2 shows the mean amount of SSAS for employees with exposures to different changes in interactional justice. The employees experiencing constant high interactional justice (stable high) had the smallest amount of SSAS as such (5.25) and when compared to the working days (0.63 per 100 working days). The negative change group (change high-low) had the highest amount of SSAS (6.14) and most days (0.75 / 100 working days). The mean amount of SSAS decreased from 1st to 2nd follow-up.

Between-individual association

Table 3 summarizes the IRR values and 95% CI of the between-individual analyses. For all the models and both

waves, the individuals experiencing constant high interactional justice (stable high) had the lowest risk for SSAS. Being younger or of female gender increased the risk. In the first model with only gender and age as covariates, the risk was increased by 12% (15% in 2007-2012 wave) or 16% (16% in 2007-2012 wave) when the individual was exposed to stable low or change to low interactional justice, respectively. Association for change to high interactional justice was not statistically significant. Adjusting the model for baseline SSAS attenuated the associations, and only interactional justice change to low in 2007-2012 data set remained at 13% increased risk (95% CI 1.02-1.26).
In general, the risk for SSAS among individuals experiencing a positive change in interactional justice (change low-high) was lower than for the individuals experiencing either a negative change or constant low interactional justice. It can also be observed on both waves that individuals experiencing a change to low interactional justice had a greater risk for SSAS than individuals exposed to constant low interactional justice. However, when adjusting for baseline SSAS (model 2) and health behaviors (model 3) the associations attenuated (IRR 1.10, 95% CI 1.00-1.21)
Within- and between individual associations from the hybrid model
Table 4 summarizes the IRR values for both within- and between-individual associations decomposed from the hybrid model when the perceived interactional justice changes from high to low. For within-individual association, the change in interactional justice from high to low was associated with IRR 1.05 (95% CI 1.01-1.09) fold increase in the risk of SSAS, and this association was robust for adjustment for various variables. In betweenindividual analysis the change was associated with IRR 1.19 (95% CI 1.10-1.29) fold increase in the risk of SSAS in model 1 and was not statistically significant once the model was adjusted for baseline SSAS (model 2) and overweight and health behaviors (model 3).
Discussion
The aim of the study was to assess the association between changes in interactional justice and SSAS among municipal employees using two methodologies: between- and within-individual. Both modelling methodologies indicated a small association between nega- tive change in interactional justice and SSAS, but the magnitude of the association was weaker in within-individual models. Also, the contribution of SSAS history and health-related covariates was examined. Adjustment for SSAS history attenuated the association in betweenindividual models whereas the association remained after all adjustments in within-individual models.
Previous studies of the association between interactional justice and sickness absence are scarce. A study by Hjarsbech et al (10) on 1034 Danish employees found no association between levels of interactional justice and long-term sickness absences. Elovainio et al (8) showed that despite the perception of interactional justice, employees had as much sickness absences from work after a major life event, but they returned to work after a longer period if they perceived interactional justice to be low, compared to those who perceived interactional justice to be medium or high. In a study by Head et al (33) on British civil servants, the risk for short-term sickness absence was 4-26% higher for individuals experiencing low interactional justice depending on the model and study population. In study by Spanier et al (34), the risk for self-reported sickness absences was 34% higher for the group that experienced low organizational injustice. Even though none of the studies analyzed the association between changes of interactional justice and SSAS, the results are comparable to this study. The previous stud-ies did not, however, adjust for the baseline SSAS and utilized between-individual modelling. The magnitudes of the associated risks are of the same order as for risks associated with increase in job demand or decreased job control (35-37), which have been reported to be in the order of 10-40%.
In this study, the magnitude of the between individual associations for dependent variables and confounders were similar in both the traditional between-individual modeling using generalized linear model and betweenindividual association decomposed from the hybrid model. Still, the magnitude of association differed from within-individual modelling suggesting unobserved time-variant differences between the individuals exist that play role in the association. Thus, ignoring unobservable differences might overstate the association. In addition, between-individual modeling was not able to capture statistically significant association between the changes in interactional justice and SSAS after adjustment for SSAS history. Our results thus suggest that within-individual model might be a better approach to study the association between changes in perceptions of justice and SSAS.

The low magnitude of the association in withinindividual analysis (5%) is not a surprise as major contributors to sickness absence are typically health-related. This reasoning is further supported by the finding that the between-individual association is higher than withinindividual association. In practice, it insinuates that individuals who report low organizational justice during some study interval are prone to having higher levels of SSAS also during the periods when they do not report low organizational justice. The analysis of reasons for this are beyond the scope of this article, but healthrelated factors cannot be excluded. Further fortification can be drawn from the observation of decreased association when health-covariates are adjusted. The modest magnitude of the association is also in line with the arguments by Zapf et al (38) that small correlations are expected in longitudinal studies as physical and mental health are influenced by a multitude of factors.

In the within-individual model, the associations were found to be robust for adjustments for gender, age, SSAS history, weight and health behaviors. The results thus suggest that negative change in interactional justice truly contributed to the association instead of only reflecting the contribution of previous sickness absence spells and weight and health behaviors. In addition to the covariates described in the text, the effects of common mental disorders (after GHQ-12 questionnaire), shift work and mentally and physically strenuous job conditions were also examined, but they did not affect the association (data not shown).

The overall decline in the amount of sickness absences with respect to study waves (table 2) gives a hint about the signs of "healthy-worker effect" (HWE) in the cohort, where the healthier employees stay longer in the working population thus effectively lowering the mean amount of sickness absences with respect to time (39). As the HWE depends on time, it is not corrected for in within-individual analysis. On the other hand, the work ability should be seen as a continuum or multidimensional rather than a binomial variable (40). This way the effect of proper organizational justice can even increase sickness absence spells, while on the other hand prolonging the working career and delaying the retirement due to work disability. This analysis is, however, outside the scope of this study.

