Gender Specific Analysis of Occupational Diseases of the Low Back Caused by Carrying, Lifting or Extreme Trunk Flexion—Use of a Prevention Index to Identify Occupations With High Prevention Needs

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Background *Gender specific analysis of the occupational disease of the lumbar spine caused by carrying, lifting, or extreme trunk flexion in Germany (OD No.2108) with the aim to identify areas of focus for prevention and research with a prevention index (PI).*
Methods *Data from the German Statutory Accident Insurance stratified by gender are shown.*
Results *From 2002 until 2009 there were 2,877 confirmed cases of an OD No. 2108 (40.1% male and 59.1% female). The PI indicated the highest prevention need for female nursing/midwifery associate professionals and male building frame and related trades workers. Patient transfer and working in extremely bent posture were the most frequent exposures.*
Conclusions *The identified occupations with high need for prevention among men come from nearly all major occupational groups whereas women cluster in occupational groups from the health and care sectors.* Am. J. Ind. Med. 57:233–244, 2014.

KEY WORDS: gender; occupational disease; lumbar spine; prevention index

INTRODUCTION

Several systematic reviews show a higher risk of low back pain for selected occupations (e.g., construction workers, nurses, farmers, professional driver, bricklayer, or forklift driver) [Lagerström et al., 1998; Lyons, 2002; Waters et al., 2005; Boschman et al., 2011; Osborne et al., 2012]. The main occupational risk factors implicated in the causation of work-related low back disorders are manual handling of materials (mainly lifting and carrying), high physical workload, frequent bending and twisting of the trunk, whole-body-vibration [Burdorf and Sorock, 1997; Lötters et al., 2003; Gallagher, 2005; Bakker et al., 2009; da Costa and Vieira, 2010; Heneweer et al., 2011], and factors related to work organization (e.g., time pressure) [Hoogendoorn

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et al., 2000; Hartvigsen et al., 2004; Punnett and Wegman, 2004; MacFarlane et al., 2009; Lang et al., 2012].

Surveillance data provide information on potential risk groups. The most complete data come from countries with compulsory reporting of suspected occupational diseases (OD) by physicians and/or data from compensation schemes to State authorities such as in Finland [Karjalainen et al., 2000] and in Germany [Baur et al., 1998a]. Diseases of the lower back are an OD in several countries in the European Union [Eurogip, 2007; Elsner, 2008], for example, Belgium (only special cases of lumbago and vibration and individual cases of heavy lifting), Denmark (chronic low back disease with pain and vibration or heavy lifting), France (disc prolapse with radicular pain or symptoms caused by vibration or heavy lifting), Latvia (osteochondrosis, radiculopathy) [Eurogip, 2007; Elsner, 2008; European Agency of Safety and Health at Work, 2010]. In some European countries (e.g., Austria, Ireland, Portugal, Spain, and Finland) diseases of the intervertebral disc can be recognized as an OD as a consequence of a work-related accident injury [Elsner, 2008]. In Germany, specific disc-related degenerative diseases of the lumbar spine due to defined workplace exposure are defined by law as an OD [BKV, 2009]. They require legal evidence for a link between the occupational exposure and the disease. Occupational exposures compensated are lifting or carrying of heavy loads over many years or performance of work in an extremely bent posture over many years (OD No. 2108) and exposure to whole-body vibration in a seated position over many years (OD No. 2110) [Federal Institute for Occupational Safety and Health, 2009].

The objective of this paper is to identify occupations with a high risk to develop an OD of the lower back in Germany in order to show the potentials for prevention and further research. A prevention index (PI) [Silverstein et al., 2002; O'Brien, 1984] is used that combines the rank information of the occupation-specific frequency for an OD and the incidence. The PI is useful in surveillance data, where no other risk estimators can be used. Due to occupational segregation, exposure to occupational risk factors differs between men and women [Punnett and Herbert, 2000; Messing et al., 2003]. Horizontal segregation refers to a concentration of the female and male working population in different economic sectors and/or professions. Vertical segregation describes the concentration of males in higher categories of the professional hierarchy. Report of (work related) low back pain may also differ between the genders [Messing et al., 2009; Silverstein et al., 2009]. As there are not enough cases of OD exposed to whole-body vibration in Germany for a gender specific analysis, the secondary data analysis of current statistics from the Statutory German Social Accident Insurance (DGUV) is focussed on ODs of the lumbar spine due to lifting or carrying of heavy loads or working in extremely bent posture (OD No. 2108).

MATERIALS AND METHODS

Statutory German Social Accident Insurance

In Germany, all employees are insured by law through different statutory accident insurance institutions that are solely paid by the employer for work-related accidents, commuting accidents, and OD [Baur et al., 1998b]. This insurance includes full-time employees and part-time employees but also temporality employed subjects (in Germany also including the so called "mini jobs"[1] and the "one-euro-jobs"[2]). State employees, soldiers, and civilian service are not covered by the statutory German social accident insurance, but by a similar Federal insurance. Self-employed persons and family workers can get voluntarily insured. School children, students, and voluntary workers are also covered by this insurance system during their activities at school and their commuting but are not subject of this analysis. The agricultural sector is covered by a separete system.

