

Occupation as a Proxy for Job Exposures? Routine Data Analysis Using the Example of Rehabilitation

Berufstätigkeit als Proxy für Arbeitsbelastungen? Routinedatenanalyse am Beispiel der Rehabilitation



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ABSTRACT

Aim of the study Job exposures are associated with health-related outcomes including sick leave and reduction in earning capacity. Rehabilitation of persons in working age aims primarily to secure or restore work capacity. Information concerning job exposures is, however, not directly available in routine data of healthcare payers. Since exposures relate to specific occupations and the current occupation is part of routine data, job exposures may be determined indirectly via job-exposure ma-

trices (JEM). The aim of the study is to describe the possibilities and challenges of the representation of job exposures by the occupation according to routine data using the example of rehabilitation.

Methods The Scientific Use File ‘SUFSDLV15B’ of the German Pension Insurance was analysed. We used data from $n = 1\,242\,171$ persons in work with at least one completed medical rehabilitation between 2008 and 2015 (dataset 1). The occupation is coded according to KldB 88 or KldB 2010 (German Classification of Occupations). In addition, data from a nationwide survey with 2530 rehabilitation patients was available (dataset 2). Job exposures are operationalized by the Job Exposure Index via JEM. The relationship to the return-to-work prognosis at the end of rehabilitation (dataset 1) and to patient reported outcome measures (dataset 2) is described.

Results Information concerning the occupation is available for about 91 % of rehabilitation measures of employed patients for the year prior to rehabilitation. At high levels of job exposures, the proportion of persons with a predicted working capacity in the last job of fewer than 3 h per day increased by a factor of 4 compared to low-level job exposures (23.5 vs. 6.1 %). On the other hand, there is a low association only to reduced working capacity in the general labour market (2.9 vs. 2.4 %). High-level job exposures are associated with self-reported, work-related impairments.

Conclusion The Job Exposure Index may offer a valid approach to depict occupation-related exposures. The index can be used in the analysis of routine data of the pension insurance and other social security funds, as well as in the linkage of individual assessment data with routine data containing the occupation, without any additional data collection effort. Due to its construction based on job classifications, it will not replace the assessment of individual burdens.

ZUSAMMENFASSUNG

Ziel der Studie Arbeitsbelastungen sind mit verschiedenen Gesundheitsindikatoren wie Arbeitsunfähigkeit und Erwerbsminderung assoziiert. Primäres Ziel der Rehabilitation von Personen im erwerbsfähigen Alter ist meist die Sicherung bzw. Wiederherstellung der Erwerbsfähigkeit. Allerdings sind

Arbeitsbelastungen in Routinedaten der Kostenträger nicht verfügbar. Da viele Belastungen typisch für einzelne Berufe sind und die Tätigkeit in Routinedaten dokumentiert ist, können Arbeitsbelastungen indirekt über die Berufstätigkeit dargestellt werden. Ziel der Arbeit ist es, Möglichkeiten und Grenzen der Abbildung von Arbeitsbelastungen durch die Tätigkeit gemäß Routinedaten am Beispiel der Rehabilitation zu beschreiben.

Methodik Das Scientific Use File „SUFRSDLV15B“ der Deutschen Rentenversicherung mit 1 242 171 Erwerbstätigen mit mindestens einer abgeschlossenen medizinischen Rehabilitation 2008–2015 wurde analysiert (Datensatz 1). Die Tätigkeit ist nach KldB 88 bzw. KldB 2010 (Klassifikation der Berufe) codiert. Zudem stehen Daten einer bundesweiten Befragung mit 2 530 Rehabilitanden zur Verfügung (Datensatz 2). Arbeitsbelastungen wurden mithilfe eines Index über die Berufstätigkeit durch Bildung von Job-Exposure-Matrizen operationalisiert. Der Zusammenhang zur Return-to-Work-Prognose am Ende der Rehabilitation (Datensatz 1) und zu selbstberichteten Beeinträchtigungen und Ressourcen (Datensatz 2) wird berichtet.

Ergebnisse Für etwa 91 % der medizinischen Rehabilitationen bei Erwerbstätigen liegen für das Jahr vor Rehabilitation Informationen zur Berufstätigkeit und damit zum Arbeitsbelastungsindex vor. Bei hohen Arbeitsbelastungen war der Anteil mit einer prognostizierten Arbeitsfähigkeit im letzten Beruf von weniger als 3 Stunden täglich etwa um den Faktor 4 im Vergleich zu niedriger Arbeitsbelastung erhöht (23,5 vs. 6,1 %). Hingegen besteht nur ein geringer Zusammenhang zur verminderten Leistungsfähigkeit auf dem allgemeinen Arbeitsmarkt (2,9 vs. 2,4 %). Hohe Arbeitsbelastungen sind mit selbstberichteten, insbesondere berufsbezogenen Beeinträchtigungen assoziiert.

Schlussfolgerung Der Arbeitsbelastungsindex bietet die Möglichkeit, berufstypische Arbeitsbelastungen valide abzubilden. Der Index kann bei Analysen von Routinedaten der Sozialversicherungsträger sowie bei Verknüpfung von Primärdaten mit Routinedaten, welche die Berufstätigkeit enthalten, ohne zusätzlichen Erhebungsaufwand eingesetzt werden. Aufgrund seiner Konstruktion über die Berufstätigkeit kann der Index die Erhebung von individuellen Belastungen nicht ersetzen.

Introduction

Job exposures are associated with various health-related outcomes such as injuries, morbidity, mortality, sick leave and reduction in earning capacity [1–7]. They can be differentiated into physical job exposures like harmful working environments (noise, dirt, heat, cold, toxic or allergic substances, carrying heavy weights, e. g.) and psychosocial job exposures like time pressure, low job autonomy, shift work or frequent overtime [8–10].

