Int Arch Occup Environ Health (2018) 91:13–21
https://doi.org/10.1007/s00420-017-1252-9

ORIGINAL ARTICLE

Health risks in the cleaning industry: a Belgian census-linked mortality study (1991–2011)

Laura Van den Borre[1] · **Patrick Deboosere**[2]

Received: 9 November 2016 / Accepted: 7 August 2017 / Published online: 14 August 2017

Abstract
Purpose Cleaning work has been associated with a wide range of occupational health hazards. However, little is known about mortality risks in the cleaning industry. This study examines differences in cause-specific mortality between cleaners, manual and non-manual workers.
Methods Using exhaustive census-linked mortality data, the total Belgian working population aged 30–60 was selected from the 1991 census. Analyses were based on 202,339 male and 58,592 female deaths between 1 March 1991 and 31 December 2011. Standardized Mortality Ratios were calculated and indirectly adjusted for smoking (SMR). In addition, Cox proportional hazards regression models were used to account for age, educational level, part-time employment and marital status.
Results Large mortality differences were observed between cleaners, manual and non-manual workers. In 2001–2011, smoking-adjusted SMRs for all-cause mortality were higher among cleaners than among non-manual workers (Men 1.25 CI 1.22–1.28; women 1.10 CI 1.07–1.13). SMRs also show cleaners had significantly more deaths due to COPD (men 2.13 CI 1.92–2.37; women 2.03 CI 1.77–2.31); lung cancer (men 1.31 CI 1.22–1.39; women 1.21 CI 1.11–1.32); pneumonia (men 1.64 CI 1.35–1.97; women 1.31 CI 1.00–1.68); ischaemic heart diseases (men 1.22 CI 1.13–1.31; women 1.40 CI 1.25–1.57) and cerebrovascular diseases (men 1.19 CI 1.05–1.35; women 1.13 CI 1.00–1.27). Mortality risks among cleaners remained elevated after adjustment for education.
Conclusions Respiratory and cardiovascular mortality is considerably higher for male and female cleaners than for non-manual workers.

Keywords Occupational health · Census-linked data · Cause-specific mortality · Cardiovascular diseases · Respiratory diseases

Introduction

Cause-specific mortality has rarely been investigated for cleaners, despite considerable knowledge on occupational health risks. Approximately 3.44 million Europeans were employed as cleaners in 2012, representing 1.6% of the EU-28 working population (Eurostat 2015). Working conditions in the industry are characterized by low earnings, high job demands and low levels of autonomy (Eurofound 2014). Depending on the specific tasks and work environments, cleaners may be exposed to chemical products, biological hazards, difficult physical working conditions and various psychosocial risk factors (Zock 2005; European Agency for Safety and Health at Work 2009; Mousaid et al. 2015).

Recent research has drawn attention to a number of adverse health effects associated with professional cleaning. Cleaners report a higher number of health problems than the general working population (Eurofound 2014). High prevalence of asthma, musculoskeletal disorders and poor

Electronic supplementary material The online version of this article (doi:10.1007/s00420-017-1252-9) contains supplementary material, which is available to authorized users.

✉ Laura Van den Borre
Laura.Van.den.Borre@vub.be

[1] Interface Demography, Department of Sociology, Vrije Universiteit Brussel, Pleinlaan 2, PL5, 2.01, 1050 Brussels, Belgium

[2] Interface Demography, Department of Sociology, Vrije Universiteit Brussel, Pleinlaan 2, PL5, 2.05, 1050 Brussels, Belgium

mental health has been reported repeatedly among cleaning personnel (Gamperiene et al. 2006; Jaakkola and Jaakkola 2006; Kumar and Kumar 2008). Current studies on health risks among cleaners have focused on specific types of morbidity (Charles et al. 2009). However, the mortality pattern of cleaners has been scarcely investigated (Cucino and Sonnenberg 2002; Harris et al. 2016).

This study examines differences in cause-specific mortality among cleaners, manual workers and non-manual workers to identify potential health risks.

Methods

Data were derived from an anonymous record linkage between the 1991 Belgian census, the population register and death certificate information. The census provides exhaustive demographic and socio-economic information of the officially registered Belgian population, including occupational type, industry of employment, type of performed labour (manual or non-manual labour), type of contract (full-time or part-time), educational level and marital status. The Belgian census was directly linked by Statistics Belgium at the individual level with the population register. The population register contains migration and mortality information for every legal citizen up to 31 December 2011. Cause-specific mortality data from death certificates were added covering the periods 1991–1997 and 2001–2011.

Study population

The Belgian working population aged 30–60 was selected from the 1991 census. The working population consisted of 1,562,551 men and 953,442 women. All-cause mortality information was derived from the population register, including 202,339 male and 58,592 female deaths between 1 March 1991 and 31 December 2011. Table 1 provides an overview of the characteristics of the study population.