The reporting of suspected cases of OD to the statutory accident insurance institutions can be provided by employees and is compulsory for physicians and the employer [Baur et al., 1998b]. Confirmation of a case report requires assessment of the kind, intensity, and duration of the specific exposure on the one hand. On the other hand a medical assessment of the disease and the discussion of the possibility of the causal association between the exposure and disease based on medical expert statements are necessary for recognition. If a case is confirmed further standardized details regarding for example, diagnosis, occupation/task, and causative substance/source are transmitted.

For some diseases, the recognition of the OD requires additional insurance conditions, for example, for OD No. 2108. The diseases must have forced the person to refrain from all endangering occupational activities that have led to the disease. For compensation further requirements have to be fulfilled. From 2002 until 2009 they were 47,772 suspected cases and 2,877 confirmed cases of an OD 2108. The compensation of a confirmed OD includes costs of treatment, medical examinations, vocational retraining as well as various allowances and pensions.

The accident insurances estimate equivalent full time employees for their economic sectors but have no information on the number of insured workers in the different occupations. From 2002 until 2009 a mean of 35,285,885 equivalent full time employees were insured [DGUV, 2011].

[1] Mini jobs are defined as jobs with a monthly income of less than 400 Euros. (cp. Ministry of Labour and Social Affairs).
[2] One-euro-jobs are jobs in addition to unemployment benefit to get an extra income (e.g., one euro per working hour) with no social insurance. (cp. Ministry of Labor and Social Affairs).

The Occupational Disease of the Lumbar Spine in Germany

The statutory insurance institutions compensate two diseases that include the lumbar spine related to the intervertebral disc. The OD No. 2108 for the lumbar spine is legally defined as "Disc-related diseases of the lumbar spine caused by the lifting or carrying of heavy loads over many years or by performance of work in an extremely bent posture over many years" (German Occupational Disease Act (BKV), 1997). Several local lumbar syndromes as well as radiculopathy or myelopathy associated with radiographically confirmed lumbar disc herniation and/or lumbar disc narrowing can be recognised as OD. No. 2108 (definition as used in Seidler et al., 2011).

The OD No. 2108 is legally defined as long term carrying and lifting of heavy loads and working in extremely bent posture. Thresholds for carrying and lifting are based on a biomechanical model (as applied by Seidler et al., 2009). Commonly, long-term duration required a minimum of 10 years and 60 work shifts per year. The bent posture required a work place with a height of at least 100 cm (corresponding 39.4 inches) or a task requiring bending the upper body from the upright position to approximately 90° and more. Ergonomic/technical experts within the different statutory accident insurance institutions perform the individual retrospective exposure assessment. Assessment includes written or oral interview questionnaires for the employee and the employer, as well as other methods if applicable.

Data

The Seventh Volume of the German Code of Social Law SGB VII regulates the collection of data on insured individuals. The data from the DGUV were provided as an aggregated data set of confirmed cases of OD No. 2108 over a 10-year period (2000–2009). For the analysis, confirmed cases for an OD No. 2108 are chosen because at this point of the OD process the association between disease and exposure has been recognized by the statutory accident insurances. The data set includes information on gender, diagnosis, age at diagnosis, the type of exposure, the duration of exposure, and the occupation that led to the OD No. 2108.

Ethic board approval and informed consent

For this secondary data analysis of anonymized aggregated register data, approval of an Ethical Review Board and written informed consent were not necessary because the German code of social law (SGB 7th book §204) explicitly allows the use of the data obtained from the German Statutory Insurance for descriptive analyses with the purpose of prevention and further development of OD regulations.

Classification of occupation

The statutory accident insurance has changed the occupational classification system between 2000 and 2009. Until the end of 2001 they used a modification of the German classification of occupations (KldB version 1988) and since 2002 they use an adapted version of the International Classification for Occupations (ISCO version 1988). The classification systems differ significantly and reclassification is problematic. Therefore, the period 2002–2009 is presented in this analysis instead of the originally intended 10-year period.

For the analysis, the third level of the ISCO88 is used. This includes a total of 116 occupational minor groups [Elias and Birch, 1994].

Statistical analysis

The PI combines two ranking information, the raw frequencies and the incidence. First described by O'Brien [1984] the PI was used by Silverstein et al. [2002] to identify high risk occupations for work-related musculoskeletal disorders in Washington State. First the absolute frequency information is used to rank the occupations from the occupation with the highest number of cases to the occupation with the lowest number of cases. The rank of the relative frequency (incidence) for the occupations is the second part of the PI. The lower the PI, the higher the needs for prevention.

