ORIGINAL ARTICLE

Construction work and risk of occupational disability: a ten year follow up of 14 474 male workers

V Arndt, D Rothenbacher, U Daniel, B Zschenderlein, S Schuberth, H Brenner

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See end of article for authors' affiliations

Correspondence to: Dr V Arndt, German Centre for Research on Ageing (DZFA), Department of Epidemiology, Bergheimer Strasse 20, D-69115 Heidelberg, Germany; arndt@dzfa.uni-heidelberg.de

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Aims: Most industrialised countries have public income maintenance programmes to protect workers in case of disability but studies addressing disability risk of specific professional groups are rare. The objective of this study was to establish a detailed pattern of the nature and extent of occupational disability among construction workers.

Methods: A cohort study was set up including 14 474 male workers from the construction industry in Württemberg (Germany) aged 25–64 years who underwent occupational health exams between 1986 and 1992. The cohort was linked to the regional pension register of the manual workers' pension insurance institution to identify workers who were granted a disability pension during the 10 year follow up. All-cause and cause specific standardised incidence ratios (SIR) and 95% confidence intervals (CI) were calculated using disability rates from the general workforce and from all blue collar workers in Germany as references.

Results: In total, 2247 (16%) members of the cohort were granted a disability pension. Major causes of disability were musculoskeletal (45%) and cardiovascular diseases (19%). In comparison with the general workforce, construction workers experienced a higher risk of disability from cancer (SIR = 1.26; 95% CI 1.08 to 1.47), respiratory diseases (SIR = 1.27; 95% CI 1.03 to 1.55), musculoskeletal diseases (SIR = 2.16; 95% CI 2.03 to 2.30), injuries/poisoning (SIR = 2.52; 95% CI 2.06 to 3.05), and all causes combined (SIR = 1.47; 95% CI 1.41 to 1.53). When compared with the blue collar reference group, increased risks of disability among construction workers were found for musculoskeletal diseases (SIR = 1.53; 95% CI 1.44 to 1.63), injury/poisoning (SIR = 1.83; 95% CI 1.50 to 2.21), and all causes combined (SIR = 1.11; 95% CI 1.07 to 1.16).

Conclusions: Musculoskeletal diseases and external causes are major factors limiting the work capability of construction workers and lead to an increased proportion of occupational disability.

Working conditions in the construction industry have improved in many developed countries during the past decades but hard physical labour with frequent lifting and carrying heavy weights, static work, exposure to vibrations, climatic influences, noise, and dust still pose considerable strains for construction workers and may deleteriously affect their health.[1 2] Construction work is also known for its high risk of fatal and non-fatal injuries. Almost 20% of all work related injuries in Germany occur in the construction industry.[3] The annual injury rate (non-fatal and fatal accidents) of 82 per 1000 construction workers is about 2.5 times the average rate of 34.5 per 1000 in all branches of industry.[3] Similar figures have been reported from the US[4] and the UK.[5] Falls are the leading cause of occupational injuries in the construction industry and constitute a substantial proportion of permanent and temporary disability.[1 6 7] In addition to accidents, musculoskeletal disorders make up a substantial part of non-fatal injuries and illnesses in construction work.[4]

Disability pensioning has emerged as an important social problem in recent years.[8] Although medical disablement is a necessary precondition for disability pension, the causes of occupational disability are complex and certain non-medical factors, such as sociodemographic, socioeconomic, and lifestyle factors (for example, smoking) have been identified as non-medical determinants of occupational disability.[8–12] In addition, work characteristics, like heavy manual work and repetitive monotonous movements, are considered to represent factors of importance for many of the conditions leading to occupational disability.[13]

There is some evidence that construction workers face a higher risk of occupational disability than workers in less physically demanding jobs.[14 15] Heavy physical work, in particular lifting and static muscular loading and uncomfortable work positions, were found to be associated with an increased risk of occupational disability due to musculoskeletal disorders but not cardiovascular or mental disease.[9] Previous research also suggested that the risk of occupational disability is higher for unskilled than for skilled workers.[14]

In a previous report, we examined mortality and morbidity among 5000 construction workers over a five year period and we found a significant increase in risk of occupational disability and a tendency towards an increased risk of all-cause mortality for construction workers in comparison with a white collar control group.[16] More specific information, however, would be of utmost interest as our earlier analysis was limited to all-cause disability and did not allow further in-depth cause specific analysis. During the last few years, we were able to enlarge the cohort and to expand the follow up period to 10 years,[17] which now enables us to establish a more detailed pattern of the nature and extent of occupational disability among construction workers in Germany. Specifically, we were interested to see whether there are specific risk groups with respect to the underlying cause of disability but also with respect to age, nationality, occupational group, and duration of employment, which would especially benefit from preventive measures. Older workers and workers who have worked for a long period in physically demanding jobs are of particular interest in this context as

aging is associated with a decline in work capacity[18] and accompanied by an increase in long term musculoskeletal disorders and other chronic diseases.[19]