Table 1 Characteristics of the study population with mortality information for 1991–2011

	Men				Women			
	N	%	PY	*D*	*N*	%	PY	*D*
Total	1,562,551	100	30,400,798	202,339	953,442	100	19,176,798	58,592
Occupational type in 1991								
Cleaners	53,140	3	1,022,488	9129	96,914	10	1,953,035	7117
All other workers	1,509,411	97	29,378,310	193,210	856,528	90	17,223,763	51,475
Non-manual workers	854,540	55	16,575,304	105,882	654,287	69	13,150,454	38,416
Manual workers	654,871	42	12,803,006	87,328	202,241	21	4,073,309	13,059
Age category in 1991								
30–34 years	348,968	22	6,990,808	16,205	258,987	27	5,270,522	6577
35–39 years	327,530	21	6,516,458	23,900	229,697	24	4,661,019	9245
40–44 years	314,047	20	6,169,554	34,470	196,942	21	3,967,456	11,745
45–49 years	239,743	15	4,613,549	38,656	130,185	14	2,596,931	10,974
50–54 years	199,703	13	3,744,262	45,164	85,989	9	1,690,871	10,376
55–59 years	132,560	8	2,366,167	43,944	51,642	5	989,999	9675
Educational degree in 1991								
No degree	266,836	17	5,100,833	47,132	142,580	15	2,846,602	11,561
Lower education	159,843	10	3,068,941	29,475	83,601	9	1,679,193	6896
Lower middle school	324,719	21	6,378,661	42,131	176,812	19	3,571,674	11,688
Higher middle school and up	727,064	47	14,378,618	73,834	504,177	53	10,215,440	25,611
No information	84,089	5	1,473,745	9767	46,272	5	863,889	2836
Type of contract in 1991								
Part-time	37,672	2	714,044	5984	303,727	32	6,141,438	16,950
Full-time	1,484,988	95	28,958,123	188,584	602,782	63	12,116,857	37,499
No information	39,891	3	728,631	7771	46,933	5	918,503	4143
Marital status								
Married	1,287,228	82	25,165,962	158,763	746,767	78	15,084,113	42,009
Single, widowed, divorced	275,323	18	5,234,836	43,576	206,675	22	4,092,685	16,583

Number of workers in 1991 (*N*); percentage of total number of workers (%); total person-time in years in 1991–2011 (PY); observed number of deaths in 1991–2011 (*D*)

Cleaners were identified using the International Statistical Classification of Occupations (ISCO): domestic cleaners; cleaners in offices and other establishments; street sweepers and related occupations; building structure cleaners and; window cleaners and related occupations (Federal Public Service Employment; Labour and Social Dialogue 2016). A total of 53,140 male and 96,914 female cleaners were identified in the 1991 Census.

In addition to cleaners, we distinguished manual and non-manual workers using information on the type of performed labour. Without taking cleaners into account, we identified 654,871 male and 202,241 female manual workers. A total of 854,540 men and 654,287 women performed non-manual work (white-collar, management, etc.) at the time of the census.

Mortality information

Cause-specific mortality information was based on the underlying cause of death as recorded on the death certificate. Data for cause-specific mortality are partially missing for 1998–2001. As a result, two time periods were considered for analysis. The first period covered 6 years and 10 months between the census date (1 March 1991) and 31 December 1997, while the second period comprised 10 years and 3 months from 1 October 2001 to 31 December 2011. The 9th and 10th revisions of the International Classification of Diseases (ICD) were used in the periods 1991–1997 and 2001–2011, respectively.

Statistical analyses

First, we examined broad categories of causes of death for the periods 1991–1997 and 2001–2011 to determine if cleaners experience elevated mortality. Causes of death were grouped in broad categories building on the structure of the International Classification of Diseases. Standardized Mortality Ratios (SMRs) and 95% confidence intervals (CI) were calculated for cleaners and manual workers by 5-year age groups with reference to non-manual workers. Analyses were performed separately for men and women.

Second, we considered possible effects of smoking, education and part-time work on mortality risks among cleaners. Analyses were performed for the period 2001–2011 due to the relatively low number of deaths for some specific causes of death in 1991–1997.

Smoking

Because smoking information was not available in the dataset, SMRs were indirectly adjusted (Axelson and Steenland 1988). Smoking prevalence data were derived from the Belgian Health Interview Survey, containing health indicators from a large representative sample of Belgian households (WIV-ISP 2015). Waves 1997, 2001, 2004 and 2008 were pooled. Smoking status (current, former and never) was obtained for cleaners, manual workers and non-manual workers between the ages of 30 and 60 years. Housekeeping and restaurant services workers; Domestic and related helpers; Cleaners and launderers; and Building caretakers, window and related cleaners were identified using ISCO codes. Information on the type of performed labour allowed us to distinguish non-manual and manual workers (excluding cleaners). Relative risk estimates for the selected smoking-related diseases were obtained from the 2014 US Surgeon General's Report (CDC 2014). Further information on the calculation of smoking adjusted SMRs (SMR_{smok}) is provided in supplementary Appendix 1.

Education

Hazard ratios (HRs) and corresponding 95% confidence intervals were calculated using Cox proportional hazards models. Cleaners and manual workers were compared to non-manual workers as the reference group. Models were fit to the attained age as time scale (Korn et al. 1997). Time was measured continuously as the age until death or censorship, using the exact date of emigration or mortality from the population register. Censorship occurred at emigration or at the end of the follow-up period. Mortality due to causes of death other than the cause under investigation was censored at time of death. Following Richiardi and colleagues, both age- and education-adjusted hazard ratios are presented (Richiardi et al. 2008). Analyses were performed controlling for age at baseline as a continuous variable. Highest educational attainment was included as a categorical variable ranging from no degree to at least a high school diploma.