As the main aim in the rehabilitation of patients in working age is usually return-to-work, working conditions can play an important role in achieving that aim. Therefore, job exposures should be considered in studies dealing with return-to-work after rehabilitation. However, individual job exposures are frequently not assessed in clinical or epidemiological studies. Common instruments to assess job exposures are extensive and often focus on certain aspects of job exposures only, e. g. the Copenhagen Psychosocial Questionnaire (COPSOQ) [11]. In routine data – for example of the Statutory Health Insurance or the German Pension Insurance –, there is no explicit information available concerning job exposures. Hence, it is not possible to take into account job exposures in routine data analyses directly.

It is known that many job exposures relate to specific occupations. This offers the possibility to represent job exposures via so-called job-exposure matrices: Job exposures measured individually in previous studies are assigned to the person's occupation. This information can then be used in any other epidemiological study or routine data analysis if the current occupation is available in the dataset. The use of job-exposure matrices is well established in occupational epidemiological research [12–18].

There are different classifications of occupations applied both for administrative purposes and for scientific studies. By law, all employers in Germany are obliged to transmit yearly information con-

cerning the occupation and education (amongst other information) for all employees to the Statutory Health Insurance. From there, this data is transferred to the German Pension Insurance and further on to the Federal Employment Agency (“Datenerfassungs- und Übermittlungsverordnung” (DEÜV)) [19]. The occupation has to be coded according to the German Classification of Occupations 2010 (KldB 2010) [20] since 1.12.2011 [21]. Before, occupations were documented according to the first 3 digits of the Classification of Occupations 1988 (KldB 88). The Federal Statistical Office used the similar Classification of Occupations 1992 (KldB 92), e. g. for the microcensus.

For international comparisons, the International Standard Classification of Occupations (ISCO) by the International Labour Organization is widely used [22]. 2008 the fourth version ISCO-08 succeeded the previous version ISCO-88 [23]. KldB 2010 and ISCO-08 are more comparable than their predecessors were. The classifications mentioned are also used for job coding in various surveys and other large epidemiological studies or survey data which is linked to routine data that contains the occupation code [24–27].

All job classifications mentioned have in common that they consist of a hierarchical structure. In KldB 2010 for example, there are 1286 occupational types nested within 700 sub-groups, 144 groups, 37 main groups and 10 occupational areas [20]. This allows to both assess and to take into consideration job exposures via job-exposure matrices on different hierarchical levels of occupations. ► **Table 1** provides an overview of the structure and usage of the most important occupation classifications in Germany and on an international level. With some limitations regarding the precision, the job classifications mentioned can be transformed into each other.

The aim of this work is to illustrate the possibilities and limitations of using the occupation documented in routine data and its

► **Table 1** Classifications of occupations: Structure and usage.

| | KldB 88 | KldB 92 | KldB 2010 | ISCO-88 | ISCO-08 |
|---|--|--|---|---|-----------------------------|
| Occupation level (n) | | | | | |
| 1 | occupational area (n = 6) | occupational area (n = 6) | occupational areas (n = 10) | major group (n = 10) | major group (n = 10) |
| 2 | occupational section (n = 33) | occupational section (n = 33) | occupational main group (n = 37) | sub-major group (n = 28) | sub-major group (n = 43) |
| | occupational group (n = 86) | occupational group (n = 88) | | | |
| 3 | occupational order (n = 334) | occupational order (n = 369) | occupational group (n = 144) | minor group (n = 116) | minor group (n = 120) |
| 4 | occupational class (n = 1 991) | occupational class (n = 2 287) | occupational sub-group (n = 700) | unit group (n = 390) | unit group (n = 436) |
| 5 | | | occupational type (n = 1 286) | | |
| Official institutions | Statutory Health Insurance | Federal Statistical Office | Statutory Health Insurance | International Labour Office | International Labour Office |
| | German Pension Funds | | German Pension Funds | European Union | |
| | Federal Employment Agency | | Federal Employment Agency Federal Statistical Office | European Union | |
| Studies (examples) | lidA - German cohort study on work, age and health | BIBB/BAuA Employment Survey | BIBB/BAuA Employment Survey | BIBB/BAuA Employment Survey | BIBB/BAuA Employment Survey |
| | | Socio-economic Panel (SOEP) | Socio-economic Panel (SOEP) | Socio-economic Panel (SOEP) | Socio-economic Panel (SOEP) |
| | | German Health Update (GEDA) | German Health Update (GEDA) | German Health Update (GEDA) | German Health Update (GEDA) |
| | | lidA - German cohort study on work, age and health | Transitions and Old Age Potential (TOP) | European Working Conditions Survey (EWCS) | |
| | | Gutenberg Health Study (GHS) | | Survey of Health, Ageing and Retirement in Europe (SHARE) | |
| KldB: German Classification of Occupations, ISCO: International Classification of Occupations, n: number of occupations | | | | | |

use as a proxy for job exposures in rehabilitation patients. For this purpose, we give both an example for a sole routine data analysis and an example for a secondary data analysis based on survey data linked to routine data. We report the association between job exposure indices according to the occupation on the one hand and return-to-work prognosis after rehabilitation and patient reported outcome measures on the other hand.