A clear strength of the study is the use of within-individual analysis to complement the between-individual analysis. The study benefits from follow-up data on employed people combined with a register-based data on sickness absence which increases the credibility on the data.

However, data from only one public sector employer was used and thus a question arises whether the results can be generalized also to private sector or to industry. Also due to the typical feature of Finnish municipal employers, the women are significantly more represented than men. Thus, the data cannot directly be generalized to all the employees but has a potential to be generalized to municipal employees or public sector employees. Also, even though the data contains baseline and two followup studies, the amount of data points for each individual in within-individual analysis is modest at best. Therefore, future studies should include more study waves to increase the number of data points as more follow-up studies become available. Increasing the number of data points would open the possibility to solve the problems related with the dichotomization of the predictor variable as with the hybrid model the interactional justice can be treated as a continuous predictor. Additionally, with a continuous predictor, also curvilinear (eg, quadratic) relationships with the outcome variable could be explored. The future studies should also aim for populations with more men and for the private or industrial sector employees.

Concluding remarks

In conclusion, the study showed that a negative change in interactional justice was associated with the risk of SSAS. In within-individual analysis, this association was robust against a number of confounders, including SSAS history, suggesting true contribution of interactional justice. In future studies, within-individual modeling might have an advantage to between-individual analysis that has typically been used.

The associated risk between the change in interactional justice and SSAS was rather small but as the association is established, paying attention to improving the interactional justice might aid in reducing SSAS without implying major costs to the employer.

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Competing interests

None declared.

## Sidebar

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Correspondence to: Mika Koskenvuori, Department of Public Health, PO BOX 20, FI-00014, University of Helsinki, Finland. [E-mail: mika.koskenvuori@helsinki.fi]

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# Harmonized definition of occupational burnout: A systematic review, semantic analysis, and Delphi consensus in 29 countries

Canu, Irina Guseva, PhD; Marca, Sandy Carla, MSc; Dell'Oro, Francesca, PhD; Balazs, Adam, PhD; Bergamaschi, Enrico, PhD; Besse, Christine, MD; Bianchi, Renzo, MD; Bislimovsk, Jovanka, PhD; Bjelajac, Adrijana Koscec, PhD; Bugge, Merete, PhD; Busneag, Carmen Iliana, MD; Caglayan, Cigdem, MD; Cernitanu, Mariana, PhD; Pereira, Cristiana Costa, PhD; Hafner, Natasa Dernovscek, PhD; Droz, Nadia, MsC; Eglite, Maija, PhD; Godderis, Lode, PhD; Gundel, Harald, PhD; Hakanen, Jari J, PhD; Iordache, Raluca Maria, PhD; Khireddine-Medouni, Imane, MD; Kiran, Sibel, PhD; Larese-Filon, Francesca, MD; Lazor-Blanchet, Catherine, MD; Legeron, Patrick, MD; Loney, Tom, PhD; Majery, Nicole, MD; Merisalu, Eda, MD; Mehlum, Ingrid Sivesind, PhD; Michaud, Laurent, MD; Mijakoski, Dragan, PhD; Minov, Jordan, PhD; Modenese, Alberto, PhD; Molan, Marija, PhD; Van der Molen, Henk, PhD; Nena, Evangelia, PhD; Nolimal, Dusan, MD; Otelea, Marina, PhD; Pletea, Elisabeta, PhD; Pranjic, Nurka, PhD; Rebergen, David, PhD; Reste, Jelena, PhD; Schernhammer, Eva, MD; Wahlen, Anny, MSc

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## ABSTRACT (ENGLISH)

Objective A consensual definition of occupational burnout is currently lacking. We aimed to harmonize the definition of occupational burnout as a health outcome in medical research and reach a consensus on this definition within the Network on the Coordination and Harmonisation of European Occupational Cohorts (OMEGA-NET). Methods First, we performed a systematic review in MEDLINE, PsycINFO and Embase (January 1990 to August 2018) and a semantic analysis of the available definitions. We used the definitions of burnout and burnout-related concepts from the Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) to formulate a consistent harmonized definition of the concept. Second, we sought to obtain the Delphi consensus on the proposed definition. Results We identified 88 unique definitions of burnout and assigned each of them to 1 of the 11 original definitions. The semantic analysis yielded a first proposal, further reformulated according to SNOMED-CT and the panelists' comments as follows: "In a worker, occupational burnout or occupational physical AND emotional exhaustion state is an exhaustion due to prolonged exposure to work-related problems". A panel of 50 experts (researchers and healthcare professionals with an interest for occupational burnout) reached consensus on this proposal at the second round of the Delphi, with 82% of experts agreeing on it. Conclusion This study resulted in a harmonized definition of occupational burnout approved by experts from 29 countries within OMEGA-NET. Future research should address the reproducibility of the Delphi consensus in a larger panel of experts, representing more countries, and examine the practicability of the definition.

## FULL TEXT

### Headnote

Objective A consensual definition of occupational burnout is currently lacking. We aimed to harmonize the definition of occupational burnout as a health outcome in medical research and reach a consensus on this definition within the Network on the Coordination and Harmonisation of European Occupational Cohorts (OMEGA-NET).

Methods First, we performed a systematic review in MEDLINE, PsycINFO and Embase (January 1990 to August 2018) and a semantic analysis of the available definitions. We used the definitions of burnout and burnout-related concepts from the Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) to formulate a consistent harmonized definition of the concept. Second, we sought to obtain the Delphi consensus on the proposed definition.