Part-time work

Cox proportional hazards models were performed separately for cleaners to gain insight into exposure duration effects related to cleaning work. There were distinct differences between cleaners and the other occupational groups regarding the distribution of part-time employment. Hence, additional analyses for the cleaning industry were performed to investigate potential mortality differences by type of contract. Hazard ratios were age-adjusted. We also controlled for marital status and educational level, as these may influence the association between part-time work and mortality risks (Honjo et al. 2015). Part-time cleaners were used as the reference group.

Results

Mortality pattern in 1991–1997 and 2001–2011

Mortality risks were higher for cleaners than for non-manual workers. Table A1 in appendix presents SMRs for cleaners and manual workers for the periods 1991–1997 and 2001–2011.

Male cleaners experienced higher mortality risks in both study periods. SMRs for all causes of death were 36% (SMR 1.36 CI 1.29–1.42) higher in 1991–1997 compared to non-manual cleaners. In 2001–2011, the difference became even more pronounced with a SMR of 1.45 (CI 1.41–1.48) among male cleaners. Elevated mortality risks among female cleaners only became apparent in 2001–2011 due to the low number of deaths in 1991–1997. They experienced 16% (SMR 1.16 CI 1.13–1.19) higher mortality in 2001–2011 compared to female non-manual workers.

Male cleaners have high SMRs for almost every category of causes of death. Both male and female cleaners seem to experience elevated SMRs for respiratory malignancies; heart diseases; cerebrovascular and other circulatory diseases and respiratory diseases. After further examination of the specific causes of death, cleaners have high SMRs for lung cancer, pneumonia, chronic obstructive pulmonary diseases (COPD), ischaemic heart diseases and cerebrovascular diseases.

Figure 1 presents SMRs and smoking-adjusted SMRs for all causes of death, lung cancer, pneumonia, chronic obstructive pulmonary diseases (COPD), ischaemic heart diseases and cerebrovascular diseases in 2001–2011. Male and female cleaners experienced higher mortality risks than non-manual workers, even after adjustment for smoking.

SMRs for all-cause mortality remained elevated among male cleaners despite a drop from 1.45 (CI 1.41–1.48) to 1.25 (CI 1.22–1.28). For female cleaners, SMRs declined from 1.16 (CI 1.13–1.19) to 1.10 (CI 1.07–1.13).

COPD mortality ratios were over 2 times higher for male (SMR 2.45 CI 2.20–2.73) and female (SMR 2.20 CI 1.92–2.51) cleaners compared to non-manual workers. Smoking-adjusted SMRs for COPD remain around 2 times higher among cleaners. Results for women show large differences in COPD mortality for cleaners and manual workers in comparison with non-manual workers.

SMRs for lung cancer dropped after adjusting for smoking from 1.72 (CI 1.62–1.84) to 1.30 (CI 1.22–1.39) for male cleaners and from 1.49 (CI 1.36–1.62) to 1.21 (CI 1.11–1.32) for female cleaners.

Smoking-adjusted SMRs for pneumonia among female cleaners (SMR_{smok} 1.31 CI 1.00–1.68) were comparable to those among other manual workers (SMR_{smok} 1.28 CI 1.06–1.54). For men, pneumonia risk was considerably higher for cleaners (cleaners SMR_{smok} 1.64 CI 1.35–1.97; manual workers (SMR_{smok} 1.06 CI 0.99–1.13).