MATERIAL AND METHODS

Study population

The baseline study population comprised 18 760 male construction workers (plumbers, carpenters, painters, plasterers, bricklayers, and unskilled workers/labourers), aged 25–64 years, who participated in a health examination by the Institution for Statutory Accident Insurance and Prevention in the Building Trade in Württemberg (a region with about 5.4 million people in the South of Germany) between 1 August 1986 and 31 December 1992 and who were members of the local manual workers' pension insurance institution. In Germany, almost all blue collar workers, including self-employed craftsmen and itinerant workers, are members of the statutory pension fund. The health examination is part of the routine occupational health surveillance and includes occupational and medical history, a physical exam, pulmonary function test, test of visual acuity, audiometry, and blood and serum analysis. Participation is voluntary but about 75% of all invited workers have participated in the medical examination during the period of recruitment. The participants were representative for the underlying source population of all construction workers with respect to age and nationality, and occupation (taking into account that we had restricted the study sample to the six largest professional groups). The study was approved by the local and regional ethics committees and by the ministry of social affairs Baden-Württemberg.

Follow up

The cohort was linked to the pension register of the manual workers' pension insurance institution Württemberg to identify workers who have been granted a disability pension during follow up. The linkage was performed at two points in time (June 1998 and March 2000) according to date of baseline examination:

- people who entered the cohort between 1986 and 1988 were linked in June 1998 (follow up closing date 31 December 1997)
- people who entered the cohort between 1989 and 1992 were linked in March 2000 (follow up closing date 30 June 1999).

As some cases of disability pensioning were approved in retrospect, a 4–6 months' lag time interval was necessary to capture all cases which have occurred during a specific time period. No follow up information was available for 4286 workers (23%), who had either moved to a different region or changed employment and been assigned another pension insurance institution. The very strict confidentiality rules in Germany did not allow us to follow these people further. Thus, the final study population comprised 14 474 construction workers who had been successfully linked with the pension register. The pension register provided information regarding vital status and whether the individual was still working, had been retired due to age, was unemployed or under vocational (re)training, or whether a disability pension (permanent or temporary) was granted. In case of multiple temporary disability pensions, only the first disability pension was reported.

The criteria and the legal framework for disability pensioning are under continuous change, but during time of follow up a disability pension was granted when the earning capacity had been permanently reduced by at least 50% because of illness, injury, or defect—irrespective of whether the injury had been work related or not—and when the worker could not be referred to another adequate occupation. A patient applies for a disability pension at the local insurance office, which requests a health certificate from the applicant's primary physician. In addition, a physician employed by the pension insurance institution examines the applicant and judges whether the patient meets the criteria for a disability pension or whether a rehabilitation measure might be appropriate first.

Statistical methods

Standardised incidence ratios (SIR) for all-cause and cause specific disability were calculated with the SAS statistical software package[20] using age (<40, 40–44, … 60–64), and sex specific annual disability rates during the entire follow up period from Germany (''Old Federal States'', the former Western Germany) as reference. The SIR is the ratio of the observed number of incident cases in the study population to the number of cases that would be expected if the study population had the same incidence rate as the reference population. An SIR of 1.0 implies that the rates are the same for the population of interest and the standard population, whereas an SIR >1.0 implies that the rate is higher for the population of interest compared with the standard population. Conversely, an SIR <1.0 implies that the death rate is lower for the population of interest compared with the standard population.

The reference rates were derived from the number of incident disability pensions over the number of insured employees as provided by the annual statistics of the Federation of German Pension Insurance Institutes (VDR).[21]

Two reference groups were chosen: (1) the general workforce, which includes both blue and white collar workers, and (2) all blue collar workers (including workers from other industrial branches such as metal working industry, chemical industry, transportation, paper and printing, timber, leather and textiles, pit and quarry, and mining), as it is known that blue and white collar workers differ with respect to pattern and risk of disability.