As the statutory accident insurances has no occupation-specific data on the number of insured employees (only equivalent full time employees), the data of the German *microcensus* are used as denominator. The *microcensus* is a regular compulsory survey of a representative one percent sample of all inhabitants in Germany. It includes data on economic activities of the population (e.g., employment status, income, education, and training) [Schwarz, 2001]. In the *microcensus* data the occupations are coded in the 3 digit code of the ISCO88. The occupation-specific numbers of cases of OD No. 2108 were related to the occupation-specific mean number of employees in one year (working population). The formula for the average annual occupation-specific incidence is shown below.

$$\text{Estimated incidence}_{\text{occupation}} = \left(\frac{\sum_{2002}^{2009}(\text{cases of OD}_{\text{occupation}})}{\sum_{2002}^{2009}(\text{working population per year}_{\text{occupation}})}\right) \times 100,000$$

The result is the estimated incidence for an OD No. 2108 per year and 100,000 working population in a specific occupation. The 95% confidence intervals were calculated using the Clopper–Pearson method [Newcombe, 2012]. Then the rank was determined from the occupation with the highest incidence (last rank = equal to the number of considered occupations) to the one with the lowest incidence (ranking = 1). The ranking of the observed absolute frequencies of the OD was applied in the same way.

With the information of the frequencies and the incidence the PI can be calculated as the mean of two ranks (see formula below) [Silverstein et al., 2002]

$$PI = \frac{\text{frequency rank} + \text{incidence rank}}{2}$$

For statistical reasons only occupations with more than five cases are presented in the analysis.

High differences between time periods could be an indicator that changes in the working population had an influence on the PI. For sensitivity analyses, the PI it was calculated separately for the years 2002 until 2005 and for 2006 until 2009 as well as for the upper and lower bounds of the confidence intervals of the incidences. The sensitivity analysis allows the evaluation of potential effects of changes over time (e.g., changes in the labor market or the OD procedures).

RESULTS

Description

The proportion of confirmed cases of OD No. 2108 was 1.5% when related to all OD in Germany for the years 2002 until 2009 (for men 0.9%, for women 2.9%).

The descriptions of the population by age at diagnosis of confirmed OD, duration of exposure, and type of exposure are shown in Table I.

Most confirmed cases are in the age category between 40 until less than 50 years. Men are more frequently in the highest age category of 60 years and more whereas women are mainly in the two age categories below 40 years. Likewise, the duration of the exposure for women tends to be shorter (59.2% less than 20 years) than for men (51.1% between 20 and 40 years). Women have a higher number of exposure to patient transfer (81.1%) followed by working in extremely bent posture (13.6%). For men, the main exposure is working in bent posture (35.2%) followed by various carrying exposures (primarily bundles of boxes, chests/cartons, bales, or bags/rolls) and patient transfer (13.8%).

Frequencies of Occupations

The number of cases for the occupations with a confirmed OD No. 2108 and the estimated incidence are shown in Table II. In the period 2002 to 2009, an OD was confirmed for 62 different occupations for men and 32 for women, respectively.

TABLE I. Characteristics of Cases with Confirmed OD NO. 2108 During 2002–2009 in Germany, by Gender

Characteristics	Men (n) (%)	Women (n) (%)
Confirmed cases OD No. 2108	1,178 (40.9%)	1,699 (59.1%)
Age by diagnosis in years		
15 until <30	5 (0.4%)	41 (2.4%)
30 until <40	57 (4.8%)	172 (10.1%)
40 until <50	250 (21.2%)	632 (37.2%)
50 until <60	476 (40.4%)	685 (40.3%)
≥60	388 (32.9%)	164 (9.7%)
No Information	2 (0.2%)	5 (0.3%)
All	1,178 (100%)	1,699 (100%)
Duration of exposure in years		
<10	161 (13.7%)	434 (25.5%)
10 until <20	272 (23.1%)	571 (33.7%)
20 until <30	337 (28.6%)	438 (25.8%)
30 until <40	265 (22.5%)	204 (12.0%
40 until <50	90 (7.6%)	36 (2.1%)
No information	52 (4.4%)	15 (0.9%)
All	1,178 (100%)	1,699 (100%)
Type of exposure		
Patient transfer	162 (13.8%)	1,378 (81.1%)
Working in bent posture	415 (35.2%)	231 (13.6%)
Carrying metal sheets, parts, plates (etc.)	114 (9.7%)	2 (0.1%)
Carrying bricks (or similar)	103 (8.7%)	2 (0.1%)
Carrying bundle of boxes, chests/cartons, bales or bags/roll (etc.)	199 (16.9%)	24 (1.4%)
Driving truck, dredge or bulldozer	5 (0.4%)	0
Carrying wooden parts or furniture parts	61 (5.2%)	2 (0.1%)
Carrying hammers (different types)	0	1 (0.1%)
Carrying working materials for miners	10 (0.8%)	0
No information	109 (9.3%)	59 (3.5%)
All	1,178 (100%)	1,699 (100%)

Adapted from © DGUV Referat BK-Statistik / ZIGUV D-53757 Sankt Augustin; from 08 Apr 11.

In Table II the occupations with the highest potential for prevention are listed. For men most confirmed cases of OD No. 2108 come from the construction industry (most frequent exposure was extreme trunk flexion and carrying different types of materials). For women only nine occupations with high frequency are identified.[3] The most frequent occupations come from the health and care sectors. In all female occupations patient transfer is the main causal exposure (that varies between 80% and 85% of all exposures within the

[3] Only occupations with a number of cases equal or higher than five are presented (see methods).