Methods

The German Pension Insurance is by far the most relevant payer for medical and vocational rehabilitation for persons in working age in Germany [28]. Usually, the main aim of these rehabilitation measures is to secure or restore the ability to work. In 2017, 1 011 578 medical rehabilitations and 165 980 vocational rehabilitations were completed [29]. Therefore, in this paper, we used data of rehabilitation measures financed by the German Pension Insurance. For this purpose, we analysed 2 different datasets:

First, we used a Scientific Use File (SUF) provided by the Research Data Centre of the German Pension Insurance (<http://www.fdz-rv.de>) (dataset 1). The longitudinal dataset called "SUFSDLV15B" contains data from 3 734 861 persons in total. Of those, 1 836 448 persons completed at least one medical rehabilitation within an

8-year time period from 2008–2015. The data is a factually anonymised sample of 20 % of all completed medical rehabilitations covered by the German Pension Insurance. Individual contribution and sociodemographic data are available for 3 more years (2005–2007). In addition, the Scientific Use File contains longitudinal data for vocational rehabilitation and persons with retirement entry (including due to disability) and data for several reference populations in the indicated time period. Because we investigate return-to-work, we included only data for n = 1 242 174 persons who were full-time or part-time employed and had completed medical rehabilitation, excluding rehabilitation aftercare or programmes like rehabilitation sports and functional training. We excluded unemployed persons and persons not working or staying at home before their rehabilitation as well.

Second, we used data from an own study conducted with 2530 rehabilitation patients insured with the German Federal Pension Insurance (dataset 2). The rehabilitants were asked by postal mail to fill in a questionnaire covering various bio-psycho-social impairments and resources shortly prior to the start of medical rehabilitation, e. g. depressive symptoms, general self-efficacy, and social support (► **Table 3**). This survey data was joined with routine data including the occupation according to KldB 88 from the insurance account and with data from the discharge report. A detailed de-

► **Table 2** Occupations and corresponding job exposure indices: Example.

| Occupations in physical security, personal protection, fire protection and workplace safety (KldB 2010: 531) [20] | | | Job Exposure Indices [39] | | | | |
|---|-------|-------|---------------------------|-------|-------|-------|-------|
| Classification Title | Digit | Code | OJI | OPI | OSI | HWI | CAI |
| Occupations in traffic, logistics, safety and security | 1 | 5 | n. a. | n. a. | n. a. | n. a. | n. a. |
| Occupations in safety and health protection, security and surveillance | 2 | 53 | 5 | 4 | 9 | 4 | 6 |
| Occupations in physical security, personal protection, fire protection and workplace safety | 3 | 531 | 7 | 6 | 9 | 4 | 7 |
| Occupations in physical security, protection of valuables, and personal protection | 4 | 5311 | 7 | 5 | 10 | 3 | 6 |
| unskilled/semiskilled tasks | 5 | 53111 | 7 | 6 | 10 | 4 | 8 |
| skilled tasks | 5 | 53112 | 7 | 6 | 10 | 4 | 8 |
| Occupations focusing on workplace safety and safety technology | 4 | 5312 | 4 | 4 | 5 | 2 | 6 |
| skilled tasks | 5 | 53122 | n. a. | n. a. | n. a. | n. a. | n. a. |
| complex tasks | 5 | 53123 | 6 | 6 | 6 | 4 | 7 |
| highly complex tasks | 5 | 53124 | 6 | 6 | 6 | 4 | 7 |
| Occupations in fire protection | 4 | 5313 | 9 | 7 | 10 | 6 | 10 |
| skilled tasks | 5 | 53132 | 8 | 6 | 10 | 5 | 9 |
| complex tasks | 5 | 53133 | 8 | 6 | 10 | 5 | 9 |
| highly complex tasks | 5 | 53134 | 8 | 6 | 10 | 5 | 9 |
| Pool attendants and lifeguards | 4 | 5314 | 7 | 7 | 9 | 4 | 8 |
| skilled tasks | 5 | 53142 | 7 | 6 | 9 | 4 | 8 |
| Private detectives | 4 | 5315 | 6 | 5 | 9 | 3 | 6 |
| skilled tasks | 5 | 53152 | 7 | 6 | 9 | 4 | 7 |
| Debt collectors | 4 | 5316 | 5 | 4 | 9 | 4 | 6 |
| skilled tasks | 5 | 53162 | 7 | 6 | 9 | 4 | 7 |
| Occupations in physical security, personal protection, fire protection and workplace safety (with specialisation, not elsewhere classified) | 4 | 5318 | n. a. | n. a. | n. a. | n. a. | n. a. |
| skilled tasks | 5 | 53182 | n. a. | n. a. | n. a. | n. a. | n. a. |
| complex tasks | 5 | 53183 | 7 | 6 | 9 | 5 | 7 |
| highly complex tasks | 5 | 53184 | n. a. | n. a. | n. a. | n. a. | n. a. |
| Supervisors and managers in physical security, personal protection, fire protection and workplace safety | 4 | 5319 | 9 | 10 | 9 | 6 | 8 |
| Supervisors in physical security, personal protection, fire protection and workplace safety | 5 | 53193 | 7 | 6 | 9 | 5 | 8 |
| Managers in physical security, personal protection, fire protection and workplace safety | 5 | 53194 | 7 | 6 | 9 | 5 | 8 |

KldB 2010: German Classification of Occupations 2010, OJI: Overall Job Exposure Index, OPI: Overall Physical Exposure Index, OSI: Overall Psychosocial Exposure Index, CAI: Carcinogenic Agents Index, HWI: Hard Working Index, n. a.: not available

scription of the study design, inclusion and exclusion criteria, and the assessments and routine data used can be found elsewhere [30, 31]. We included in our analyses all 2 019 patients with a documented occupation and return-to-work prognosis at the end of rehabilitation as specified previously [32].

Ethical approval was obtained for the analyses of both datasets from the ethics committee of the Charité – Universitätsmedizin Berlin (EA1/204/15 and EA1/207/18). The survey was registered at ClinicalTrials.gov (NCT02304601, Universal Trial Number U1111–1215–9823) and the participants gave written informed consent. We carried out this work according to the Good Epidemiological Practice and the Good Practice of Secondary Data Analysis [33, 34]. The reporting follows the German Reporting Standard for Secondary Data Analyses (STROSA) [35].