Exact 95% confidence limits were calculated with the SISA software.[22] In case of 15 and more observed cases the Poisson approximation was employed.[23] Person time under risk was calculated for each study participant from date of baseline examination until closure of follow up. Reasons for censoring before closure of follow up comprised old age retirement, 65th birthday (and not retired), death (before age 65), or unemployment/vocational (re)training (65 is the usual age for retirement in Germany). SIRs were calculated for the total cohort but also for each occupational group (to detect potential job specific patterns), for different age groups (to detect age specific differences), by nationality, and by duration of employment.

Information on cause of disability, which was coded according to the 9th revision of the International Classification of Diseases (ICD-9), could be obtained for 97.6% of all those who were granted a disability pension. We employed the method described by Rittgen and Becker to adjust for missing information on cause of disability.[24] Under the assumption that the availability of the information on cause of disability is neither related to the exposure under consideration (for example, working in the construction industry) nor to the diagnosis, it can be easily shown that the unknown number of diagnosis specific disability pensions can be derived from the known number of disability pensions with this particular diagnosis, divided by the proportion of all known causes of disability among all disability pensioners. Analysing the data without the imputation did not change the overall findings.

Table 1 Characteristics of the study population at baseline examination

	n	%
Occupation		
Plumbers	2156	15
Carpenters	2012	14
Painters	2281	16
Plasterers	1695	12
Bricklayers	4359	30
Labourers	1971	14
Age at baseline examination		
25–39 years	6424	44
40–44 years	1529	11
45–49 years	1953	14
50–54 years	2586	18
55–59 years	1680	12
60–64 years	302	2
Mean (SD) years	41.7 (10.8)	
Nationality		
German	11974	83
Former Yugoslavia	737	5
Italian	674	5
Turkish	655	4
Other	434	3
Duration of employment in construction industry (years)*		
<15	4914	38
15–29	4448	34
⩾30	3684	28
Mean (SD)	20.7 (11.9)	
Total	14474	100

*Unknown duration of employment: n = 1428.

RESULTS

The characteristics of the study population are shown in table 1. With over 30%, bricklayers constituted the largest professional group in our sample. Mean age of the study population at baseline was 41.7 years and over 80% of the cohort members were of German nationality, followed by migrants (or their descendants) from former Yugoslavia, Italy, and Turkey. On average, cohort members had worked for over 20 years in the construction industry.

During follow up 2247 men were granted a disability pension (mean age at retirement 56.1 years), and 761 men were granted an old age pension (mean age 63.4 years). 2765 study members were censored because they got unemployed and/or underwent some vocational training (mean age 51.3 years). In addition, 208 workers were censored because they died before age 65 (mean age 60.0 years). At the end of the follow up 8493 men out of 14 474 (59%) were still working.

The crude disability rate was 2049 per 100 000 person years, however risk of disability strongly increased with age (table 2). The major reasons for occupational disability were musculoskeletal disorders (n = 975; 45%), cardiovascular diseases (n = 399; 19%), neoplasms (n = 170; 8%), and mental disorders (n = 165; 8%). Dorsopathies (n = 523) represented the majority of all musculoskeletal disorders with intervertebral disc disorders (n = 203) and spondylosis (n = 189) as major underlying diagnoses. Although musculoskeletal disorders were the leading cause of disability in all age categories, their proportion among all cases of disability strongly increased with age whereas some other causes like mental disorders, injury, and poisoning were important contributors to occupational disability among young age groups mainly.

In comparison with the general workforce (table 3), construction workers experienced a higher risk of occupational disability for a number of causes including cancer (SIR = 1.26), diseases of the respiratory system (SIR = 1.27), musculoskeletal diseases (SIR = 2.16), injury and poisoning (SIR = 2.52), and all causes combined (SIR = 1.47). More specifically, statistically significantly higher disability rates were found for cancer of the oral cavity and pharynx (SIR = 1.84), chronic obstructive lung disease (SIR = 1.33), arthropathies (SIR = 2.66), dorsopathies (SIR = 1.76), accidents (SIR = 2.49), and other external causes (mainly complications of medical care, SIR = 3.04). Although overall no increased risk for cardiovascular diseases (SIR = 1.09) including ischaemic heart disease (SIR = 0.86) and hypertension (SIR = 0.88) was found, higher risks for disability were observed for the ICD categories ''heart failure and other heart disease'' (SIR = 1.60) and ''diseases of the arteries, arterioles, and capillaries'' (SIR = 1.35). Other diagnoses such as cancer of the digestive (SIR = 1.25) and urogenital system (SIR = 1.48), and non-malignant diseases of the digestive system (SIR = 1.20) including liver diseases (SIR = 1.20) and skin disorders (SIR = 1.61) were more common in our sample of construction workers but the differences were not statistically significant. Furthermore, we observed no substantially increased disability risk for cancer of the respiratory system (SIR = 1.02), mental disorders (SIR = 0.95), diseases of the nervous system and sense organs (SIR = 1.02), cerebrovascular disease (SIR = 1.06), and pneumoconiosis (SIR = 0.55).