TABLE II. Selected Occupation with Highest Prevention Needs of Confirmed Cases with OD NO. 2108 During 2002–2009 in Germany, by Gender and Occupational Classification (ISCO88) (Sorted by PI)

Gender	Occupation (ISCO88 code)	Cases of OD No.2108	Number employed[a] (in thousand)	Estimated incidence[b] (95%–CI)	Frequency rank	Incidence rank	PI[c]
Men	Building frame and related trades workers (712)	277	4,079	0.85 (0.24–2.03)	1	3	2
	Nursing and midwifery associate professionals (323)	81	922	1.10 (0.50–3.11)	4	1	2.5
	Miners, shot firers, stone cutters and carvers (711)	43	614	0.88 (0.49–2.87)	7	2	4.5
	Mining and construction labourers (931)	33	779	0.53 (0.32–1.87)	10	5	7.5
	Personal care and related workers (513)	33	1,044	0.40 (0.24–1.40)	10	7	8.5
	Material-recording and transport clerks (413)	50	3,851	0.16 (0.09–0.51)	6	11	8.5
	Motor vehicle drivers (832)	87	7,26	0.15 (0.07–0.42)	3	14	8.5
	Health associate professionals, except nursing (322)	30	770	0.49 (0.30–1.78)	12	6	9
	Building finishers and related trades workers (713)	93	8,775	0.13 (0.06–0.37)	2	17	9.5
	Forestry and related workers (614)	11	246	0.56 (0.44–3.12)	20	4	12
	Food processing and related trades workers (741)	21	1.625	0.16 (0.11–0.67)	13	11	12
Women	Nursing and midwifery associate professionals (323)	846	5,505	1.92 (0.33–4.24)	1	1	1
	Health associate professionals, except nursing (322)	191	2,507	0.95 (0.31–2.37)	3	2	2.5
	Personal care and related workers (513)	422	6,637	0.77 (0.19–1.83)	2	3	2.5
	Social work associate professionals (346)	74	2,914	0.32 (0.15–0.92)	4	4	4
	Other personal service workers (514)	7	3,009	0.03 (0.02–0.21)	5	6	5.5
	Domestic and related helpers, cleaners and launderers (913)	7	6,019	0.01 (0.01–0.11)	5	7	6
	Material-recording and transport clerks (413)	6	2,021	0.04 (0.03–0.30)	7	5	6
	Housekeeping and restaurant services workers (512)	6	7,848	0.01 (0.01–0.08)	7	7	7
	Shop, stall and market salespersons and demonstrators (522)	6	10,423	0.01 (0.01–0.06)	7	7	7

Adapted from DGUV Referat Statistik—Leistungen, Berufskrankheiten, Sonderaufgaben D-53757 Sankt Augustin; from March 11, 2013.
Listed occupations.
Men: 11 out of 29 occupations with $n \geq 5$ and the lowest PI, 11 because there were two occupations with a PI of 12 (total: $n = 62$ occupations).
Women: 9 occupations with $n \geq 5$ cases (total: $n = 35$ occupations).
Not listed occupations.
Men: 18 occupations with $n \geq 5$ cases but a PI >12 are: (721) Metal moulders, welders, sheet-metal workers, structural-metal preparers, and related trades workers, (723) Machinery mechanics and fitters, (724) Electrical and electronic equipment mechanics and fitters, (833) Agricultural and other mobile plant operators, (742)Wood treaters, cabinet-makers and related trades workers, (933) Transport labourers and freight handlers, (821) Metal- and mineral-products machine operators, (346) Social work associate professionals, (828) Assemblers, (722) Blacksmiths, tool-makers and related trades workers, (311) Physical and engineering science technicians, (222) Blacksmiths, tool-makers and related trades workers, (522) Shop, stall and market salespersons and demonstrators, (822) Chemical-products machine operators, (932) Manufacturing labourers, (512) Housekeeping and restaurant services workers, (813) Glass, ceramics and related plant operators, (827) Food and related products machine operators, (812) Metal-processing plant operators.
33 out of 62 occupations with $n < 5$ cases (3 with $n = 4$; 6 with $n = 3$; 7 with $n = 2$; 17 with $n = 1$); no information about occupation $n = 55$.
Women: 26 out of 35 occupations with $n < 5$ (4 with $n = 3$; 6 with $n = 2$; 16 with $n = 1$); no information about occupation $n = 19$.
[a]Mean number of employees from German microcensus data.
[b]Estimated incidence per year and 100,000 employees. Estimated by using data from the German microcensus, 2002–2009.
[c]PI, Prevention index.

affected occupations) followed by extreme trunk flexion (that varies between 10% and 15%).

Table III shows the type of exposure for the three occupations with the highest prevention needs (as listed in Table II). In these occupations working in extreme bent posture was the most frequent exposure for men followed by patient transfer. For women patient transfer is most frequent category and than working in bent posture.