Results We identified 88 unique definitions of burnout and assigned each of them to 1 of the 11 original definitions. The semantic analysis yielded a first proposal, further reformulated according to SNOMED-CT and the panelists' comments as follows: "In a worker, occupational burnout or occupational physical AND emotional exhaustion state is an exhaustion due to prolonged exposure to work-related problems". A panel of 50 experts (researchers and healthcare professionals with an interest for occupational burnout) reached consensus on this proposal at the second round of the Delphi, with 82% of experts agreeing on it.

Conclusion This study resulted in a harmonized definition of occupational burnout approved by experts from 29 countries within OMEGA-NET. Future research should address the reproducibility of the Delphi consensus in a larger panel of experts, representing more countries, and examine the practicability of the definition.

Key terms epidemiology; exhaustion; job stress; occupational health.

Despite more than half a century of research on occupational burnout, little is known about its prevalence, etiology, treatment, or prevention. The lack of consensus on the nature of burnout has led to a proliferation of definitions and measures of the construct (1). This state of affairs has precluded a reliable estimation of its incidence and prevalence and has negatively affected the quality of research on this outcome. In the context of increasing burnout complaints (2-5) and recognition of incapacity for work due to mental ill-health (6), the need for a harmonized definition of this concept seems urgent.

A definition standardizes and regulates how a particular term should be used, ie, it is a sentence that fixes and establishes both the meaning of an expression and the syntax of its use (7). Therefore, definitions have an instrumental value as they help to systematize knowledge (8). Moreover, when introducing a new term into a vocabulary, definitions enhance its formalexpressive power. Controlled vocabulary or terminology is designed by a group of experts and only contains authorized technical terms of a specific field (8). In the field of medicine, the

Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) is the most comprehensive and reliable terminology (9, 10). For example, it contains the term 'burnout' and its definition. Nonetheless, most professionals are unaware of its existence, instead referring to the International Statistical Classification of Diseases and Related Health Problems (ICD) (İl). Yet, the ICD is a coding system aimed at statistically classifying medical information. ICD is not a nomenclature of medical terms, aiming to provide their definition. This explains why, the entity "burn-out" was introduced in the 10th revision of ICD (ICD-10) without any definition (12). Conversely, the somewhat arbitrary definition of burnout provided in ICD-11 appears misleading. However neither its changed ICD code (from Z73 to QD85) nor transfer from the subsection "Problems related to life management difficulty" to the subsection "Problems related to employment or unemployment" would justify the sudden need for a definition of burnout in the ICD. Instead, the introduction of a new term (eg, "work-related burnout") along with an appropriate definition may be warranted, given that such a term has not yet been defined in any official medical terminology.

In controlled terminology, a definition is a sentence suggesting that a new term (the definiendum) should be considered as synonymous with another, already known term or expression (the definiens) (7). The only exception is the so-called "ostensive definition", where the term is interpreted by pointing to an object and naming it (eg, "You will be called XYZ"). In fact, the term burnout was originally introduced using an ostensive definition (13), and only later explained by Freudenberger (14) and many others. All of them are explanations, not definitions for a controlled vocabulary. Some are so-called "meaning explanations", attempting to explore what people understand by a term such as burnout, and others are descriptions, enumerating properties and attributes of burnout. All belong to the natural language vocabulary.

Given this situation, we aimed to (1) formulate a harmonized definition of the concept of occupational burnout for its introduction in the medical vocabulary and (2) reach a consensus on the definition and most appropriate term to designate this concept within the the Network on the Coordination and Harmonisation of European Occupational Cohorts OMEGA-NET, part of the EU European Cooperation in Science and Technology (COST) Action (15, 16).

## Methods

We conducted this research in two parts. First, we performed a systematic review of all existing definitions of occupational burnout and a semantic analysis of the 11 original definitions. We used Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) definitions of burnout and burnout-related concepts to propose the terms and a definition of the concept. Secondly, we sought to obtain consensus on our proposal using the Delphi technique (17, 18).

### Systematic review and semantic analysis

Search strategy and selection criteria. The search was conducted within the context of a broader systematic review, aimed at addressing all causative predictors of burnout in workers (PROSPERO CRD42018105901) (19). We searched the literature published between January 1990 and August 2018 on MEDLINE, PsycINFO and EMBASE. [The complete search strings applied for each database are available at the Unisanté data repository (DOI: 10.16909/DATASET/22).] We validated this search strategy by achieving exhaustiveness of the studies included in the latest systematic review on occupational burnout (2). In addition, we checked the reference lists of all retrieved articles and reviews to look for additional studies, which could be included.

We included original research focused on workers, published in European languages between 1990-2018 in peer-reviewed journals. Among them, we selected studies which (i) examined the relationship between exposure to any kind of factors (eg, occupational, organization, individual) and the onset of burnout; (ii) used a longitudinal design, (iii) assessed exposure before the onset of burnout, and (iv) had a minimum of 50 participants per exposed group. When multiple publications described the same study, we included the publication with the most complete reporting of study results. We conducted a double screening of relevant studies: the first screening was based on the title and abstract of all publications identified through the literature search. All studies which met the inclusion criteria, or for which it was not possible to check these criteria, were included in the second screening, which was based on reading the full text. The literature corpus was equally allocated between the 14 OMEGA-NET reviewers. In parallel, the second reviewer independently read all the studies. Therefore, two independent reviewers conducted both