Job Exposure Index

The Job Exposure Index was first introduced by Kroll in 2011 [9] based on the BIBB/BAuA Employment Survey 2006 using data from about 20 000 persons in work aged 15 years or older in Germany [36]. In 2015, an update of the index was published using data of the BIBB/BAuA Employment Survey 2012 [37, 38]. 39 items assessing different kinds of job exposures were included into the Overall Job Exposure Index via job-exposure matrices by assigning the assessed job exposures to the coded occupations. Multi-level-analyses were applied to take advantage of the hierarchical structure of the job classifications (► **Table 1**) and to take into account the limited number of cases per single occupation. Furthermore, these analyses were adjusted for gender, age, working time in hours per week, and time in years working in the current occupation [9]. Be-

► **Table 3** Association of the Overall Job Exposure Index (OJI) and patient reported outcome measures.

| patient-reported outcome measures [31] (scales, range, polarity) | mean (SD) stratified according to overall job exposures (OJI) | | | |
|---|---|----------------------|----------------|------------|
| | low (n = 776) | moderate (n = 1 025) | high (n = 218) | Cohens d * |
| specific work-related problems (SIMBO-K) ** | 31,2% | 35,5% | 41,7% | 0,253 |
| best work ability (WAS, 0–10, –) | 4,9 (2,6) | 4,4 (2,8) | 4,1 (2,8) | 0,300 |
| subjective prognosis of gainful employment (SPE, 0–3, +) | 1,3 (1,1) | 1,5 (1,1) | 1,6 (1,1) | 0,303 |
| depressive symptoms (HADS-D, 0–21, +) | 7,4 (4,3) | 7,8 (4,4) | 8,0 (4,2) | 0,128 |
| anxiety (HADS-A, 0–21, +) | 8,5 (4,3) | 8,9 (4,3) | 9,0 (4,4) | 0,100 |
| general self-efficacy (GSE, 10–40, –) | 28,2 (5,8) | 27,8 (6,1) | 28,2 (6,0) | 0,000 |
| social support (IRES, 0–10, –) | 6,7 (2,7) | 6,7 (2,7) | 6,6 (2,8) | 0,067 |
| health behaviour (IRES, 0–10, –) | 6,4 (1,9) | 6,3 (1,9) | 6,8 (1,7) | 0,216 |
| ability to function in daily life (IRES, 0–10, –) | 4,8 (2,2) | 4,8 (2,2) | 4,5 (2,1) | 0,160 |
| impairment due to pain (PDI, 0–70, +) | 26,7 (15,0) | 28,3 (15,3) | 26,7 (15,9) | 0,003 |
| comorbidity (SCQ, 0–39, +) | 6,7 (4,1) | 6,9 (4,1) | 7,5 (4,7) | 0,190 |

+ : higher value means higher impairment, –: higher value means lower impairment. SD: standard deviation, SIMBO-K: Screening Instrument for Detecting the Need of Work-Related Medical Rehabilitation (short form), WAS: Work Ability Score, SPE: Subjective Prognosis of Gainful Employment Scale, HADS: Hospital Anxiety and Questionnaire, GSE: General Self-Efficacy Scale, IRES: Indicators of Rehabilitation Status Questionnaire, PDI: Pain Disability Index, SCQ: Self-administered Comorbidity Questionnaire; n = 2019. * Cohens d: low vs. high overall job exposures. ** SIMBO-K: percentage of present specific work-related problems

cause of too low number of cases for some occupations in the Employment Survey, the Job Exposure Index is not available for every single occupational code on all levels of the job classifications. In ISCO-08 e. g., the Overall Job Exposure Index is available in 85.5% of the 4-digit-codes, 90.8% of the 3-digit-codes and 95.4% of the 2-digit codes [39].

The Overall Job Exposure Index (OJI) is composed of all 39 items. Additionally, sub-indices are available which cover specific facets of job exposures: the Overall Physical Exposure Index (OPI), the Overall Psychosocial Exposure Index (OSI), the Carcinogenic Agents Index (CAI), and the Hard Working Index (HWI). CAI and HWI are single-item scales, the other indices are multi-item scales. All 5 indices can have values between 1 and 10 indicating the extent of job exposures according to 10 deciles. Consequently and by definition, 10% of the population is working in an occupation with the lowest job exposures (value '1') and 10% have an occupation with the highest job exposures (value '10'). The Overall Job Exposure Index and its sub-indices are available for the job classifications KldB 92, KldB 2010, ISCO-88 and ISCO-08 [39]. An example for the values of the 5 job exposure indices is given for the occupational group 531 according to KldB 2010 (occupations in physical security, personal protection, fire protection, and workplace safety) in ► **Table 2**.

Data analysis

We applied the Job Exposure Index and the sub-indices to both datasets described above. First, since the occupation is coded partly according to KldB 88 and the Job Exposure Index is not available for that classification, we transformed the KldB 88 into the KldB 92 on the level of the 3-digit occupational orders [40]. From the years 2011/2012 on, the occupation is documented according to KldB 2010 for an increasing share of the cases [20].

Afterwards, we matched the values of all job exposure indices to the occupations beginning from the most accurate level (5-digits level occupational codes for KldB 2010 and 3-digits for KldB 92

(► **Table 1**). In case the job exposure indices were not available on that level, we moved on to the next higher level (one digit less). All job exposure indices were categorized into low (1st and 2nd decile), moderate (3rd to 8th decile) and high job exposures (9th and 10th decile) [39].

We calculated the prevalence of low, moderate and high overall job exposures for completed medical rehabilitation measures of employed persons. We used the occupation documented in the year prior to the rehabilitation.