Estimated Incidence

In order to estimate the incidence, the number of confirmed cases of OD No 2108 is related to the data on occupation-specific number of employees in the German *microcensus* provided by the German Federal Statistics Office. Table II shows the average annual incidence (with 95% CI) per 100,000 employees for selected occupations. Occupations among males with the highest estimated incidence are nurses, miners, and building frame and related trades work. For females the highest incidence is estimated for nurses, health associated professionals, and personal care and related workers.

Prevention Index

The occupation-specific number of OD No. 2108, the incidence rankings for men and women ranked by the PI are shown in Table II.

The male occupations with the highest PI are building frame and related trades workers, nurses and midwifery associate professionals, as well as miners, shot firers, stone cutters and carvers. Miners have a low frequency rank (=7)

TABLE III. Occupation with Highest Prevention Needs 2002–2009 in Germany, by Gender, Occupational Classification (ISCO88) and Type of Exposure

Gender	Occupation (n)	Type of exposure	Number (percent)
Men	Building frame and related trades workers (n = 277)	Carrying natural stone, not further differentiated	6 (2.2%)
		Carrying bricks, plates, pipes and other mineral-bounded parts	8 (2.9%)
		Carrying metal sheets	3 (1.1%)
		Carrying wooden parts	18 (6.5%)
		Carrying furniture parts	5 (1.3%)
		Driving dredge	2 (0.7%)
		Driving bulldozer	2 (0.7%)
		Carrying cases, boxes, cartons, buckets	3 (1.1%)
		Carrying equipment and parts for miners	2 (0.7%)
		Working in extreme bent posture	225 (81.2%)
		No information	3 (1.1%)
	Nursing and midwifery associate professionals (n = 81)	Patient transfer	67 (82.7%)
		Working in extreme bent posture	12 (14.8%)
		No information	2 (2.5%)
	Miners, shot firers, stone cutters and carvers (n=43)	Carrying metal sheets	1 (2.3%)
		Carrying bricks, plates, pipes and other mineral-bounded parts	2 (4.7%)
		Carrying equipent and parts for miners	8 (18.6%)
		Working in extreme bent posture	28 (65.1%)
		No information	4 (9.3%)
Women	Nursing and midwifery associate professionals (n = 846)	Patient transfer	717 (84.8%)
		Working in extreme bent posture	102 (12.1%)
		No information	27 (3.2%)
	Health associate professionals, except nursing (n = 191)	Patient transfer	175 (91.6%)
		Working in extreme bent posture	13 (6.7%)
		No information	3 (1.6%)
	Personal care and related workers (n = 422)	Patient transfer	330 (78.2%)
		Working in extreme bent posture	84 (19.9%)
		No information	8 (1.9%)

Adapted from © DGUV Referat BK-Statistik / ZIGUV D-53757 Sankt Augustin; from Feb 10, 2012.

but a high incidence rank (=2). On the contrary, motor vehicle drivers have a high frequency rank (=3) and a low incidence rank (=14). For males the PI ranges from 2 to 27.5.

The female occupations with the highest PI are nurses and midwifery associate professionals, health associate professionals (except nursing), as well as personal care and related work. The female occupations showed only a small (or no) difference between frequency rank and incidence rank (see Table II). For women the PI ranges from 1 to 7.

Sensitivity Analysis

The temporal variation in the PI for the periods 2002 until 2005 and 2006 until 2009 are shown in Table IV. There is little variation in the PI and the frequency rank between the two time periods (2002 until 2005 and 2006 until 2009) and the whole time period. Some variations in the incidences are observed among men for miners, shot firers, stone cutters and carvers, mining and construction laborers, and personal care and related workers. The greatest difference appears in the personal care and related workers. For women, the frequencies differ between the periods for personal care and related workers and there are fewer occupations with $n \geq 5$ cases. There was a change in the classification system in the year 2002 leading to some misclassifications in the transition period. If the lower and upper bounds of the 95% CI of the incidence are used to build the PI, there are no great variations in the rankings for men and women (not shown).

DISCUSSION

The aim of this study was to identify areas of focus for prevention and research regarding ODs of the lumbar spine. The PI helps to identify occupations with a high probability to have a confirmed OD of the lumbar spine caused by heavy lifting or work with extreme trunk flexion (OD No. 2108). The analysis was based on confirmed cases of an OD No. 2108 in Germany for the time period between 2002 and 2009 (1,178 men and 1,699 women).

High Risk Occupations and Exposures

Occupations with the lowest PI, indicating the highest needs for prevention, were nursing and midwifery associate professionals in general and for women additionally health associate professionals (except nursing), and personal care and related workers and for men building frame and related workers, and miners, shotfirers, stone cutters and carvers, respectively. Based on retrospective exposure assessment and medical expert opinion, the main work exposures for the three most affected occupations among women were patient transfer (about 80%), and work in extremely bent posture (between 7% and 20%). Causal occupational exposures for nursing and midwifery associate professionals among men also included patient transfer (about 80%) and bent posture (15%). Male building frame and related trade workers were exposed mainly to work in bent posture (63%), carrying bricks (21%), and carrying wooden parts (6%). Male miners, shotfirers, stone cutters, and carvers had the highest exposure to working in an extremely bent posture (65%) and carrying parts for underground mining (19%). ODs of the lumbar spine caused by whole body vibration were not included in this analysis because the number of confirmed cases over the 8-year period ($n = 73$) did not allow for a detailed analysis ($n = 1/104$ female case; most frequent occupations were motor vehicle drivers with 21 cases, and agricultural and other mobile plant operators with 32 cases).