When compared with the blue collar reference group, the differences in disability risk were less distinct for most diagnoses mentioned above but still statistically significant for all causes combined (SIR = 1.11), musculoskeletal diseases (SIR = 1.53), in particular arthropathies (SIR = 1.87) and dorsopathies (SIR = 1.25), and accidents (SIR = 1.81).

Table 4 addresses the associations of age, nationality, occupation, and duration of employment with the risk of occupational disability among construction workers. In

Table 2 Cause of occupational disability by age

			By age (years) (during follow up)*						
Cause of occupational disability (ICD-9)	Total number	Mean age	25–39 (n = 57)	40–44 (n = 57)	45–49 (n = 127)	50–54 (n = 413)	55–59 (n = 1134)	60–64 (n = 459)	All ages (n = 2247)
Neoplasms (ICD 140–239)	170	54.3	11%	11%	17%	10%	7%	5%	8%
Mental disorders (ICD 290–319)	165	53.4	21%	15%	12%	12%	6%	4%	8%
Nervous System (ICD 320–389)	71	53.9	8%	13%	5%	4%	3%	2%	3%
Circulatory system (ICD 390–459)	399	56.4	11%	17%	21%	20%	18%	20%	19%
Respiratory system (ICD 460–519)	95	56.2	2%	4%	5%	4%	5%	3%	4%
Digestive system (ICD 520–579)	45	55.3	2%	6%	2%	2%	2%	1%	2%
Musculoskeletal system (ICD 710–739)	975	57.3	25%	23%	23%	36%	49%	56%	45%
Injury and poisoning (ICD 800–999)	99	54.5	13%	6%	7%	6%	5%	3%	5%
Other	222	55.0	6%	4%	7%	5%	5%	6%	5%
All causes	2247	56.1	100%	100%	100%	100%	100%	100%	100%
Rate (per 100 000 person years)			134	425	912	2390	6616	8551	2049

*Percentages within same age category.

Table 3 Standardised incidence ratios (SIR) of all-cause and cause specific disability within the total cohort

	Study cohort	Reference "general work force"		Reference "blue collar workers"	
Cause of disability	**Observed**	**Expected**	**SIR (95% CI)**	**Expected**	**SIR (95% CI)**
Cancer (ICD 140–208)	161	127.5	1.26 (1.08–1.47)	162.2	0.99 (0.85–1.16)
Cancer of the oral cavity and pharynx (ICD 140–149)	28	15.2	1.84 (1.22–2.66)	21.4	1.31 (0.87–1.89)
Cancer of the digestive system (ICD 150–159)	44	35.3	1.25 (0.91–1.67)	44.0	1.00 (0.73–1.34)
Cancer of the respiratory system (ICD 160–165)	32	31.4	1.02 (0.70–1.44)	42.6	0.75 (0.52–1.06)
Cancer of the urogenital system (ICD 179–189)	29	19.6	1.48 (0.99–2.12)	24.2	1.20 (0.80–1.72)
Mental disorders (ICD 290–319)	165	173.4	0.95 (0.81–1.11)	212.1	0.78 (0.67–0.91)
Neurotic disorders, personality disorders, and other non-psychotic mental disorders (ICD 300–316)	132	114.0	1.16 (0.97–1.37)	139.5	0.95 (0.79–1.12)
Nervous system and sense organs (ICD 320–389)	71	69.5	1.02 (0.80–1.29)	83.4	0.85 (0.66–1.07)
Circulatory system (ICD 390–459)	399	367.1	1.09 (0.98–1.20)	473.5	0.84 (0.76–0.93)
Hypertension (ICD 401–405)	45	51.3	0.88 (0.64–1.17)	67.4	0.67 (0.49–0.89)
Ischemic heart disease (ICD 410–414)	115	134.3	0.86 (0.71–1.03)	165.3	0.70 (0.57–0.84)
Heart failure, other heart disease (ICD 420–429)	81	50.6	1.60 (1.27–1.99)	66.0	1.23 (0.97–1.53)
Cerebrovascular disease (ICD 430–438)	70	65.7	1.06 (0.83–1.35)	80.8	0.87 (0.68–1.09)
Diseases of arteries, arterioles, and capillaries (ICD 440–448)	65	48.0	1.35 (1.05–1.73)	70.3	0.92 (0.72–1.18)
Respiratory system (ICD 460–519)	95	74.8	1.27 (1.03–1.55)	102.9	0.92 (0.75–1.13)
Chronic obstructive pulmonary disease and allied conditions (ICD 490–496)	90	67.4	1.33 (1.07–1.64)	94.2	0.96 (0.77–1.17)
Pneumoconiosis and other lung diseases related to external agents (ICD 500–508)	1	1.8	0.55 (0.01–3.08)	2.0	0.51 (0.01–2.81)
Digestive system (ICD 520–579)	45	37.5	1.20 (0.88–1.61)	50.1	0.90 (0.66–1.20)
Liver and gallbladder diseases (ICD 570–579)	30	25.0	1.20 (0.81–1.71)	33.9	0.89 (0.60–1.26)
Skin (ICD 680–709)	7	4.3	1.61 (0.65–3.32)	6.6	1.06 (0.43–2.19)
Musculoskeletal system (ICD 710–739)	975	450.5	2.16 (2.03–2.30)	637.2	1.53 (1.44–1.63)
Arthropathies (ICD 710–719)	321	120.8	2.66 (2.37–2.96)	172.1	1.87 (1.67–2.08)
Dorsopathies (ICD 720–724)	523	296.4	1.76 (1.62–1.92)	417.4	1.25 (1.15–1.37)
Injury and poisoning (ICD 800–999)	106	42.1	2.52 (2.06–3.05)	57.9	1.83 (1.50–2.21)
Accidents (ICD 800–959)	99	39.8	2.49 (2.02–3.03)	54.7	1.81 (1.47–2.20)
Other external causes (ICD 960–999)	7	2.3	3.04 (1.22–6.27)	3.1	2.24 (0.91–4.65)
All causes (ICD 001–999)	2247	1527.1	1.47 (1.41–1.53)	2020.9	1.11 (1.07–1.16)