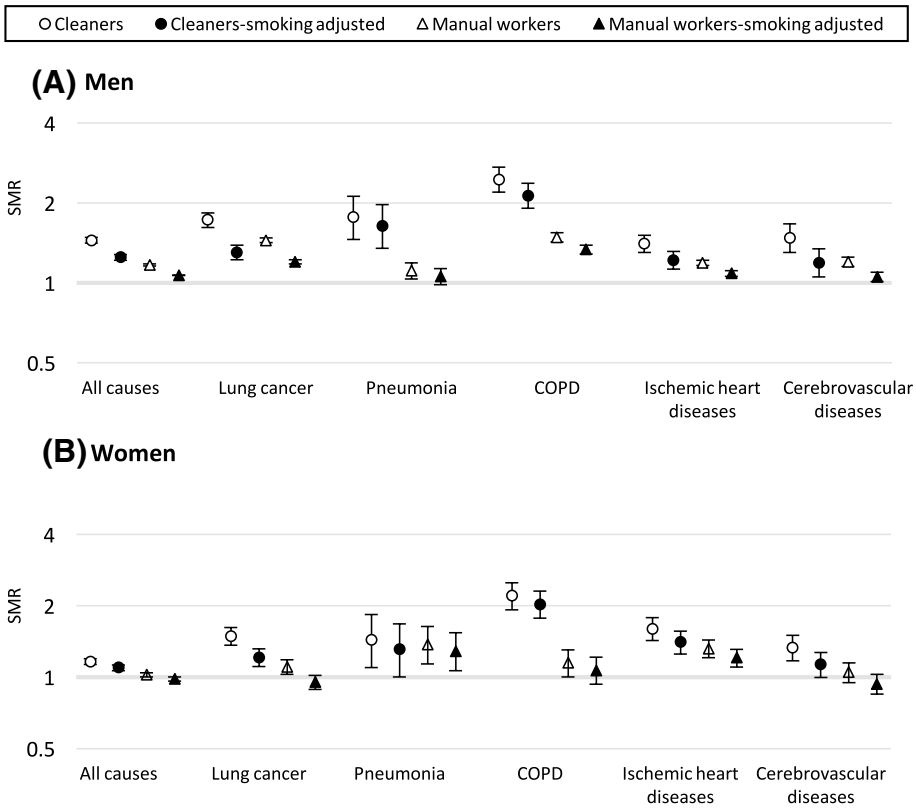

Fig. 1 Standardized mortality ratios and 95% confidence intervals for cleaners and manual workers with reference to non-manual workers, by sex, 2001–2011

Male and female cleaners had smoking-adjusted SMRs for ischaemic heart diseases of 1.22 (CI 1.13–1.31) and 1.40 (CI 1.25–1.57), respectively. Smoking-adjusted SMRs for cerebrovascular mortality were 20% higher among male cleaners (SMR_{smok} 1.20 CI 1.06–1.35) and 13% higher for female cleaners (SMR_{smok} 1.13 CI 1.00–1.27) compared to non-manual workers.

Education

Figure 2 shows the hazard ratios for the five aforementioned causes with adjustments for educational level. The pattern in age-adjusted hazard ratios was similar to our findings based on SMRs unadjusted for smoking. Hazard ratios declined after controlling for educational level. Nonetheless, results remained significant except for pneumonia (HR 1.19 CI 0.88–1.61) and cerebrovascular mortality (HR 1.11 CI 0.96–1.28) among female cleaners. Overall, lower educational levels were associated with increased mortality risks for all causes of death under investigation. Tables A2 and A3 in appendix present results for types of cleaners with reference to non-manual workers. Hazard ratios are higher for all types of cleaners compared to non-manual workers. After the inclusion of educational level in the model, hazard ratios remain elevated.

Part-time work

The group of cleaners was selected for further analyses to investigate potential mortality differences between part-time and full-time work. Table 2 presents HRs for mortality among full-time cleaners with reference to part-time cleaners in 2001–2011.

Male cleaners working full-time had lower mortality ratios than their colleagues in part-time employment. Age-adjusted HRs for full-time cleaners were lowest for mortality due to COPD (HR 0.63 CI 0.42–0.95); mortality due to ischaemic heart diseases (HR 0.70 CI 0.51–0.96); and all-cause mortality (HR 0.87 CI 0.78–0.96).

Women, on the other hand, had higher HRs for full-time cleaning work compared to part-time cleaning work. Age-adjusted HRs were highest for lung cancer (HR 1.18 CI 0.99–1.41); cerebrovascular diseases (HR 1.11 CI 0.86–1.43); ischaemic heart diseases (HR 1.08 CI 0.85–1.35); and all-cause mortality (HR 1.08 CI 1.03–1.14).