Gender Perspective

The observed gender differences probably partly reflect gender-specific career choices and different administrative procedures for the confirmation of an OD within the nine statutory accident insurance institutions.

The identified occupations with at least 5 cases between 2002 and 2009 came from different economic sectors. Women with a confirmed OD No. 2108 came from five major groups of the ISCO88 classification (professionals, technicians and associate professionals, clerks, service and sales workers, and elementary occupations). Nursing and midwifery professionals are considered as health professional in the ISCO classification. However, exposure to physical work demand is common for these professions in Germany. Male cases came from nearly all major groups (only armed forces, which are not included in the data, and managers had no confirmed cases).

The data show the picture of a highly horizontally segregated workforce in Germany. As different accident insurance institutions are assigned to the different economic sectors and the process of verifying the legal definitions and requirements of the OD might differ between the institutions, gender differences within the health, and care sector were further analyzed. In the two most affected health and care occupations the number of male cases was much lower than the number of women (for nurse and midwifery professionals 81 male and 846 female cases and for personal care occupations 33 male and 422 female cases). This also applies to male health associate professionals except nursing (30 male and 191 female cases). The proportion of female workers in the three occupations with the lowest PI varies between 76.5% for health care and associate professionals (except nursing) to about 86.4% for personal care and related workers (estimated from the *microcensus*). In the health care sector, men and women display little difference in age at diagnosis (most frequent categories 40 until 50 for men and

TABLE IV. Sensitivity of the Prevention Index (PI) for Selected Occupations with Highest Prevention Needs of Confirmed Cases with OD NO. 2108 During 2002–2009 in Germany, by Gender, Occupation, and Year of Registration (Sorted by PI)

		Year of registration					
		2002–2005			2006–2009		
Gender	Occupation (ISCO88 code)	Frequency rank (frequency)	Incidence rank (estimated incidence[a]; 95%CI)	PI[b]	Frequency rank (frequency)	Incidence rank (estimated incidence[a]; 95%CI)	PI[b]
Men	Building frame and related trades workers (712)	1 (140)	3 (1.70; 0.48–4.06)	2	1 (137)	4 (1.70; 0.48–4.06)	2.5
	Nursing and midwifery associate professionals (323)	4 (42)	1 (2.30; 1.03–6.48)	2.5	4 (39)	3 (2.09; 0.96–5.97)	3.5
	Miners, shot firers, stone cutters and carvers (711)	9 (16)	5 (1.26; 0.77–4.49)	7	6 (27)	1 (2.27; 1.19–7.02)	3.5
	Mining and construction laborers (931)	7 (20)	4 (1.34; 0.77–4.49)	5.5	13 (13)	8 (0.80; 0.52–3.06)	10.5
	Personal care and related workers (513)	19 (5)	15 (0.24; 0.19–1.42)	17	5 (28)	5 (1.32; 0.68–4.05)	5
	Material-recording and transport clerks (413)	6 (25)	9 (0.35; 0.19–1.10)	7.5	7 (25)	12 (0.30; 0.16–0.95)	9.5
	Motor vehicle drivers (832)	2 (45)	11 (0.32; 0.14–0.88)	6.5	3 (42)	13 (0.28; 0.13–0.80)	8
	Health associate professionals, except nursing (322)	11 (15)	6 (1.07; 0.67–3.91)	8.5	11 (15)	6 (0.89; 0.56–3.26)	8.5
	Building finishers and related trades workers (713)	2 (45)	14 (0.25; 0.11–0.70)	8	2 (48)	13 (0.28; 0.12–0.76)	7.5
	Forestry and related workers (614)	15 (8)	2 (1.80; 1.31–8.37)	8.5	n.a.	n.a.	n.a.
	Food processing and related trades workers (741)	12 (9)	12 (0.28; 0.20–1.22)	12	14 (12)	10 (0.37; 0.24–1.46)	12
Women	Nursing and midwifery associate professionals (323)	1 (377)	1 (3.47; 0.63–7.72)	1	1 (469)	1 (4.20; 0.69–9.24)	1
	Health associate professionals, except nursing (322)	2 (100)	2 (2.22; 0.72–5.50)	2	3 (91)	3 (1.65; 0.55–4.12)	3
	Personal care and related workers (513)	4 (28)	4 (0.22; 0.12–0.69)	4	2 (394)	2 (2.80; 0.50–6.21)	2
	Social work associate professionals (346)	3 (55)	3 (1.03; 0.42–2.76)	3	4 (19)	4 (0.30; 0.18–1.02)	4
	Domestic and related helpers, cleaners and launderers (913)	5 (5)	5 (0.03; 0.03–0.19)	5	n.a.	n.a.	n.a.