The association of job exposures according to all 5 Job Exposure Indices with the return-to-work prognosis after medical rehabilitation was analysed taking into account three different items of the rehabilitation discharge report (► **Fig. 2**): First, the capacity to work in the last job. Second, the capacity to work in any other job on the general labour market. The responses of these 2 items were categorised in 'able to work less than 3 h per day' versus 'able to work at least 3 h per day'. Third, the recommendation of a subsequent vocational rehabilitation (present vs. not present) was analysed. All information given in the discharge report is based on the appraisal of the responsible physician at the end of rehabilitation [41]. We included all cases with a documented occupation according to KldB 2010. To evaluate potential differences dependent on the consulted job classification, the association of job exposures to the return-to-work-prognosis is described comparing the Overall Job Exposure Index according to KldB 92 and the Overall Job Exposure Index according to KldB 2010 (► **Fig. 3**).

To determine the association between self-reported impairments and resources we report mean values and standard deviations of the included scales stratified to the level of overall job exposures (► **Table 3**) [31]. The effect size is described with Cohens d for low versus high job exposures. For this purpose, we analysed the survey data (dataset 2), for all other analyses the Scientific Use File (dataset 1).

Results

Over all reported years, the mean percentage of occupations documented by either KldB 88 or KldB 2010 is 91 %. In 2015, only 4.1 % of medical rehabilitation treatments for the studied population have no occupation documented in the Scientific Use File. ► **Fig. 1** shows that in 2011/12, the documentation of occupations according to KldB 2010 begins and reaches its highest percentage in 2015 with 66.3 %, leaving an additional 29.6 % cases coded according to KldB 88.

The transformation of job classification KldB 88 into KldB 92 was possible for 89.5 % cases ($n = 1\,148\,314$) of medical rehabilitations, for 1.5 % ($n = 19\,709$) the transformation was not possible and for 9.0 % ($n = 114\,914$) of the cases no occupation was documented. For cases with an occupational code available according to KldB 92 after transformation, the Job Exposure Index could be assigned to the 3-digit occupational orders in 95.5 % and to the 2-digit occupational groups in the remaining 4.5 % of cases. For KldB 2010, in 99.0 % of cases the job exposure scores could be assigned to the 5-digit occupational types, and in the other 1.0 % to one of the higher levels of occupations.

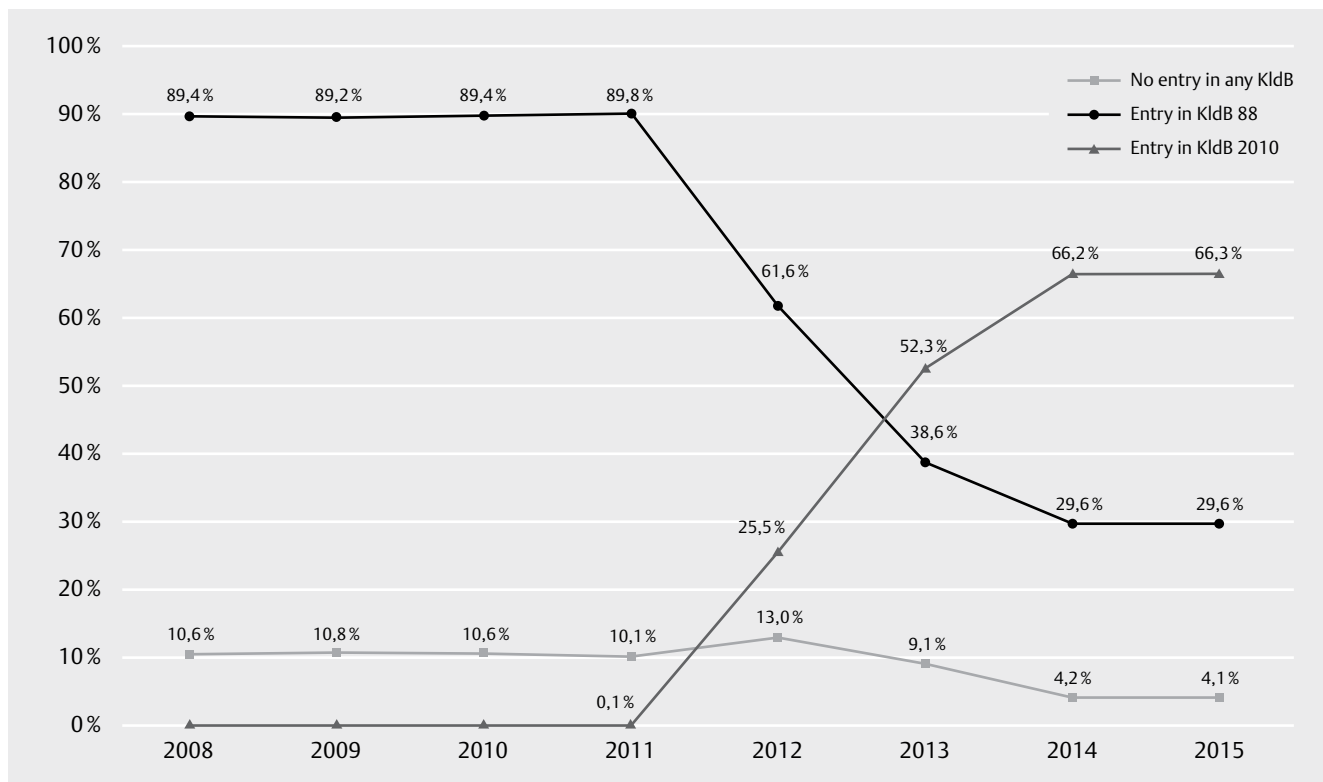
Prevalence of job exposures

Among all cases of medical rehabilitation with a documented occupation using the Overall Job Exposure Index ($n = 1\,147\,387$) as basis for the calculation of prevalences of job exposures, there are 14.3 % cases with a low exposure level, 62.0 % with a moderate exposure level and 23.7 % with a high exposure level.