screenings. A third reviewer helped resolving disagreements.
For this study, OMEGA-NET reviewers extracted for each study: the reference, year of publication, definition of burnout as formulated by the authors (ie, used definition) and the source(s) of this definition (ie, referenced definition(s)) using a standardized data extraction form (MS Excel). The first and second authors double-checked all extracted data.
Semantic analyses and definition proposal
The referenced and used definitions were split between original definitions (ie, a definition published for the first time by the authors to introduce their theoretical concept) and secondary definitions [ie, a definition by the same author(s), based on the same concept as the original definition, but formulated using a different wording (synonyms)]. All definitions (original and secondary) constituted the corpus of our semantic research. However, the analytical sub-corpus only included the original definitions and two additional definitions published after the completion of the literature search (20, 21).
We conducted the semantic analysis in three phases: In phase 1, we examined the concepts and their expressions in terms of hyponymy and hyperonymy, corresponding to the lower (more specific) and upper (more general) levels in the concept's semantic hierarchy, respectively. We selected hyponyms and hyperonyms occurring/recurring in at least three different definitions. The choice of this number is arbitrary, but justified, as the choice of a low number prevents the loss of potentially interesting information. We considered that the (hyponymic or hyperonymic) terms that appeared only once or twice were too specific and hence not worth taking into account. Definitions of burnout were all structured in a heterogeneous way and described in the form of (i) a list of simple terms (eg, stress, boredom, frustration), (ii) a list of nominalizations with some specifications (eg, "feeling of exhaustion and fatigue, being unable to shake a lingering cold, suffering from frequent headaches and gastrointestinal disturbances"), but also (iii) in a more discursive way (eg, "They lose all concern, all emotional feelings, for the persons they work with..."). We also considered discursive descriptions as lists of elements, so that, for example, "they lose all concern" can be interpreted and evaluated as "loss of all concern". In this way, single terms and multi-word expressions can be considered as isolated semantic elements, independently from a specific and actualizing syntactic context.
In phase 2, we reorganized the results of phase 1 into the ideal structure for the medical description of burnout as a syndrome, ie, a multi-level conceptual framework based on symptoms. To enhance the precision of the level to which symptoms should be attributed, we excluded all information about the context of burnout development and the specific population prone to burnout, which were in the definitions.
In phase 3, we calculated the effective presence of each element on each level, in each definition. We deduced a semantic proposal of a definition of occupational burnout based on shared elements (ie, the elements that occurred in more than half or >7 out of the 13 definitions of the analytical sub corpus).
Furthermore, we consulted the last release (July 2019) of SNOMED-CT International Edition for the terms "burnout", "exhaustion", and "occupation(al)" and extracted their definitions and the definitions of their hyperonyms and hyponyms. We summarized the extracted information and formulated a definition proposal based on SNOMED-CT's terminology, following the fundamentals of medical concept formation (7).
Consensus search through the Delphi process
We considered as experts all members of OMEGANET and external experienced health practitioners with >10 years of practice and knowledge of occupational burnout. We used purposive sampling among OMEGANET members and snowball sampling with the external health practitioners. The latter method was implemented through the national focal points of the European Agency for Safety and Health at Work (EU-OSHA) (22) and OMEGA-NET members, who we asked to identify at least one health practitioner in each of the 33 OMEGA-NET participating countries (16). We used this approach previously (6) and found it effective. The working language was English. We sent an invitation by e-mail describing the Delphi protocol and time-schedule. This initial e-mail helped to establish a relationship with and verify the e-mail addresses of experts. It also provided the denominator to calculate the response rate.
We a priori defined the consensus valid if at least 75% of participants rated the definition >7 on a 9-point Likert scale

(23). We provided to the expert panel a synthesis of the evidence resulting from the systematic literature review and semantic analysis, which were conducted prior to the consensus process. Therefore, panelists received all pertinent information enabling their evidence-based decision-making (24). We also sent them detailed instructions of the process.

We restricted the process to two rounds as more rounds would have increased the panel's attrition (25). In the first round, we used a questionnaire with a choice of two terms for designating the concept of occupational burnout and the proposal of its definition. Panelists were asked to rate their agreement with the definition using a 9-item Likert scale. Panelists were also asked, in an open-ended question, to explain their rating and express the reasons of their agreement/disagreement with the definition statement. They were also encouraged to share their comments and/or suggestions for amendments on the proposed definition. We sent two reminders to non-responders by e-mail. We collated the responses of the first-round questionnaire and used them to create the second-round questionnaire, which presented a slightly revised statement of definition. Panelists also received a document summarizing the first round rating statistics along with a selection of free-text responses to represent the breadth of opinion of participants. Experts reconsidered their previous opinion and rerated their degree of agreement with the new proposed definition. The reratings were summarized and assessed for degree of consensus. At the end of the process, all participants were provided the results.

Results

The systematic literature search produced 5297 items. After the first and second screenings of 2935 abstracts and 443 articles, respectively, 248 studies met the inclusion criteria (figure 1). After comparative analysis of the 248 extracted definitions, we grouped together those with very similar content. This resulted in 88 distinct definitions. Most definitions were ranked as secondary, referring to 1 of the 11 original definitions (14, 26-37). The references of the 248 studies, 88 secondary definitions and their indexation to 11 original definitions are available upon request via Unisanté data repository (DOI: 10.16909/DATASET/22). Table 1 presents the statements of all original definitions, their comparative features and the theoretical ground of their development. Figure 2 presents these original definitions in a chronological way, along with the number of their secondary definitions, the frequency and the timespan of their citations in the studies included in the systematic review. The second revision of Masłach &Jackson's definition (30, 38, 39) was the fourth to be published but appears as the most commonly used definition (76%) for assessing burnout as a health outcome in workers. However, a two-fold revision of this definition and the subsequent publication of nine other new definitions attests that Masłach &Jackson's definition has no unanimous acceptance. The second most common definition was that of Shaufeli &Enzman (34) (39% of citations). While Masłach &Jackson's definition describes burnout in terms of three core dimensions (emotional exhaustion, depersonalization and personal accomplishment), which can be measured by a self-administrated scale (the Masłach Burnout Inventory or MBI), Shaufeli &Enzman's definition is largely descriptive, listing 132 symptoms, which they considered likely of burnout cases (34). Considering the chronology of the original definitions, a comparative analysis revealed some minor and inconsistent changes in the theoretical models on which the identified definitions were based and an increasing complexification of the definition content (table 1).