SIR, standardised incidence ratio; 95% CI, 95% confidence interval.

addition to all-cause disability, table 4 also depicts some details of disability due to musculoskeletal disorders and accidents which appear to represent areas of specific concern among construction workers.

Stratifying the cohort by age revealed a widening gap in all-cause disability with increasing age between construction workers and the general workforce. Similarly, duration of employment was a strong predictor for disability risk as indicated by the sharp increase in relative risk of disability with longer employment in the construction industry. When we stratified the sample into workers of German and non-German nationality, workers of non-German nationality showed a statistically significantly lower risk of all-cause disability than German workers ($p<0.001$). With respect to job title, highest disability rates (all causes combined) were found for bricklayers, plasterers, labourers, and carpenters.

The association of age, duration of employment, nationality, and job title with disability caused by musculoskeletal disorders and accidents appeared to be stronger than with all-cause disability although the overall pattern was very similar. Interestingly, however, the association between age and disability due to musculoskeletal disorders seemed to be U-shaped, with highest relative risks among the youngest and the older age groups, whereas relative risk with respect to disability due to accidents was highest among the older age groups and smallest among the younger. For both outcomes, age adjusted relative risk of occupational disability sharply increased with longer duration of employment. Risk of disability due to accidents was highest for plasterers, carpenters, labourers, and bricklayers whereas risk of disability due to accidents was not increased for plumbers.

DISCUSSION

Most industrialised countries have public income maintenance programmes to protect workers in case of disability[8] but studies addressing disability risk of specific professional groups are rare. Construction workers in particular are difficult to study as they frequently change work sites, are often hired for temporary appointments, and frequently change employers.[25]

The results of our study indicate that musculoskeletal disorders and cardiovascular diseases represent main causes of occupational disability among construction workers. More importantly, however, is the finding that construction workers do not only experience a higher risk of all-cause disability than the general work force but also appear to experience a higher risk of disability than blue collar workers in general. This increase in risk of disability is mainly due to disorders of the musculoskeletal system and accidents. In particular, older and experienced construction workers seem to be at increased risk of occupational disability as the relative risk of disability increases with older age and with longer duration of employment in the construction industry.

Major causes of disability

The identification of cardiovascular disease and musculoskeletal disorders as major causes of occupational disability leading to early retirement is apparently a reflection of both the prevalence of the conditions in the general population and the environment and type of work involved in construction industry.[1] Cardiovascular diseases and musculoskeletal disorders have also been major causes of occupational disability in the general population. Over 1.8 million male workers were awarded a disability pension in the area of former Western Germany during the period 1986–99. Among those, 25% were caused by cardiovascular diseases and over 28% by musculoskeletal disorders. In contrast, musculoskeletal disorders caused over 45% and cardiovascular diseases represented approximately 19% of all cases of occupational disability in our cohort of construction workers.