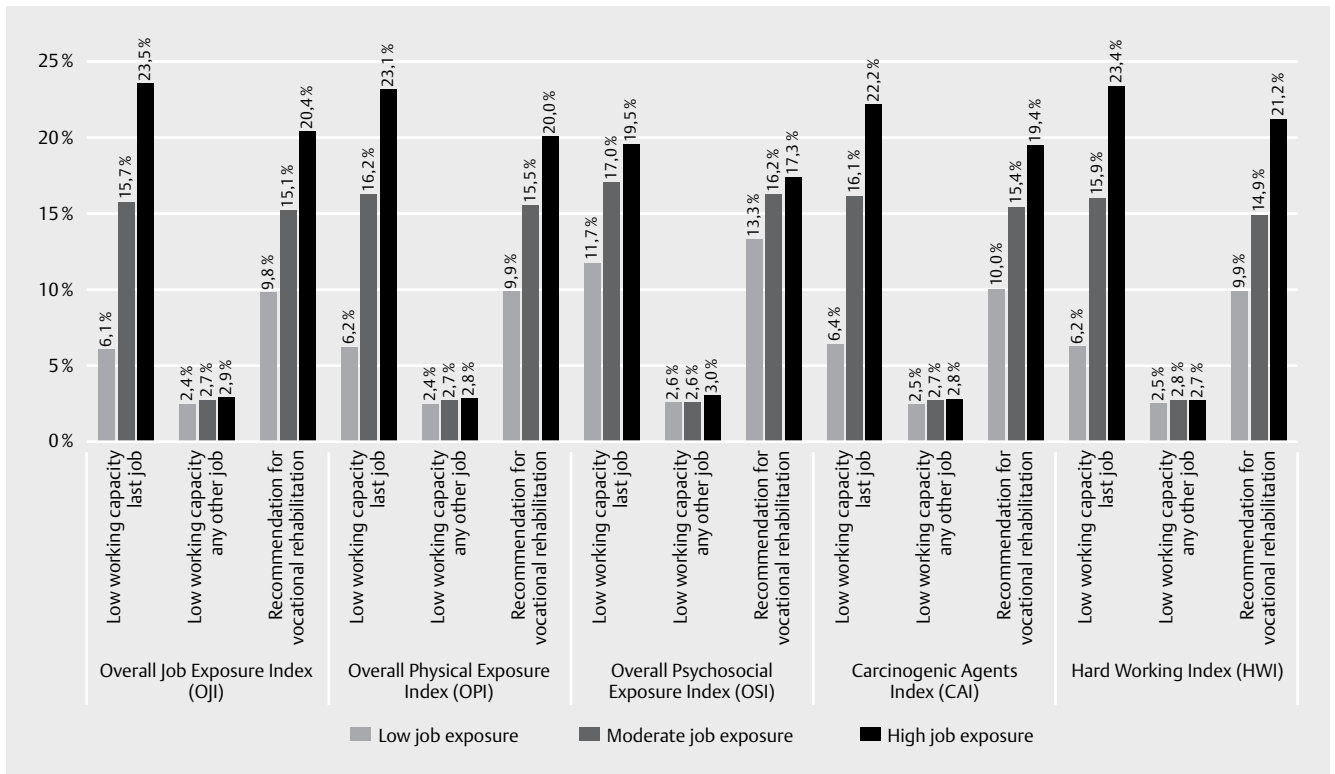
Association with return-to-work

► **Fig. 2** shows the percentage of persons with a reduced working capacity in the last job and in any other job of under 3 h per day after rehabilitation treatment and the percentage of recommendations for subsequent vocational rehabilitation. Results are reported for all five job exposure indices using the job classification KldB 2010. The analysis shows, that over all 5 indices, a higher job exposure level is associated with a higher percentage of persons having a working capacity of less than 3 h per day in the last job and a higher percentage of recommendations for vocational rehabilitation after finishing their rehabilitation treatment. When job exposures are high, the proportion of persons with a predicted working capacity of less than 3 h per day in the last job is increased by a factor of about 4 compared to low-level job exposures (23.5 vs. 6.1 %). In contrast, the association to reduced working capacity in the general labour market hardly differed according to the level of job exposures (2.9 vs. 2.4 %). This pattern can be found in all five job exposure indices. The differences between low and high job exposures for the 3 outcomes were the least distinct for the Overall Psychosocial Exposure Index.