Phase 1 of the semantic analysis revealed an absence of homogeneity in the structure of the original burnout definitions. Indeed, they sometimes referred to symptoms but also to causes or to effects. Moreover, some definitions were very precise in their terminology while others only contained generic terms. Therefore, in phase 2 of analysis, we applied an adaptation of the structural-generative semantics approach (40-43). When all the concept elements shared in the sub-corpus were classified according to a hierarchy based on three main levels (psychological, physical and behavioral), we observed that burnout symptoms at the psychological level were more numerous than those at the physical level and the latter were more numerous than the symptoms at the behavioral level. Phase 3 enabled us to calculate the occurrence of the symptoms in the original definitions for each level and layer. Elements that occurred in >7 out of 13 original definitions (11 original definition plus two recent definitions) (20, 21) were retained for a shared semantic definition proposal. Table 2 summarizes the results of the semantic analysis. Further details on this analysis can be found elsewhere (Dell'Oro &Guseva Canu. From semantic

decomposition of the lexicon to extra-linguistic understanding of its use in the definitions of 'burn-out' as a work-related health condition: advantages and limits of semantic decomposition emerged from a practical application. Submitted to J Applied Linguistics.)

The resulting shared definition of occupational burnout was as follows: "a syndrome characterized by 'deterioration of well-being' and more precisely 'exhaustion', 'weariness' and 'negative attitude' at the psychological level, and 'deterioration of well-being' with presence of 'exhaustion' at the physical level. It is not yet possible to specify any symptom at the behavioral level. Importantly, in 12 of the 13 definitions, burnout is explicitly related to workplace." Table 3 presents the terms included in the shared semantic definition as defined in SNOMED-CT. 'Burnout' and 'physical AND emotional exhaustion state' are both descriptors of the same concept in SNOMED-CT. However, even if 'burnout' is an acceptable term for this concept, 'physical AND emotional exhaustion state' is specified as the preferred term in the English language reference set of both Great Britain and the United States of America. The term 'exhaustion' is defined as 'general problem AND/OR complaint' and 'energy and stamina'. The term 'exhaustion due to exposure' is hyponym of 'exhaustion'. We identified the concept of 'problems at work' as the most relevant exposure to put in relation with 'exhaustion due to exposure'. The 'problems at work' concept is defined as 'work and retirement-related problems' and has 12 hyponyms including 'bullied at work', 'discord in the workplace', and 'stressful work schedule'. 'History taking' is specified as a method for diagnosing problems at work. Finally, the qualifier 'occupational' is defined as a 'modifier related to clinical specialty AND/OR occupation' (table 3).

Considering these definitions, we proposed to introduce a new concept using two synonymous terms: 'occupational physical AND emotional exhaustion state' (term 1) and 'occupational burnout' (term 2). We defined it as follows: "In a worker, occupational physical AND emotional exhaustion state or occupational burnout is an exhaustion due to exposure to problems at work". This proposal was submitted for experts' approval.

Among the 100 experts invited, 60 formally agreed to participate. A high participation rate in the first and second rounds (92% and 83%, respectively) maintained the panel composition stable in terms of the characteristics considered (table 4). The proportion of physicians, psychologists and researchers was well balanced, with >70% of participants having a research and/or clinical experience of >15 years. At the first round, the experts clearly leaned towards the term 2 'occupational burnout'. However, the definition statement proposed at the first round raised many comments. These comments mainly concerned six topics: (i) insufficient recognition of the ICD-11 definition, (ii) relevance of using the qualifier 'occupational', (iii) terminology used for the concept definition, (iv) omission of symptoms other than exhaustion, (v) concern with the term 'exposure', and (6) concern with the term 'problems at work'. The concerns about the ICD-11 definition further justified our decision to use SNOMED-CT's terminology. Moreover, as a result of the experts' comments, we accepted the suggestion to add the qualifier 'prolonged' to the term 'exposure' and to replace the term 'problem at work' by 'work-related problems'. The revised definition submitted for the second round vote was as follows: "In a worker, occupational burnout or occupational physical AND emotional exhaustion state is an exhaustion due to prolonged exposure to work-related problems". This definition received 82% of grades >7, and was consensually approved in the second round.

## Discussion

The harmonized definition of occupational burnout that emerged from this study looks extraordinarily simple but responds to the fundamentals of definition formation. It is a conditional definition because the application of the concept introduced by the definition is conditional on specific circumstances, such as having an occupational activity, as indicated in the definition by the expression 'in a worker'. In general, a term introduced by a conditional definition cannot be replaced by its definiens in all contexts (7). Therefore, this term could also fit the ICD-11 hierarchy. Moreover, this definition is an operational definition (44, 45) as it suggests the use of a history taking procedure, assessing the problems at work, and a clinical examination to ascertain whether the patient suffers from physical and emotional exhaustion. In fact, the operationalization of an attribute is characterized by the indication of some operations (eg, clinical examination, history taking) that enables investigators to decide whether the attribute is present or absent (45).

The term 'work-related problems' deserves discussion, as it was strongly debated among panelists. The challenge

was to find a well-defined term that would cover most, if not all, work-related stressors or risk factors. In this respect, the concept 'problems at work', defined in SNOMED-CT as an attribute of 'work and retirement-related problems', was considered the best option. The concept 'problems at work' has 12 hyponyms and involves 7 additional, more specific concepts, including 'discord in the workplace', 'uncongenial work environment', 'stressful work schedule', and 'difficulty adjusting to work situation' (table 3). Not all these examples are 'problems'. While it should be possible to extend the list of hyponyms under the concepts of 'problems at work' or 'work-related problems', it would be difficult to find a more inclusive and better-defined concept.