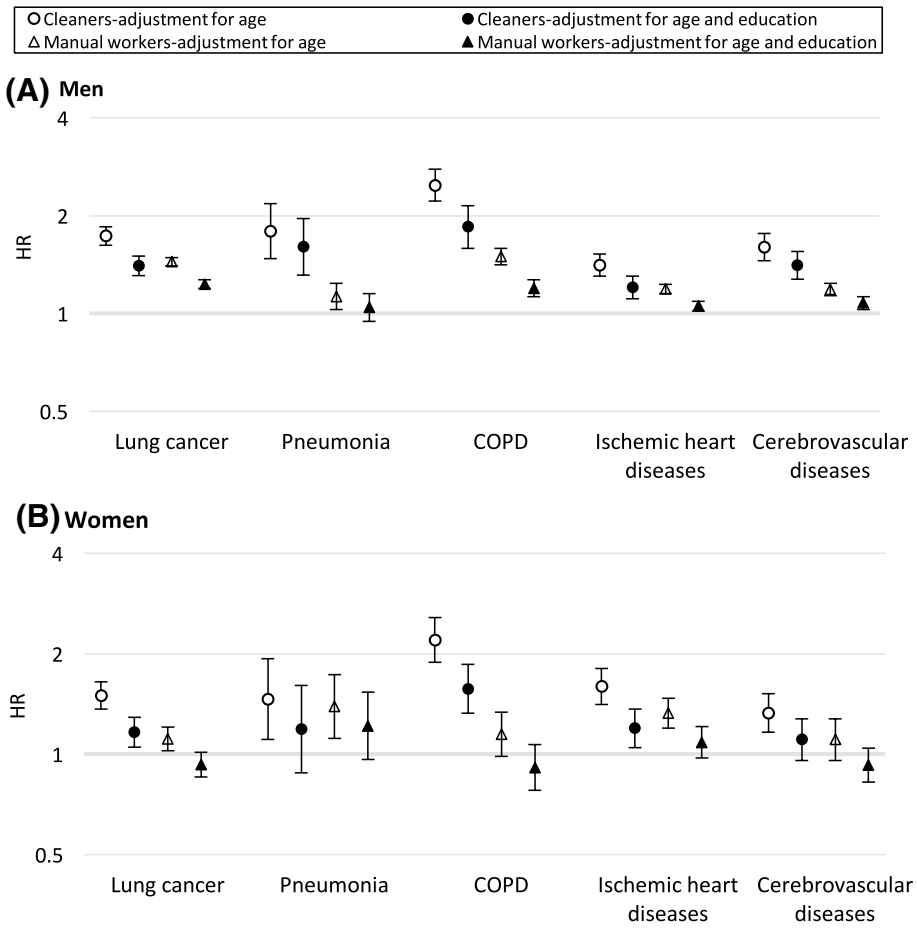

Fig. 2 Hazard ratios and 95% confidence intervals for cleaners and manual workers with reference to non-manual workers, by sex, 2001–2011

Table 2 Hazard ratios and 95% confidence intervals for full-time cleaners with reference to part-time cleaners in 2001–2011, by sex

Men	Part-time cleaners ($N = 2117$)		Full-time cleaners ($N = 45{,}271$)				
	D	HR	*D*	HR	CI	HR_a	CI
All causes of death	308	1	5433	0.87	0.78–0.96	0.91	0.81–1.01
Lung cancer	48	1	869	0.88	0.66–1.18	0.90	0.68–1.21
Pneumonia	5	1	103	–	–	–	
COPD	25	1	306	0.63	0.42–0.95	0.67	0.44–1.00
Ischaemic heart diseases	42	1	583	0.70	0.51–0.96	0.73	0.53–1.00
Cerebrovascular diseases	11	1	240	1.12	0.61–2.06	1.19	0.65–2.19
Women	Part-time cleaners ($N = 55{,}104$)			Full-time cleaners ($N = 33{,}406$)			
	D	HR	*D*	HR	CI	HR_a	CI
All causes of death	2846	1	1846	1.08	1.03–1.14	1.04	0.98–1.10
Lung cancer	297	1	213	1.18	0.99–1.41	1.13	0.95–1.35
Pneumonia	38	1	22	–		–	
COPD	132	1	81	1.01	0.77–1.34	0.94	0.71–1.24
Ischaemic heart diseases	184	1	120	1.08	0.85–1.35	1.01	0.80–1.27
Cerebrovascular diseases	149	1	100	1.11	0.86–1.43	1.06	0.82–1.37

Absolute number of deaths (*D*), Hazard ratio adjusted for age (years) at baseline (HR), 95% confidence interval (CI), Hazard ratio adjusted for age (years) at baseline, educational level and marital status (HR_a), Hazard ratios not calculated due to small number of deaths (–)

The results from the multivariate analysis show HRs for male and female cleaners were slightly modified by low educational levels and being unmarried. Low educational level groups had higher mortality risks. Being unmarried was associated with higher mortality ratios. After adjustment for age, educational level and marital status, HRs for men and women in full-time cleaning work approximated the reference group.

Discussion

Working in the Belgian cleaning industry in 1991 was associated with higher mortality risks during the subsequent 20-year period. Cleaners experienced significantly more deaths due to lung cancer, COPD, pneumonia, ischaemic heart diseases and cerebrovascular diseases than non-manual workers.

Recent studies suggest an association with occupational exposure types in the cleaning industry. A potential carcinogenic effect of chlorinated solvents on lung cancer has been reported in two large population-based case–control studies (Vizcaya et al. 2013; Mattei et al. 2014). COPD has been associated with an abnormal response of the lungs to noxious particles and gases (Salvi and Barnes 2009). Chronic respiratory symptoms seem to be related to the use of disinfectants (Preller et al. 1995). Contrary to previous studies, we did not find an association between cleaning and asthma (Jaakkola and Jaakkola 2006; Vandenplas et al. 2013; Vizcaya et al. 2015). It is possible that our classification may have failed to grasp health outcomes due to industry-specific allergens (Karjalainen et al. 2002). Alternatively, asthma may have an important intermediate rather than direct effect in the causal pathway leading to death (Soto-Campos et al. 2013).

The excess in pneumonia mortality may be an indication of biological risk factors in cleaning work, such as exposure to *Aspergillus fumigatus* (European Agency for Safety and Health at Work 2009). In addition, chronic obstructive lung disease has been reported as a risk factor for pneumonia, as well as for cardiovascular mortality (Koivula et al. 1994; Huiart et al. 2005; Curkendall et al. 2006). Increased risks for mortality due to ischaemic heart diseases have been reported among female cleaners with possible explanations including low job control, shift work and dust exposure (Sjögren et al. 2003).