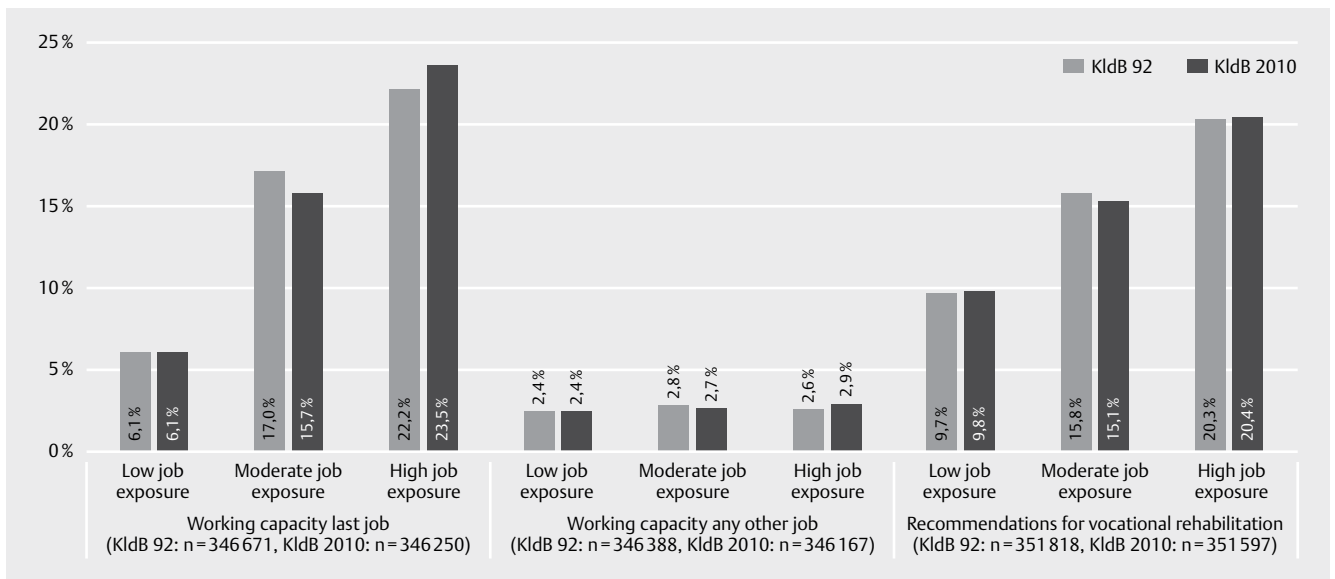
► **Fig. 3** demonstrates the association between overall job exposures and three parameters of the return-to-work-prognosis comparing the Overall Job Exposure Index based on the occupation according to the job classification KldB 92 and KldB 2010. In general, the differences between both classifications are rather small for all exposure categories and outcomes. The differences are most pronounced for the valuation of working capacity in the last job.



► **Fig. 1** Available entries in job classifications from 2008 to 2015 (year of start of rehabilitation) for cases of medical rehabilitation treatment in working population (in %) ($n = 1\,282\,937$). KldB: German Classification of Occupations.



► **Fig. 2** Association of Job Exposure Indices according to KldB 2010 and low working capacity in the last job (n = 346 250), low working capacity in any other job (n = 346 167) and recommendation for vocational rehabilitation (n = 351 597) (in %). KldB: German Classification of Occupations.



► **Fig. 3** Association of the Overall Job Exposure Index and the return-to-work prognosis comparing the job classifications KldB 92 and KldB 2010 (in %). KldB: German Classification of Occupations.

Association with self-reported impairments and resources

The analysis of the survey data (dataset 2) shows that there is an association between job exposures and various patient reported outcome measures. Higher job exposures and job-related scales

are associated with effect sizes of around 0.3 according to Cohens d. The association of other impairments and resources with job exposures were less pronounced or there was no association revealed (► **Table 3**). For the Overall Physical Exposure Index and the Hard Working Index the calculated effect sizes were slightly higher, for

the Overall Psychosocial Exposure Index lower than for the Overall Job Exposure Index (data not shown).

Discussion

The Job Exposure Index and its sub-indices could be linked to the vast majority of medical rehabilitations of employed persons. The prevalence of high job exposures is estimated at 23.7%. On the whole, this is comparable to the results of the BiBB/BAuA Employment Survey [9]. The percentage of a low work capacity after rehabilitation in the last job practised before rehabilitation roughly rises by the factor four when high job exposures are present in contrast to low job exposures. For the recommendation for a subsequent vocational rehabilitation, the percentage increased by a factor of about two when comparing employees with high and low job exposure. On the contrary, the capacity to work in any other job on the general labour market after rehabilitation hardly differed between the 2 groups of job exposures (high vs. low) (► **Fig. 2**). This indicates that the Job Exposure Index is indeed capable to reflect exposures related to specific occupations. In line with the results of previous studies, the analyses of the sub-indices indicate that physical job exposures are related more specifically to occupations than psychosocial job exposures [9].

In addition to the routine data analyses, survey data reveals an association of job exposures with several self-reported impairments and resources (► **Table 3**). Estimated effect sizes are small or very small. The largest effect sizes were detected for the association with job-related scales. This finding is plausible and congruent with previous analyses using the first version of the Job Exposure Index [32]. In other studies using the Job Exposure Index, there was a significant association described with sick leave, depressive symptoms and the subjective general health status [9, 37].

The results of our analyses of job exposures determined by the 5-digit-level occupational types according to KldB 2010 were similar to those taking into account the 3-digit-level occupational orders according to KldB 92 (► **Fig. 3**). At first sight, one would expect to have more pronounced results for the 5-digit-level-analyses. It remains unclear if the findings point out a lower validity of the occupational codes at the most accurate level of the job classification or if the results are due to the small heterogeneity of job exposures on that level (► **Table 2**). It was shown that the variability of job exposures is largest at the higher levels of the job classifications [9]. In addition, the index is not available for all occupations on the most accurate level anyway. Summarizing the present findings, it may be sufficient to apply the Job Exposure Index to the 3-digit-level when analysing routine data of the social security funds.

Limitations

The Job Exposure Index is based on job-exposure matrices. Job-exposure matrices are well established to reflect job exposures for various research questions including the association of job exposures to subjective health, injuries, early retirement, lifestyle factors, and health behaviour [4, 12, 14, 15]. It has been shown for single exposures and diseases that the use of job-exposure matrices can provide similar results as the individual assessment of work-related exposures [42–44].

However, job-exposure-matrices including the Job Exposure Index are not able to describe extensive risk assessments of single specific job exposures precisely. This is valid for psychosocial job exposures in particular. Instead, the Job Exposure Index by Kroll reflects the overall level of job exposures and sorts all occupations in a hierarchical order according to the extent of overall (physical and psychosocial) job exposures. This allows – in contrast to other job-exposure-indices or to job classifications – an easy application of the Job Exposure Index in secondary data analyses for all occupations according to KldB or ISCO. Only one degree of freedom is needed for the adjustment of job exposures in multivariate analyses. Other existing job-exposure-matrices are restricted to certain occupations or to specific facets of job exposures [9].