Regarding the meaning of the word 'problem', we consulted three dictionaries to consider possible negative cultural perceptions associated with it. The Oxford English Dictionary (OED) defines a problem as "a difficult or demanding question; a matter or situation regarded as unwelcome, harmful, or wrong and needing to be overcome; a difficulty." The Webster dictionary, defines a problem as "la: a question raised for inquiry, consideration, or solution; b: a proposition in mathematics or physics stating something to be done; 2a: an intricate unsettled question; 2b: a source of perplexity, distress, or vexation; 2c: difficulty in understanding or accepting." Finally, Cambridge Academic Content Dictionary, defines a problem as "al: a situation, person, or thing that needs attention and needs to be dealt with or solved." These three definitions, and in particular Webster's definitions 2b and 2c seemed to fit pretty well the 'concerns', 'constraints', 'issues' and 'situations', mentioned by some of the experts, which could be all summarized using the term 'problems'. None of the other terms better fits our context as they are not well-defined terms within the SNOMED-CT and are subject to a wide interpretation according to the cited dictionaries. Therefore, the terms 'problems at work' and 'work-related problems' appeared to be the most convenient and clearest terms available. Indeed, they cover a large set of situations and have an extensible list of hyponyms, allowing for the introduction of new concepts corresponding to the additional work-related risk factors, if necessary. Finally, the term 'prolonged' was added to the final definition as all the panelists agreed that it is important to specify the duration of exposure as part of necessary causal condition. The choice between the qualifiers 'chronic' or 'prolonged' to the term 'exposure' was debated. According to SNOMED-CT, the terms 'prolonged' and 'chronic' are not synonyms. The term 'prolonged' is defined as a qualifier value of duration and has no synonyms, while the term 'chronic' is defined as a qualifier value of courses and has an acceptable synonym 'chronic course - prolonged duration'. In the OED, 'chronic' is defined as "Lasting a long time, long-continued, lingering, inveterate; opposed to acute. Continuous or constant." While 'prolonged' is defined as "Of extended duration; protracted. Frequently with negative connotation. Extended, lengthened in space." As exposure should not necessary be constant to result in a burnout, it appeared preferable to use the term 'prolonged' to complete the definition. The timespan of 'prolonged' still remains to be addressed. We believe that it would be possible, at least partially, in the systematic review of burnout predictors (in progress) and in the near future.

If accepted more generally, this definition may reduce the semantic chaos surrounding the concept of occupational burnout and improve medical research, treatment and prevention of this outcome. It may also clarify whether burnout should be classified as a disease (6, 46). In SNOMED-CT, 'burnout' is classified under the clinical finding hierarchy, which only includes concepts that refer to diagnoses. Consequently, according to SNOMED-CT's classification, 'burnout' is a diagnosable disease, which is contradictory with the absence of a validated diagnostic standard. Before such a standard becomes available, professionals should be encouraged to use the most valid patient-reporting outcome measures of exhaustion. Although exhaustion constitutes the core component of occupational burnout, as highlighted in our definition, no fewer than 132 other possible symptoms (affective, cognitive, physical, behavioral, and motivational) have been mentioned in past literature reviews (21, 34). A thorough clinical examination of these symptoms would help define diagnostic criteria for occupational burnout.

Study limitations

This study has at least three limitations. First, in order to select only studies of the highest quality with a documented definition of burnout in workers, our semantic research corpus excluded cross-sectional studies, studies published in other databases, and the grey literature, We identified 88 unique definitions in 248 studies. On the other hand, Rosenstein et al (1) reviewed 182 longitudinal and cross-sectional studies from five databases and identified at least

142 unique definitions. This suggests that the authors of the studies in Rosenstein et al's review most likely used their own definitions, and we may have missed some that might be original. Nevertheless, we used the quantitative criteria in the semantic analysis based on the number of original definitions in the analytical sub-corpus. Hence, we can reasonably rule out a potential selection bias. Moreover, the semantic analysis, conducted prior to the consultation of SNOMED-CT, resulted in a similar definition as SNOMED-CT's definition.

Second, our expert panel only represented countries that are part of OMEGA-NET. Therefore, we cannot speculate on the reproducibility of the experts' selection and the representativeness of our panel in other countries. The use of a randomized sampling method for expert selection was not possible, but all EU-OSHA national focal points have a network to provide input to the EU-OSHA's work and to disseminate products and information to national stakeholders. They presumably used this network to identify experts and assess their eligibility. External experts represented 45% of the panel and our statistical analysis showed that Delphi results were independent of the OMEGA-NET membership and other characteristics of the experts. Lastly, the size of our expert panel was not very large. This can affect the stability of the results. However, few Delphi studies on mental health had >50 experts (17).

Third, we conducted our literature review up to 2018. Although no new definition of burnout has been introduced in the scientific literature since then, several factor-analytic studies have recently concluded that burnout-and most notably, exhaustion-was reflective of a depressive condition (47, 48). Because our temporal limit was 2018, we did not incorporate these findings in our analyses. We note, however, that the harmonized definition of occupational burnout that emerged from the present study may be helpful in resolving the issue of burnout-depression overlap (49).

Future research should address the reproducibility of our results in a larger expert panel, representing more countries, and examine the utility of the formulated definition of burnout for researchers and practitioners.

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Conflict of interest

None declared.

Protection of research participants

All participants provided formal consent for participation. Delphi panelists' personal data used for the panel characterization were de-identified and destroyed after the study completion. Participation to the Delphi process was anonymous until the study completion and disclosed upon written consent for the authorship purpose.