Table 4 Standardised incidence ratios (SIR) for all-cause disability and disability due to musculoskeletal disorders and accidents by age, nationality, occupation, and duration of employment

	All causes			Musculoskeletal system (ICD 710–739)			Accidents (ICD 800–959)		
		Reference "GWF"	Reference "BCW"		Reference "GWF"	Reference "BCW"		Reference "GWF"	Reference "BCW"
	Obs	SIR (95% CI)	SIR (95% CI)	Obs	SIR (95% CI)	SIR (95% CI)	Obs	SIR (95% CI)	SIR (95% CI)
Total	2247	1.47 (1.41–1.53)	1.11 (1.07–1.16)	975	2.16 (2.03–2.30)	1.53 (1.44–1.63)	99	2.49 (2.02–3.03)	1.81 (1.47–2.20)
Age (years) (during follow up)									
25–39	57	0.97 (0.73–1.26)	0.81 (0.61–1.05)	13	2.12 (1.13–3.63)	2.05 (1.09–3.51)	7	1.30 (0.52–2.67)	1.04 (0.42–2.15)
40–44	57	1.03 (0.78–1.34)	0.78 (0.59–1.01)	12	1.38 (0.71–2.41)	1.12 (0.58–1.96)	2	0.85 (0.10–3.06)	0.61 (0.08–2.32)
45–49	127	1.13 (0.94–1.34)	0.85 (0.71–1.01)	29	1.32 (0.88–1.89)	1.03 (0.69–1.47)	7	1.68 (0.67–3.46)	1.24 (0.50–2.55)
50–54	413	1.40 (1.26–1.54)	1.07 (0.97–1.18)	140	2.09 (1.76–2.46)	1.53 (1.29–1.80)	21	2.53 (1.57–3.87)	1.82 (1.13–2.78)
55–59	1134	1.56 (1.47–1.66)	1.22 (1.15–1.29)	533	2.22 (2.04–2.42)	1.61 (1.47–1.75)	49	3.33 (2.47–4.41)	2.42 (1.79–3.21)
60–64	459	1.69 (1.54–1.85)	1.15 (1.05–1.26)	248	2.37 (2.09–2.69)	1.50 (1.32–1.69)	13	2.95 (1.57–5.05)	1.90 (1.01–3.26)
Nationality									
German	2017	1.54 (1.48–1.61)	1.17 (1.12–1.22)	895	2.29 (2.14–2.45)	1.62 (1.52–1.73)	91	2.71 (2.18–3.33)	1.97 (1.59–2.42)
Other	227	1.04 (0.91–1.19)	0.78(0.69–0.89)	79	1.34 (1.06–1.67)	0.95 (0.75–1.18)	8	1.31 (0.57–2.58)	0.95 (0.41–1.88)
Occupation									
Plumbers	169	0.96 (0.82–1.12)	0.72 (0.62–0–84)	70	1.42 (1.11–1.80)	1.00 (0.78–1.27)	7	1.36 (0.55–2.81)	0.99 (0.40–2.05)
Carpenters	266	1.41 (1.25–1.59)	1.07 (0.94–1.21)	128	2.28 (1.90–2.71)	1.61 (1.35–1.92)	16	3.16 (1.81–5.13)	2.31 (1.32–3.75)
Painters	252	1.01 (0.89–1.15)	0.76 (0.67–0.86)	93	1.28 (1.03–1.56)	0.90 (0.72–1.10)	13	2.00 (1.06–3.42)	1.45 (0.77–2.48)
Plasterers	348	1.70 (1.53–1.89)	1.29 (1.16–1.44)	164	2.67 (2.28–3.11)	1.89 (1.62–2.21)	21	4.14 (2.56–6.33)	3.00 (1.86–4.59)
Bricklayers	891	1.74 (1.63–1.86)	1.32 (1.23–1.41)	403	2.65 (2.40–2.92)	1.88 (1.70–2.07)	29	2.25 (1.51–3.23)	1.63(1.09–2.34)
Labourers	321	1.62 (1.45–1.81)	1.22 (1.09–1.37)	117	1.99 (1.64–2.38)	1.40 (1.16–1.68)	13	2.54 (1.35–4.34)	1.85 (0.99–3.17)
Duration of employment									
<15 years	201	1.15 (0.99–1.32)	0.88 (0.76–1.01)	63	1.56 (1.20–2.00)	1.14 (0.87–1.46)	9	1.25 (0.57–2.37)	0.95 (0.43–1.80)
15–29 years	554	1.28 (1.18–1.39)	0.96 (0.89–1.05)	213	1.78 (1.55–2.04)	1.27 (1.10–1.45)	24	2.14 (1.37–3.19)	1.54 (0.99–2.29)
⩾30 years	1246	1.67 (1.58–1.76)	1.26 (1.19–1.33)	596	2.46 (2.27–2.67)	1.72 (1.59–1.87)	57	3.57 (2.70–4.62)	2.54 (1.93–3.30)