Tobacco consumption is a major risk factor for respiratory and cardiovascular mortality (CDC 2014). However, mortality risks remained higher for cleaners compared to non-manual workers after indirect adjustment for smoking. This method is based on hypothesized differences in smoking behaviour and international research on the relative risks of smoking (Steenland et al. 1984). Smoking prevalence for cleaners, manual and non-manual workers was similar in each of the four waves of the national health survey, indicating consistency in smoking habits by occupational group. A variety of relative risks have been reported for smoking due to differences in classification, in the amount smoked

and in the use of incidence or mortality (van de Mheen and Gunning-Schepers 1996; Thun et al. 2013). Our adjustment is based on relative risks from the Cancer Prevention Study II that followed approximately 1.2 million Americans from 1982 until 1988. According to a recent update of these smoking-related mortality risks, comparable estimates based on large cohorts are not available for adults under the age of 55 (CDC 2014).

Considering the strong association between high smoking prevalence and low educational attainment, our results adjusted for educational level may also provide an indication of the influence of smoking on mortality risks (Huisman et al. 2005). Although mortality differences between occupational groups declined, excess mortality among cleaners remained even after controlling for education. Further research efforts are required to determine the relation between smoking, occupational exposures and mortality for the cleaning industry, but it is highly probable that the abundance of chemical and biological hazards in the cleaning industry constitutes an important contribution to the excess mortality among cleaners (Montano 2014).

Excess mortality among female cleaners was not apparent until the second period under investigation. First, this result may be explained by different industries of employment for male and female cleaners. Cleaning practices have developed largely independently per sector, depending on the specific requirements (Fryer and Asteriadou 2009). In industrial settings, more male cleaners were employed. The specific chemical composition and the use of cleaning products may lead to increased exposure to hazardous agents (Gerster et al. 2014). Industrial cleaning processes have recently been associated with a higher risk of COPD than domestic cleaning after controlling for sex and lifetime smoking exposure (De Matteis and Cullinan 2015).

Second, there may be a selection bias prior to the 1991 census. Female cleaners may leave the workforce more easily than male cleaners when experiencing health problems. In traditional male-breadwinner households, the salary of women complements the income of their partners. If households depend on men as the principal wage earner, it might be more difficult for them to stop working in case of health problems. The census data show that more cleaners left the workforce than other workers. Female cleaners did so even more than do their male colleagues. For cleaners, we found that 59% of men and 52% of women were still working 10 years later. Approximately 66% and 64% of men and women in all other jobs in 1991 were still at work in 2001.

Results also showed sex differences in the effect of part-time work. Men employed as full-time cleaners experienced lower mortality compared to part-time cleaners, whereas full-time female cleaners had elevated mortality risks. A Swedish mortality study reported a similar differential effect of full-time work by sex (Nylen et al. 2001). The explanation may lie in gender-specific motivations for part-time work, as supplementary analyses reveal the same pattern among manual and non-manual workers. When experiencing impaired health, men may be more likely to regard part-time work as a last resort before quitting their jobs. Men working full-time compared to part-time in manual and non-manual jobs had HRs of 0.79 (CI 0.76–0.83) and 0.85 (CI 0.81–0.89) in 2001–2011, respectively. Although this can also be the case for women, part-time work is also a means for healthy women to combine the economic benefits of employment with traditional household tasks. We found that married women who worked as cleaners did so more often in part-time employment than married women in other jobs (65 vs. 32%). The large majority of married men (95%) worked full-time, regardless of employment in the cleaning industry.

The main advantage of this study was the availability of census-linked cause-specific mortality data. The large follow-up period of 20 years made it possible to analyse changes in the mortality pattern over time. The anonymous linkage at individual level minimized the nominator-denominator bias. The data provided a snapshot of the occupational distribution for the total Belgian population in 1991.

The study also has some limitations. First, specific occupational information was only available for one point in time. Findings may be confounded by exposures during previous or ensuing jobs. Poor health may have caused cleaners to leave the work force prior to the 1991 census. Because this study focuses on the working population, healthy worker effects may bias our results. It is also possible that former cleaners are included in the reference population. Cleaners experiencing health problems may have transitioned to jobs with fewer health risks such as non-manual labour jobs. Our results are possibly an underestimation of the true health situation of cleaners due to the considerable staff turnover and the importance of undeclared work in the sector. Domestic cleaners were largely undetected until 2004, when new fiscal and parafiscal regulations have been introduced to combat informal work (Mousaid et al. 2015).

Second, specific information on occupational exposure is not available. Cleaners regularly use different products depending on their specific tasks, complicating the exposure profiles even further. Moreover, exposure to cleaning products may have changed over time as a result of the development of environmentally friendly cleaning products and new technologies, such as micro fibre and steam technology (Garza et al. 2015). In order to better understand the health effects of cleaning products, detailed exposure information from past and current working positions is needed.

Third, the study design does not account for health effects from additional psychosocial, lifestyle or material risk factors. High psychosocial demands have been associated with cleaning work, (Mousaid et al. 2017) as well as with elevated risks for cardiovascular diseases (Strand and Tverdal 2004).

People in low socio-economic positions tend to engage in more unhealthy behaviours (Pampel et al. 2010). The elevated SMRs for alcohol-related diseases, suicide and accidents among male cleaners may be an indication of this. Due to the complex interplay of causal mechanisms, our results may also reflect health effects from risk factors not or indirectly related to cleaning work. Future research efforts should endeavour to understand the risk profile of cleaners in and out of the workplace.