**Sidebar**

Guseva Canu, I, Marca SC, Dell'Oro F, Balázs Á, Bergamaschi E, Besse C, Bianchi R, Bislimovska J, Koscec Bjelajac A, Bugge M, Busneag CI, Çağlayan C, Cernițanu M, Costa Pereira C, Dernovšček Hafner N, Droz N, Eglite M, Godderis L, Gündel H, Hakanen JJ, Iordache rM, Khireddine-Medouni I, Kiran S, Larese-Filon F, Lazor-Blanchet C, Légeron P, Loney T, Majery N, Merisalu E, Mehlum IS, Michaud L, Mijakoski D, Minov J, Modenese A, Molan M, van der Molen H, Nena E, Nolimal D, Otelea M, Pletea E, Pranjic N, Rebergen D, Reste J, Schernhammer E, Wahlen A. Harmonized definition of occupational burnout: A systematic review, semantic analysis, and Delphi consensus in 29 countries. Scand J Work Environ Health. 2021;47(2):95-107. doi:10.5271/sjweh.3935

1 Center for Primary Care and Public Health (Unisanté), Faculty of Biology and Medicine, University of Lausanne, Switzerland.

2 Faculty of Arts, University of Lausanne, Switzerland.
3 Center for Hellenic Studies, Harvard University, USA.
4 Division of Occupational Health, Department of Preventive Medicine, Faculty of Public Health, University of Debrecen, Hungary.
5 Department of Public Health Sciences and Pediatrics, University of Turin, Italy.
6 Department of Psychiatry, Lausanne University Hospital (CHUV), Prilly, Switzerland.
7 Institute of Work and Organizational Psychology, University of Neuchâtel, Neuchâtel, Switzerland.
8 Institute of Occupational Health of RNM, WHO CC, Skopje, RN Macedonia.
9 Institute for Medical Research and Occupational Health, Zagreb, Croatia.
10 National Institute of Occupational Health, Oslo, Norway.
11 National Romanian Television, Occupational Health Department, Bucharest, Romania.
12 Department of Public Health, Faculty of Medicine, Kocaeli University, Kocaeli, Turkey.
13 Management and Psychology department, Nicolae Testemitanu State University of Medicine and Pharmacy, Chisinau, Republic of Moldova.
14 Environmental Health Department, National Institute of Health, Porto, Portugal.
15 Epidemiology Unit, Institute of Public Health, University of Porto, Porto, Portugal.
16 Clinical Institute of Occupational, Traffic, and Sports Medicine, University Medical Centre, Ljubljana, Slovenia.
17 Occupational Health Unit, Service of Hospital Preventive Medicine, Lausanne University Hospital (CHUV), Lausanne, Switzerland.
18 Department of Occupational and Environmental Medicine, Rīga Stradins University, Riga, Latvia.
19 Department of Primary Care and Public Health, University of Leuven, Belgium.
20 Clinic for Psychosomatic Medicine and Psychotherapy, University of Ulm, Germany.
21 Work Careers and Workability Department, Finnish Institute of Occupational Health, Helsinki, Finland.
22 Alexandru Darabont National Research and Development Institute for Occupational Safety and Health, Bucharest, Romania.
23 Division of Non-Communicable Diseases and Trauma, Public Health France, Saint-Maurice, France.
24 Institute of Public Health, Department of Occupational Health and Safety, Hacettepe University, Turkey.
25 Unit of Occupational Medicine, University of Trieste, Italy.
26 Department of Psychiatry, Sainte-Anne Hospital, Medical Faculty University, Paris, France.
27 College of Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai, United Arab Emirates.
28 Multisectoral Occupational Health Service, Luxembourg, Luxembourg.
29 Estonian University of Life Sciences, Tartu, Estonia.
30 Psychiatric Liaison Service, Lausanne University Hospital, Lausanne, Switzerland.
31 Institute of Occupational Health of RNM, WHO CC, Skopje, RN Macedonia.
32 Department of Biomedical, Metabolic and Neural Sciences, University of Modena &Reggio Emilia, Italy.
33 Department of Occupational Medicine, Medical Faculty University of Tuzla, Bosnia and Herzegovina.
34 Coronel Institute of Occupational Health, Netherlands Center for Occupational Diseases, Amsterdam Public Health Research Institute, The Netherlands.
35 Medical School, Democritus University of Thrace, Alexandroupolis, Greece.
36 National Institute of Public Health of Slovenia, Ljubljana, Slovenia.
37 Carol Davila University of Medicine and Pharmacy, Bucharest, Romania.
38 Department of Occupational Medicine, Medical Faculty University of Tuzla, Bosnia and Herzegovina.
39 Occupational and Health Psychologist. Shared Ambition, People management, Amersfoort, The Netherlands.
40 Institute of Occupational Safety and Environmental Health, Riga Stradinš University, Latvia.
41 Department of Epidemiology, Center for Public Health, Medical University of Vienna, Vienna, Austria.
42 Swiss Association of Work &Organization Psychologists, Switzerland.

Correspondence to: Prof. I. Guseva Canu, Unisanté, Department of occupational and environmental health, Route de la Corniche, 2, 1066 Epalinges-Lausanne, Switzerland. [E-mail: irina.guseva-canu@unisante.ch]

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## DETAILS

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# Bibliography

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Jonsson, J., Matilla-Santander, N., Kreshpaj, B., Orellana, C., Johansson, G., Burström, B., . . . Bodin, T. (2021). Exploring multidimensional operationalizations of precarious employment in swedish register data – a typological approach and a summative score approach. Scandinavian Journal of Work, Environment & Health, 47(2), 117-126,117A. doi:https://doi.org/10.5271/sjweh.3928