GWF, general work force; BCW, blue collar workers; Obs, number of observed cases; SIR, standardised incidence ratio; 95% CI, 95% confidence interval.

All-cause disability

Several studies reported that blue collar workers are at higher risk of occupational disability than white collar workers.[9 10 13] Therefore, our finding that construction workers do not only experience a higher risk of all-cause disability than the general work force (composed of white and blue collar workers), but also a higher risk of disability than the blue collar reference is noteworthy and indicates that construction workers may represent a high risk group for occupational disability. Construction differs markedly from most other types of manufacturing in the extent of the safety and health risks to workers.[26] Construction companies rarely provide steady employment and the frequently changing worksite, together with a huge number of small enterprises, makes it difficult to implement preventive programmes to protect the health of these workers.[27] Although it has been argued that individual factors (such as alcohol consumption and smoking) as well as environmental factors (such as legislation and labour market) affect the likelihood of disability pensioning,[13] the increased disability risk among our cohort of construction workers is presumably also related to work characteristics, such as heavy manual work, repetitive monotonous movements, and the high accident risk. Such work characteristics may increase the risk of occupational disability and fit very well to the observed pattern of diagnoses in our study with its high proportion of musculoskeletal disorders and accidents.[8 13] Our results are further supported by data from the US Health and Retirement Study, which found that construction workers are more susceptible to a number of chronic health conditions, such as musculoskeletal problems, chronic lung disease, and emotional/psychiatric disorders, and by a Swedish study, which found that occupational disability was more common both in men with medium and high physical work load (in particular construction and metal workers) compared with men with low physical work load.[28 29]

Cause specific disability risk

Our data indicate that the increased risk of disability among construction workers is mainly due to disorders of the musculoskeletal system and accidents. There is strong evidence that heavy physical work with lifting, static muscular loading and uncomfortable work positions is associated with an increased risk of occupational disability, particularly musculoskeletal disorders.[9 30 31] This pattern is also reflected by the job specific analysis indicating that plasterers, bricklayers, carpenters, and labourers are at highest risk of becoming disabled due to musculoskeletal disorders. Plumbers and painters also experience static muscular loading and uncomfortable positions, but lifting and handling of heavy loads are less common than in the other professional groups considered within our study.[32]

The hazards of construction work with respect to accidents are well established. Our results show that older construction workers in particular experience a higher risk of occupational disability from accidents. Although there is some discussion whether older or younger workers are at higher risk of injuries, there is sound evidence that in the case of an accident, older workers tend to be injured more severely.[33–39]

Construction workers are potentially exposed to a number of carcinogenic substances, such as asbestos and silica, and to other substances such as organic solvents and ''bystander exposures'' present in shared work spaces;[40] however, studies addressing cancer risk of construction workers have shown conflicting results.[40–44] Our cause specific analysis revealed an increased risk of disability caused by cancer of the oral cavity and the pharynx but not to any other major cancer site when compared to the general workforce. The observed increase in risk of cancer of the oral cavity and the pharynx might be partly explained by the high rates of smoking and heavy alcohol consumption,[45 46] but other factors such as occupational exposure to carcinogens (for example, asbestos) and co-carcinogens (such as cement) have been discussed as additional specific risk factors for construction workers.[47 48]

Age, duration of employment, nationality

Our findings indicate that older workers represent a particularly vulnerable group with respect to risk of occupational disability. Although it cannot be ruled out that older workers are more likely to be warranted a disability pension either due to a lack of alternative job opportunities or by ''bridging'' those nearly at retirement age into pension, our results suggest that older workers deserve specific attention for future prevention measures (including providing job alternatives in sufficient numbers). This is of specific concern as it is expected that the proportion of older workers in the construction industry will be increasing due to the demographic change and a tendency among young people to work in less physically demanding jobs.