In addition, the Job Exposure Index takes into account the high intra-class-correlation of job exposures within different levels of job classifications by applying multilevel analyses. Furthermore, the Job Exposure Index is adjusted for factors that are associated with job exposures (age, gender, working hours per week, and time in years working in the current occupation). Other job-exposure-matrices did not take these aspects into consideration [16]. Meanwhile, the Job Exposure Index developed by Kroll has been applied to various national and international datasets [9, 32, 37, 45–47].

The validity of the occupational code in routine data of the social security funds has been questioned [48, 49]. Our findings – an existent association of job exposures and the work capacity in the last job on the one hand, but a virtually non-existent or low association to the work capacity in any other job on the other hand – indicate that the documented occupational code reflects the real occupation at least to a substantial degree. This corresponds to the appraisal of the occupational code by Grobe and Ihle [21]. To enhance the quality of the documentation of occupations, the Federal Employment Agency offers an online-tool and a free telephone hotline for companies to determine the correct occupational code according to KldB 2010 (<http://bns-ts.arbeitsagentur.de>). However, the occupations according to KldB 88 have to be considered less valid, as there was no verification or controlling mechanism implemented.

Besides, there were more missing values for the occupation before the introduction of the KldB 2010 (about 10 to 11% from 2008 to 2011 and about 4% from 2014 to 2015, ► **Fig. 1**). A selection bias due to missing values cannot be ruled out. Especially persons working in lower-skilled occupations may be underrepresented. Furthermore, data from the German Pension Insurance include information concerning rehabilitation measures financed by the German Pension Insurance only. Hence, self-employed persons and public officials e. g. are underrepresented or not represented at all.

Application of the Job Exposure Index

There are numerous possibilities to apply the Job Exposure Index to routine and survey data. The necessary condition is the coding of the occupation according to KldB 92, KldB 2010, ISCO-88, ISCO-08 or a classification that can be transformed into one of these job classifications (e. g. KldB 88) (► **Table 1**). The Research Data Centre of the German Pension Insurance offers different cross-sectional and longitudinal Scientific Use Files for the scientific community upon request (<http://www.fdz-rv.de>). These datasets combine data from all 16 agencies of the German Pension Insurance and include

the occupational code according to KldB 88 and KldB 2010, respectively. The Scientific Use Files are widely used in rehabilitation research [50–56].

It should be mentioned that the Scientific Use Files provided are a powerful resource that needs some experience and careful considerations in order to get useful results. Data is stored for persons and events, respectively in the different datasets provided. For most analyses it is necessary to merge person-related information (age, sex, e. g.) with events (medical rehabilitation, vocational rehabilitation, times of disability pension, e. g.) which is not always self-explanatory for this kind of longitudinal dataset. Also, a good bit of knowledge is necessary to understand the explanation of the content of variables from the codebook provided, which is only available in German. Sometimes it has proven useful to contact the Research Data Centre for further clarification.

In addition to the German Pension Insurance, the German Federal Employment Agency is an important funder of vocational rehabilitation in Germany [57]. Various Scientific Use Files are provided by the Research Data Centre of the German Federal Employment Agency at the Institute for Employment Research (IAB). The Sample of Integrated Labour Market Biographies (SIAB) allows to track the occupation over time [58]. Another Scientific Use File is called Panel Study Labour Market and Social Security (PASS-ADIAB) and links survey data to administrative data of the IAB [59].

The occupation according to KldB is available in the data of the statutory health insurances in principle as well [48]. In contrast to the German Pension Insurance, there are currently no Scientific Use Files available of any of the health insurance funds. In addition, the occupational code is not part of the combined health care dataset at the German Institute of Medical Documentation and Information (DIMDI). The Institute for Applied Health Research (InGef) provides the only known database which contains the occupational code and covers data from different statutory health insurances. In general, the accessibility to data of health insurance funds is limited so far. However, for specific epidemiological studies, it was possible to combine data from different statutory health insurances or to match data from the German Pension Insurance with health insurance data including the occupational code [24, 60–62]. The Federal Statistical Office annually conducts the microcensus, a dataset which includes the coded occupation. Every 4 years, health-related outcomes are part of the survey [63].

In addition to pure routine data analyses, it is possible to either link data from epidemiological studies to routine data containing the occupational code or to assess and code the occupation in studies themselves. The German Socio-Economic Panel Study (SOEP), the German Cohort Study on Work, Age and Health (IidA), the Gutenberg Heart Study and surveys from the Robert Koch-Institute are examples for the latter approach [25, 26, 64]. The linkage of routine and survey data is more and more frequent in rehabilitation research [32, 65–68]. On an international level, Scientific Use Files of the European Working Conditions Survey (EWCS) and the Survey of Health, Ageing and Retirement in Europe (SHARE) are available [22, 45, 69]. In addition, SHARE was linked with administrative data from the German Pension Insurance (SHARE-RV) [70]. These datasets enable analyses of the association of job exposures and health-related outcomes, too.

Conclusion

Routine data of the German Pension Insurance and other social security providers includes the information of the occupation for the vast majority of insured persons in working age. Applying the Job Exposure Index, this information may be used to represent job exposures. The Job Exposure Index enables researchers to take into account occupation-specific job exposures in routine data analyses or in survey data linked to routine data that contains the occupation according to the German or international job classification without any additional data collection effort. This opens up new possibilities in rehabilitation research and beyond.

It has to be emphasised, however, that the Job Exposure Index is not capable of replacing the individual assessment of job exposures. Furthermore, psychosocial job exposures are less precisely represented by the Job Exposure Index than physical job exposures. The validity of the index on the different levels of job classifications and the utility of the Job Exposure Index and its sub-indices should be further researched.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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