Objectives This study aimed to explore multidimensional operationalizations of precarious employment (PE) in Swedish register data using two approaches: (i) a typological approach and (ii) a dimensional, summative scale approach. It also examined the distribution of sociodemographic and occupational characteristics of precarious employees in Sweden. Method Register data was retrieved on individuals and their employers in the Swedish workforce. Five items corresponding to three dimensions of PE were operationalized: contractual relationship insecurity, contractual temporariness, multiple jobs/sectors, income level, and lack of unionization. First, latent class analysis was applied and a typology of six employment types emerged. Second, a summative scale was constructed by scoring all PE-items. Results Three types of PE were found using the typological approach, which were characterized by direct employment, solo self-employment and multiple job holding, respectively. The summative scale score ranged between -10 and +2 (average: -1.8). Particularly poor scores were seen for solo self-employed, multiple job holders/multiple sectors, and low income. Female gender, young age, low education and foreign origin were prone to precariousness. PE was more frequent among certain economic sectors and occupations. Conclusions Using an existing register of labor market data, two operationalizations of PE were constructed and rendered promising for exposure assessment. Hence, the operationalizations could be of interest for countries with similar data structure. Both approaches highlighted precarious combinations of employment conditions and pointed towards the existence of a wide continuum of precariousness on the labor market. Etiological studies and research assessing trends over time are needed to validate these findings.

Schram, J. L. D., Groeniger, J. O., Schuring, M., Proper, K. I., van Oostrom, ,S.H., Robroek, S. J. W., & Burdorf, A. (2021). Working conditions and health behavior as causes of educational inequalities in self-rated health: An inverse odds weighting approach. Scandinavian Journal of Work, Environment & Health, 47(2), 127-135,127A. doi:https://doi.org/10.5271/sjweh.3918

The novel causal mediation approach 'inverse odds weighting' showed that working conditions and health behaviors accounted for more than half of the educational inequalities in self-rated health. Preventive interventions focusing on improving working conditions and health behavior among lower educational groups may contribute to reducing these educational inequalities in self-rated health. Objective Using a novel mediation method that presents unbiased results even in the presence of exposuremediator interactions, this study estimated the extent to which working conditions and health behaviors contribute to educational inequalities in self-rated health in the workforce. Methods Respondents of the longitudinal Survey of Health, Ageing, and Retirement in Europe (SHARE) in 16 countries were selected, aged 50-64 years, in paid employment at baseline and with information on education and self-rated health (N=15 028). Education, health behaviors including body mass index (BMI)] and working conditions were measured at baseline and self-rated health at baseline and two-year follow-up. Causal mediation analysis with inverse odds weighting was used to estimate the total effect of education on self-rated health, decomposed into a natural direct effect (NDE) and natural indirect effect (NIE). Results Lower educated workers were more likely to perceive their health as poor than higher educated workers relative risk (RR) 1.48, 95% confidence interval (CI) 1.37-1.60]. They were also more likely to have unfavorable working conditions and unhealthy behaviors, except for alcohol consumption. When all working conditions were included, the remaining NDE was RR 1.30 (95% CI 1.15-1.44). When BMI and health behaviors were included, the remaining NDE was RR 1.40 (95% CI 1.27-1.54). Working conditions explained 38% and health behaviors and BMI explained 16% of educational inequalities in health. Including all mediators explained 64% of educational inequalities in self-rated health. Conclusions Working conditions and health behaviors explain over half of the educational inequalities in selfrated health. To reduce health inequalities, improving working conditions seems to be more important than introducing health promotion programs in the workforce.

Boot, C. R. L., & Bosma, A. R. (2021). How qualitative studies can strengthen occupational health research. Scandinavian Journal of Work, Environment & Health, 47(2), 91-93,91A. doi:https://doi.org/10.5271/sjweh.3943

The Scandinavian Journal of Work, Environment and Health (SJWEH) has a strong reputation in publishing high quality studies using quantitative research methods in the field of occupational health. Studies using qualitative research methods, however, are rarely published in the Journal. Here, Boot and Bosma explain how qualitative studies can contribute to the field of occupational health research and to SJWEH's aim to promote high quality and impactful research in the field of occupational and environmental health and safety and increase knowledge through scientific publications.

Pedersen, J. E., M.Sc, Strandberg-Larsen, K., Andersson, M., PhD., & Hansen, J., PhD. (2021). Breast cancer among danish women occupationally exposed to diesel exhaust and polycyclic aromatic hydrocarbons, 1964–2016. Scandinavian Journal of Work, Environment & Health, 47(2), 154-162,154A. doi:https://doi.org/10.5271/sjweh.3923

Objective The aim of this study was to explore the association between occupational exposure to diesel exhaust and polycyclic aromatic hydrocarbons (PAH), respectively, and breast cancer subtypes. Methods The study included 38 375 women <70 years with incident breast cancer, identified in the Danish Cancer Registry, and 5 breast cancer-free controls per case who were randomly selected from the Danish Civil Registration System and matched on year of birth. Full employment history was obtained for all study subjects from a nationwide pension fund, and exposure to diesel exhaust and PAH was assessed using a job exposure matrix. Conditional logistic regression was used for estimation of odds ratios (OR) with adjustment for reproductive factors and socioeconomic status. Results No noteworthy associations were observed for overall breast cancer in women exposed to diesel exhaust. However, diesel exhaust modestly elevated the risk of estrogen receptor negative breast tumors before age 50 OR 1.26, 95% confidence interval (CI) 1.09-1.46]. Duration- and dose-response relationships were further observed for this subtype in this age group. No notable risk patterns were generally observed for PAH exposure. Conclusion Occupational exposure to diesel exhaust may increase the risk of early-onset estrogen receptor negative breast tumors in women. Future studies exploring this association are warranted.

Bjorvatn, B., PhD., Pallesen, S., PhD., Waage, S., PhD., Thun, E., PhD., & Blytt, K. M., PhD. (2021). The effects of bright light treatment on subjective and objective sleepiness during three consecutive night shifts among hospital nurses – a counter-balanced placebo-controlled crossover study. Scandinavian Journal of Work, Environment & Health, 47(2), 145-153,145A. doi:https://doi.org/10.5271/sjweh.3930