Adapted from DGUV Referat Statistik—Leistungen, Berufskrankheiten, Sonderaufgaben D-53757 Sankt Augustin; from 11.03.2013.
n.a., not applicable; occupations with $n < 5$.
Women: 2002–2005: 24 occupations and 19 with $n < 5$ cases; 2006–2009: 23 occupations and 19 with $n < 5$ cases.
Men: 2002–2005: 51 occupations and 30 with $n < 5$ cases; 2006–2009: 51 occupations and 30 occupations with $n < 5$ cases.
[a]Estimated incidence per year and 100,000 employees. Estimated by using the mean employed population from the German microcensus.
[b]PI, prevention index.

50 until 60 for women), and duration of exposure (most frequent categories from 10 until 20 years and from 20 to 30 years for both genders). Also in the care sector, there are little differences between the genders, regarding the most frequent age categories (from 50 until 60 years for both genders), and duration of exposure (from under 10 years until under 20 years). Thus, in contrast to comparisons across economic sectors, comparisons within one sector show no differences between man and women regarding age at diagnosis and duration of exposure.

If the analyses of OD would not be stratified by gender, some occupations that are relevant for one gender would remain undetected. In a non-stratified analysis for example, the domestic and related helpers, cleaners, and launderers have a PI of 28.5 (frequency rank 28, incidence rank of 29) whereas the PI in a stratified analysis for women is 6 (frequency rank is 5, incidence rank is 7).

Strength and Limitations

This study has several strengths. The analyzed data include all cases for an OD No. 2108 from the Statutory German Social Accident Insurance for the years from 2002 until 2009 and thus nearly all Germans subject to statutory social insurance. On average per year, the German workforce from 2002 until 2009 was around 40 million and thereof 27 million socially insured employees (estimated from the German Federal Employment Agency and the German Federal Statistics Agency). This allows for a gender specific analysis of the OD in Germany with the identification of occupations with high needs for prevention.

The limitations of the study are the general problems of secondary data analyses. The data on exposure and disease were collected for administrative reasons and not for research. Information on non-occupational causes of diseases of the lumbar spine (e.g., certain predisposing medical conditions like scoliosis, and vertebral fractures) were excluded in the process of the assessment for an OD to make sure that the occupational exposure was causal for the disease. However, information on exposure, disease, and confounders of the denominator (the occupation-specific working population) are missing.

The comparatively low number ($n = 2{,}877$ over 8 years) of confirmed cases can be explained by high legal barriers and medical conditions that must be fulfilled for the confirmation of an OD No. 2108, for example, the commonly required weights and duration of exposure (hours worked with carrying, lifting, and in bent posture, the amounts of work shifts and the years worked in the occupation). The OD No. 2108 has the lowest ratio of confirmed versus suspected ODs in Germany [Hagemeyer et al., 2005]. This has also an effect on the reporting of OD No. 2108.

The data from the German statutory accident insurance do not include all workers in Germany. Public servants, soldiers, and the agricultural sector are missing. There were on average 2.2 million public servants working in Germany (per year from 2002 until 2009). In the agricultural sector during 2002 until 2009 there were on average 581,874 insured persons per year with about 85 recognized cases (from 2002 until 2009) for an OD No. 2108 [Statutory Accident Insurance of the Agricultural Sector, 2011]. As a consequence, the risk of occupations in the agricultural sector is underestimated. From 2002 until 2009 there were on average 263,500 soldiers per year in Germany. If public servants, soldiers, and the working population in the agricultural sector are added and related to the employed population, around 8.3% of the employees in Germany are missing in the presented analysis.

For the estimation of the occupation-specific incidence a different data source for the denominator has to be used as information on the occupation-specific number of insured employees is not available from the statutory accidence. In addition the classification of occupations of ODs changed between 2001 and 2002 from KldB88 to ISCO88. As a consequence, the number of confirmed cases of OD 2108 was related to the number of employees based on the representative *microcensus*. As the *microcensus* covers only 1% of the German resident population this could lead to selection effects regarding the number of employees in rare occupations. Further, family workers and self-employed can be included in the number of confirmed cases. For the years 2002 until 2009 there were on average per year around four million self-employed and about 374,250 family workers per year [Federal Statistical Office, 2013]. These groups might be included in the data from the German Statutory Accident Insurance. This will lead to a conservative estimate for the incidence.

Some occupations identified with the PI in the presented analysis are underrepresented in the literature and are not listed in the annex of the OD act for OD No. 2108 [Federal Ministry of Labour and Social Affairs, 2006]. This includes male electricians and vehicle drivers (who can be exposed to a combination of carrying, lifting, and to whole-body vibration, in Germany OD No. 2110), female kindergarten workers, sales assistants, and physical therapist, respectively. Here further research is needed.