Older construction workers are also those who are more likely to have worked for many years in the construction industry. At first sight, it is therefore not surprising to see a strong positive association between duration of employment—which may also be considered as a proxy for the dose of exposure—and relative risk of occupational disability. However, this dose-response relation persisted even after control for age and thus gives further support to the above mentioned work relatedness of the increased disability risk among our cohort of construction workers.

In our study, migrants from other countries experienced a substantially lower disability rate than German construction workers. This phenomenon may reflect either a healthy migrant effect caused by a selection process in the 1960s when workers from Southern European countries with good physical health were hired to work in Germany or an ''unhealthy re-migration effect'' in which socially successful, healthier migrants have stayed in Germany while less healthier ones have returned home before becoming manifestly ill.[49] Alternatively, formal and informal sociocultural barriers and a different attitude towards the retirement process may be discussed as a further explanation for the difference in disability risk between migrant and German workers. This explanation may be, however, less important as the health status of German and foreign workers seems to differ indeed. For example, we have recently observed a 25% lower mortality rate among migrant workers compared with German construction workers.[17]

Occupational disability emerged as an important outcome in epidemiological research during the past decade but only a few longitudinal studies have been published so far. The comparison of the disability rates observed in our study population with rates derived from the general population is a first step towards a deeper understanding of the complex process of early retirement because of health reasons. However, the picture is somewhat incomplete as we were only able to address the main diagnosis for each case and we could not distinguish between permanent and temporary disability pensioning. However, 85% of all disability pensions, which were granted in Germany during the follow up period, were permanent. No information was given regarding potential concomitant diseases responsible for disability or for external causes of injury (E-code).

Another limitation of our study is that the range of covariates considered in our analysis was restricted to some basic sociodemographic factors (that is, age, nationality, occupational group) and that the impact of other factors—in particular lifestyle habits—could not be controlled in the external comparison group. Also, it would be of utmost

Main messages

- Construction workers do not only experience a higher risk of all-cause disability than the general work force but also experience a higher risk of disability than blue collar workers in general.
- The increased burden of disability among construction workers is mainly caused by disorders of the musculoskeletal system and accidents.
- The relative increase in disability risk increases with age and with longer duration of employment in the construction industry, indicating that older and experienced construction workers seem to be at particular risk of occupational disability.

Policy implications

- The increased risk of occupational disability among construction workers, which is mainly caused by disorders of the musculoskeletal system and accidents, calls for further efforts to sustain the health of construction workers.
- Older workers represent a vulnerable group and deserve specific attention for future prevention measures (including providing job alternatives in sufficient numbers).

interest to address the role of specific work conditions and other occupational factors. We were able to use two reference groups: general work force and blue collar workers. The latter group has the advantage of being more similar with respect to socioeconomic status and lifestyle factors but simultaneously contains the potential of diluted work related effects (for example, high physical work load).

A common limitation inherent in studies which rely on voluntary participation is the potential for bias due to self selection of the study members. Although our study sample does not differ from the underlying source population of all construction workers in terms of basic demographics, we cannot rule out differences in health status as has been described in a study from the Swedish construction industry[27] which reported that non-participants of OSH screening programmes had poorer health than participants. Similarly, we are also concerned about those who quitted the construction industry because of a health reason before the baseline examination took place. This potential selection bias has also been referred to as ''healthy worker survivor effect''[50] and results from a selection process in that those who remain employed tend to be healthier and presumably experience lower disability risk than those who left employment before the baseline examination.[51]

Over 77% of all cohort members could be successfully linked to the pension register. Those 4286 workers who have been lost to follow up during the 10 year period tended to be older (mean age 45.0 years) and to be more often of foreign origin (35%). At the time of baseline examination no differences were apparent with respect to cardiovascular or respiratory diseases but findings related to musculoskeletal disorders were more common among those lost to follow up (49% *v* 39%). This potential healthy worker survivor effect may however yield an underestimation of the true disability risk of construction workers. Despite this potential for underestimation of some effects, our study provides strong evidence of an increased disability risk among construction workers, which is mainly caused by disorders of the musculoskeletal system and accidents and which calls for further efforts to sustain the health of construction workers.

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Authors' affiliations

V Arndt, D Rothenbacher, H Brenner, German Centre for Research on Ageing, Department of Epidemiology, Heidelberg, Germany
U Daniel, B Zschenderlein, S Schuberth, Occupational Health Service, Workmen's Compensation Board for Construction Workers Württemberg, Böblingen, Germany

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