In conclusion, this study provided a strong indication of the adverse health effects of professional cleaning on population level. Male and female cleaners experienced high mortality due to respiratory cancer and respiratory diseases, which is potentially associated with exposure to chemicals in cleaning products. Future research should target specific respiratory hazards in the cleaning industry. Policy makers should take action to improve existing prevention strategies. Training expenses regarding healthy cleaning practices should be fully reimbursed. Easy access to the Federal Training Fund should be facilitated for small cleaning companies. Due to the multitude of small and very small companies, cleaners are difficult to reach. Social partners should make an effort to inform employers and cleaners about safe practices of cleaning agents.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding The Research Council of Vrije Universiteit Brussel (VUB) supported the study. Laura Van den Borre is a PhD fellow at the Research Foundation-Flanders (FWO).

References

Axelson O, Steenland K (1988) Indirect methods of assessing the effects of tobacco use in occupational studies. Am J Ind Med 13:105–118. doi:10.1002/ajim.4700130107

CDC (2014) The health consequences of smoking—50 years of progress: a report of the surgeon general. Centers for Disease Control and Prevention (US), Atlanta (GA). Available at: https://www.surgeongeneral.gov/library/reports/50-years-of-progress/full-report.pdf. Accessed 14 Mar 2017

Charles LE, Loomis D, Demissie Z (2009) Occupational hazards experienced by cleaning workers and janitors: a review of the epidemiologic literature. Work 34:105–116. doi:10.3233/WOR-2009-0907

Cucino C, Sonnenberg A (2002) Occupational mortality from squamous cell carcinoma of the esophagus in the United States during 1991–1996. Dig Dis Sci 47:568–572. doi:10.1023/A:1017968103311

Curkendall SM, DeLuise C, Jones JK et al (2006) Cardiovascular disease in patients with chronic obstructive pulmonary disease, Saskatchewan Canada: cardiovascular disease in COPD patients. Ann Epidemiol 16:63–70. doi:10.1016/j.annepidem.2005.04.008

De Matteis S, Cullinan P (2015) Occupational asthma in cleaners: a challenging black box. Occup Environ Med. doi:10.1136/oemed-2015-102985

Eurofound (2014) Industrial cleaning: working conditions and job quality. European Foundation for the Improvement of Living and Working Conditions, Dublin. Available at: http://www.eurofound.europa.eu. Accessed 11 Jan 2017

European Agency for Safety and Health at Work (2009) The occupational safety and health of cleaning workers. Office for Official Publications of the European Communities, Luxembourg. Available at: https://osha.europa.eu/en/tools-and-publications/publications/literature_reviews/cleaning_workers_and_OSH. Accessed 11 Jan 2017

Eurostat (2015) Services to buildings and landscape activities statistics- NACE Rev. 2. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Services_to_buildings_and_landscape_activities_statistics_-_NACE_Rev._2. Accessed 29 Mar 2017

Federal Public Service Employment; Labour and Social Dialogue (2016) Joint Committee for the cleaning enterprises (Jc 121). Available at: http://www.employment.belgium.be/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=7992. Accessed 19 Jan 2017

Fryer PJ, Asteriadou K (2009) A prototype cleaning map: a classification of industrial cleaning processes. Trends Food Sci Technol 20:255–262. doi:10.1016/j.tifs.2009.03.005

Gamperiene M, Nygård JF, Sandanger I et al (2006) The impact of psychosocial and organizational working conditions on the mental health of female cleaning personnel in Norway. J Occup Med Toxicol 1:1–10. doi:10.1186/1745-6673-1-24

Garza JL, Cavallari ÃJM, Wakai S et al (2015) Traditional and environmentally preferable cleaning product exposure and health symptoms in custodians. Am J Ind Med 58:988–995. doi:10.1002/ajim.22484

Gerster FM, Vernez D, Wild PP, Hopf NB (2014) Hazardous substances in frequently used professional cleaning products. Int J Occup Environ Health 20:46–60. doi:10.1179/2049396713Y.0000000052

Harris E, Palmer KT, Cox V et al (2016) Trends in mortality from occupational hazards among men in England and Wales during 1979–2010. Occup Environ Med 73:385–393. doi:10.1136/oemed-2015-103336

Honjo K, Iso H, Ikeda A et al (2015) Employment situation and risk of death among middle-aged Japanese women. J Epidemiol Community Health 69:1012–1017. doi:10.1136/jech-2015-205499

Huiart L, Ernst P, Suissa S (2005) Cardiovascular morbidity and mortality in COPD. Chest 128:2640–2646. doi:10.1378/chest.128.4.2640

Huisman M, Kunst AE, Mackenbach JP (2005) Inequalities in the prevalence of smoking in the European Union: comparing education and income. Prev Med 40:756–764. doi:10.1016/j.ypmed.2004.09.022

Jaakkola JJK, Jaakkola MS (2006) Professional cleaning and asthma. Curr Opin Allergy Clin Immunol 6:85–90. doi:10.1097/01.all.0000216849.64828.55