Comparison with Other Studies

Comparison with other data sources covering low back related disability in the German workforce is difficult due to dissimilar legal definitions in the different social-insurance systems for sick-leave, disability pensions, and OD and due to different classifications of occupations. Thiede [2012] used data from the German Statutory Pension Insurance Scheme (DRV) for disability pension due to back disorders with the KldB88 classification and identified vehicle drivers, bricklayers, and unskilled workers (w/o further information) as mainly affected male occupations. Cleaners, sales assistants, and office workers were the most frequent occupations for women. Liebers et al. [2013] analyzed sick leave due to back pain (ICD M54) based on data from the statutory health insurance in Germany with the KldB88 classification. The range of occupations with a high risk was similar for males with a broad spectrum of non-qualified and qualified manual and service workers. Sick-leave due to back pain among women clustered in fewer occupations (mainly non-qualified and qualified manual and service workers among women). However, sick-leave among women also covered many occupations within plant and machine operators and assemblers (e.g., metal processing and finishing plant operators, and rubber, plastic and paper products machine operators), and from craft and related trades (e.g., food processing). Further research is needed in order to answer the question whether exposure in these occupations leads to work-related back pain but does not suffice the requirements for an OD No. 2108 or if the OD is underreported in these occupations.

Based on the information available to the investigator, a comparison with other European surveillance systems is only possible for musculoskeletal ODs in general but not specifically for the low back [European Agency of Safety and Health at Work, 2010]. Among countries with an OD related to the spine, Belgium has the highest numbers of accepted cases for MSDs in the mining and manufacturing, the construction industries, and the transport and communication industries [European Agency of Safety and Health at Work, 2010]. Based on the voluntary surveillance scheme in the UK by occupational physicians and rheumatologists, one of the most prominent work-related diseases are disorders of the lumbar spine [Cherry et al., 2000; Chen et al., 2005] with the health care sector, the construction sector, and the public administration as the most concerned industries [Cherry et al., 2000].

Use of the Prevention Index

The PI requires two types of ranking information, the frequency rank and the incidence rank. As a consequence the availability of three rankings (frequency, incidence, and PI) renders the decision on the most important field for prevention difficult if the rankings differ. If the main interest is to reduce the number of cases for an OD, then the frequencies should be used. However, if the identification of preventive needs is only geared towards the absolute number of OD cases, considerable high risk tasks in rare occupations stay unnoticed. Therefore, high individual risks can only be taken into consideration based on the incidence in the single occupational groups. If it is more important to reduce the risk for an OD than the incidence is the method to identify occupations with a high risk. The strength of the PI is that it allows for a combination of frequency and incidence. The equal weighting of the frequency rank, based on absolute OD numbers and the incidence rank of an OD in the PI calculation may appear somewhat arbitrary.

The weakness of the PI is that some information is lost. First, for large occupational groups with heterogeneous occupational exposures and high frequency rank, the low incidence rank might be misleading. Second, the extent of the variations in the number of cases and in the incidence between the different occupations becomes indistinguishable because only the ranking information is used. Third, the information of the confidence interval of the incidence is not part of the PI.

Several relative and absolute risk estimates (e.g., attributable risks) are available for the quantification of the effects of occupational risk factors. The best estimates would be expected from population-based prospective cohort studies. However, information on the occupational exposure is rarely detailed enough and objective case ascertainment is often missing. No studies with estimation of population attributable risks for heavy physical lifting or extreme work postures were retrieved. The strength of the PI is that it can be applied to surveillance data with broad coverage of the working population where information on the non-diseased population is lacking.

The numbers of employees in the identified high risk occupations for men were decreasing for most occupations over the time from 2002 until 2009. Alternatively, the numbers of employees in the identified occupations for women were mainly increasing. This can be explained by the fact that the identified male occupations mainly come from the construction and mining sectors that have suffered from an economic decline within the last decade whereas the number of employees in the health and care sectors have increased. The sensitivity analysis shows the robustness of the PI. If the frequency ranks are stratified by year of confirmation (2002–2005 vs. 2006–2009), the PI for men and women varies less than the incidence rank and the frequency rank. The observed differences in the frequencies rank and the incidence rank for some of the occupations could be explained by different job tasks in the same occupational group (e.g., only few vehicle drivers may be exposed to heavy lifting), or by a low number of employees which leads to a higher incidence.

For potential improvements of the PI, consideration of the number of employees at risk, the confidence bounds of the incidence, task-specific information on the spectrum and intensity of exposures, and heavier weights for the incidence than for the frequency as discussed by Silverstein et al. [2002] might be considered.

Conclusion and Research Needs

Regarding confirmed ODs of the lumbar spine caused by carrying, lifting or extreme trunk flexion in Germany, there is no difference whether occupations with high needs for prevention are identified by the number of cases, the incidence or the PI for women. With all three methods nurses, health related professionals, and personal care and related workers are mainly affected. For men, the three methods lead to different rankings in the occupations. The mainly affected male occupations came from a broad spectrum of occupations including the health and care sectors with occupation in the construction industry as the most prominent. Given the constraints of ODs for the identifications of preventive needs regarding legal requirements for exposure and disease, extended preventive strategies are needed in these occupations. Further research is required for selected occupations (e.g., kindergarten workers, sales assistants, physical therapists, as well as plant and machine operators and assemblers). Generalizability of the results to countries with different economic structures and legislative and administrative requirements regarding ODs, needs verification. Applicability of the PI for the prevention of low back pain in the workforce compared to other measures (e.g., population attributable risk) should be further investigated.

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