Karjalainen A, Martikainen R, Karjalainen J et al (2002) Excess incidence of asthma among Finnish cleaners employed in different industries. Eur Respir J 19:90–95. doi:10.1183/09031936.02.00201002

Koivula I, Sten M, Mäkelä PH (1994) Risk factors for pneumonia in the elderly. Am J Med 96:313–320. doi:10.1016/0002-9343(94)90060-4

Korn EL, Graubard BI, Midthune D (1997) Time-to-event analysis of longitudinal follow-up of a survey: choice of the time-scale. Am J Epidemiol 145:72–80. doi:10.1111/mono.12024

Kumar R, Kumar S (2008) Musculoskeletal risk factors in cleaning occupation-A literature review. Int J Ind Ergon 38:158–170. doi:10.1016/j.ergon.2006.04.004

Mattei F, Guida F, Matrat M et al (2014) Exposure to chlorinated solvents and lung cancer: results of the ICARE study. Occup Environ Med 71:681–689. doi:10.1136/oemed-2014-102182

Montano D (2014) Chemical and biological work-related risks across occupations in Europe: a review. J Occup Med Toxicol Lond Engl 9:28. doi:10.1186/1745-6673-9-28

Mousaid S, Bosmans K, Huegarts K, Vanroelen C (2015) The service voucher system, health and health inequalities. Brussels. Available at: http://www.sophie-project.eu/pdf/SVS.pdf. Accessed 21 Sept 2016

Mousaid S, Huegaerts K, Bosmans K, Julià M, Benach J, Vanroelen C (2017) The quality of work in the Belgian service voucher system'. Int J Health Serv 47:40–60. doi:10.1177/0020731416677478

Nylen L, Voss M, Floderus B (2001) Mortality among women and men relative to unemployment, part time work, overtime work, and extra work: a study based on data from the Swedish twin registry. Occup Environ Med 58:52–57. doi:10.1136/oem.58.1.52

Pampel FC, Krueger PM, Denney JT (2010) Socioeconomic disparities in health behaviors. Annu Rev Sociol 36:349–370. doi:10.1146/annurev.soc.012809.102529

Preller L, Heederik D, Boleij JS et al (1995) Lung function and chronic respiratory symptoms of pig farmers: focus on exposure to endotoxins and ammonia and use of disinfectants. Occup Environ Med 52:654–660. doi:10.1136/oem.52.10.654

Richiardi L, Barone-Adesi F, Merletti F, Pearce N (2008) Using directed acyclic graphs to consider adjustment for socioeconomic status in occupational cancer studies. J Epidemiol Community Health 62:e14. doi:10.1136/jech.2007.065581

Salvi SS, Barnes PJ (2009) Chronic obstructive pulmonary disease in non-smokers. Lancet 374:733–743. doi:10.1016/S0140-6736(09)62116-4

Sjögren B, Fredlund P, Lundberg I, Weiner J (2003) Ischemic heart disease in female cleaners. Int J Occup Environ Health 9:134–137. doi:10.1179/oeh.2003.9.2.134

Soto-Campos JG, Plaza V, Soriano JB et al (2013) Causes of death in asthma, COPD and non-respiratory hospitalized patients: a multicentric study. BMC Pulm Med 13:73. doi:10.1186/1471-2466-13-73

Steenland K, Beaumont J, Halperin W (1984) Methods of control for smoking in occupational cohort mortality studies. Scand J Work Environ Health 10:143–149. doi:10.5271/sjweh.2349

Strand BH, Tverdal A (2004) Can cardiovascular risk factors and lifestyle explain the educational inequalities in mortality from ischaemic heart disease and from other heart diseases? 26 Year follow up of 50 000 Norwegian men and women. J Epidemiol Community Health 58:705–709. doi:10.1136/jech.2003.014563

Thun MJ, Carter BD, Feskanich D et al (2013) 50-Year trends in smoking-related mortality in the United States. N Engl J Med 368:351–364. doi:10.1056/NEJMsa1211127

van de Mheen PJ, Gunning-Schepers LJ (1996) Differences between studies in reported relative risks associated with smoking: an overview. Public Health Rep 111:420–427

Vandenplas O, D'Alpaos V, Evrard G et al (2013) Asthma related to cleaning agents: a clinical insight. BMJ Open 3:e003568. doi:10.1136/bmjopen-2013-003568

Vizcaya D, Christensen KY, Lavoué J, Siemiatycki J (2013) Risk of lung cancer associated with six types of chlorinated solvents: results from two case-control studies in Montreal, Canada. Occup Environ Med 70:81–85. doi:10.1136/oemed-2012-101155

Vizcaya D, Mirabelli MC, Gimeno D et al (2015) Cleaning products and short-term respiratory effects among female cleaners with asthma. Occup Environ Med. doi:10.1136/oemed-2013-102046

WIV-ISP (2015) Health Interview Survey 1997, 2001, 2004, 2008. Available at: https://hisia.wiv-isp.be/SitePages/Home.aspx. Accessed 21 Mar 2017

Zock JP (2005) World at work: cleaners. Occup Environ Med 62:581–584. doi:10.1136/oem.2004.015032