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RESPIRATORY SYMPTOMS AMONG DANISH WASTE COLLECTORS*

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Abstract: Waste collectors are exposed to vehicle exhaust, bad weather conditions and microorganisms which may increase the risk of respiratory problems. This nationwide survey among Danish waste collectors evaluates self-reported respiratory symptoms with focus on chronic bronchitis. Altogether 1,515 (76%) male Danish waste collectors and a comparison group of 423 park workers completed a questionnaire on work conditions and health problems. An exposure matrix, based on measurements of airborne microorganisms among samples of waste collectors with different working conditions, was constructed for this study and applied to the questionnaire data. By use of this matrix each waste collector was categorized according to exposure levels of three parameters of microorganism exposures (viable fungi, fungal spores, total microorganisms). Adjusted prevalence proportion ratios (PPR) for selected pulmonary symptoms were estimated with generalized linear models. Significantly increased PPRs appeared for cough (PPR = 1.3), itching nose (1.9), wheeze (1.4), and chronic bronchitis (2.3). No significant differences in prevalence appeared between different working conditions among the waste collectors. The PPR of bronchitis increased significantly with increasing estimated concentrations of all selected microbial parameters. In conclusion, this cross-sectional study showed that waste collectors compared to park workers have moderately increased prevalences of several respiratory problems. The causes are probably exposure to vehicle exhaust and aerosols containing microorganisms.

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INTRODUCTION

Waste collectors are exposed to organic dust containing microorganisms, vehicle exhaust and bad weather conditions, which may all contribute to respiratory problems such as cough, phlegm, chest tightness, itching nose, wheeze, asthma and chronic bronchitis [7, 11, 16, 19].

Based on routinely collected notifications to the Danish working environment service on possible occupational diseases, it has recently been indicated that Danish waste collectors have an increased incidence of several respiratory diseases compared with the general work force [21]. However, no adjustment for important confounders such as previous occupational exposures, residential area, tobacco smoking habits or age, was possible in the crude analysis, and the causal factors remain unknown.

In order to evaluate whether waste collectors have increased prevalences of respiratory disorders, and if such problems may be related to the level of bioaerosol exposure, we have combined questionnaire data from a

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nationwide cross-sectional study with an exposure matrix. The study was initiated as a part of the Danish research program on occupational safety and health in waste collection and recycling [14].

MATERIALS AND METHODS

Study population. In 1994 we intended to obtain information on all Danish waste collectors from private and public companies. Altogether 2,412 waste collectors from 262 companies were identified from company and trade union records including the names and private addresses of the workers [10]. In total, 109 workers who were either dead, retired or unemployed and 11 women were excluded. The response rate among the participating 1736 male waste collectors was 76%. However, further 221 persons were later excluded due to wrong job title, change of jobs etc., thus resulting in a total of 1,515 male waste collectors with completed questionnaires.

A comparison group of 1,460 municipal workers with outdoor work (i.e. mainly park and road workers) was selected from 12 different municipalities spread over the entire country. After exclusion of retired persons etc. (n = 30) and females (n = 32) we received a response rate of 82%. For this particular study on respiratory disorders, we included only the subgroup of workers who identified themselves as male park workers (n = 423), since they were expected to have the lowest exposure to vehicle exhaust and microorganisms [16].

Questionnaire. Information on exposures and self-reported health symptoms was collected by a self-administrated questionnaire which was mailed to the private address of the waste collectors and the persons in the comparison group. Personal data such as age, gender, respiratory diseases among first degree relatives, and tobacco smoking habits were obtained. Questions on general occupational exposures included duration of current employment, working hours per week, and former occupational exposures (inorganic dust, organic dust, irritant gases and fumes). Waste collector specific exposures included most frequent type of truck used (low loaded compactor, platform, high loaded compactor), approximate proportions of working time used with collection of different types of waste (mixed household waste, paper and glass, garden), type of collection unit (wheeled bins and containers, bins without wheels, sacks), and job function (runner, loader and driver) [10].

Questions about respiratory symptoms (cough, phlegm, chest tightness, having a cold, wheeze and breathlessness) were based on the British Medical Research Council respiratory questionnaire [20]. The questions on respiratory health symptoms were dichotomized depending on whether the symptoms occurred weekly or more often versus more rare. Asthma and chronic bronchitis were assessed based on self-reported symptoms in accordance with the clinical definitions [20].

Job Exposure Matrix. An exposure matrix, based on distinctive combinations of governing bioaerosol exposure parameters among waste collectors (type of waste, collection unit at the households, collection vehicle, and the main job function of the waste collector) was applied to the questionnaire data. Level of exposure in each matrix cell was estimated based on personal sampling in the field. For cells with no measured data the exposure level was extrapolated from cells with measured data using exposure modifiers and a multiplicative model. Further details on the construction of the matrix are given elsewhere [3]. Concentrations of culturable fungi (colony forming units per m^3 (cfu/m^3)), total counts of fungal spores ($cells/m^3$), and total counts of microorganisms ($cells/m^3$) were used as exposure parameters. An individual exposure concentration of each parameter was calculated for all waste collectors. A crude daily dose of each microbiological parameter was estimated for each worker by multiplying the median exposure concentration for the working process, the job type associated ventilation rate [3], and the self-reported number of daily working hours as waste collector. We regarded the comparison group as having no or little microbial exposure.

Statistical analysis. The most common type of waste collected and the main type of collection unit were considered as the activity where a person spent more than 50% of weekly working hours. Waste collectors using equal or less than 50% of working hours within one single activity were considered as mixed exposed. For those working in crews of at least three persons and with rare job rotation (e.i. monthly or rare), the main job was considered as the job carried out for more than 50% of working hours. The remaining group of waste collectors was considered as a mixed group [3].

Based on the calculated individual exposure concentration and doses, the workers were divided into three exposure levels:

i) comparison group,
ii) low, and
iii) high according to the three microbial parameters.

The cutpoints were based on the range of exposure or dose level for each microbial parameter in order to ensure a relatively high exposure contrast and an appropriate number of exposed workers in the high exposure groups [18].

Prevalence proportion ratios (PPR), and asymptotic 95% confidence intervals (95% CI), and p-values of symptoms were estimated by using generalized linear models with binomial error and log link function (adjusted for age, amount of smoked tobacco, residential area, previous occupational exposure to irritant gases and fumes, inorganic and organic dusts and familial atopy) [15, 22]. Tests for trends in risk with increasing exposure and dose levels were assessed by using ordinal scores for exposure or dose into the generalized linear models [2].

Table 1. Characteristics of waste collectors and comparison group members.

Item	Waste collectors (N=1,515)		Comparison group (N=423)	
	Mean or percentage[a]	Standard deviation	Mean or percentage[a]	Standard deviation
Age*** (years)	39.4	9.7	43.5	10.8
Seniority in current job*** (years)	9.4	7.4	12.8	7.9
Skilled vs. unskilled*** (%)	42	49	56	50
BMI[b] (kg/m^2)	26.1	3.7	25.9	3.8
Tobacco smoking				
• current smoker (%)	53	50	51	50
• former smoker* (%)	18	38	25	43
• gram tobacco/day[c]	10.3	11.4	9.1	10.1

*($p < 0.05$; Mann-Whitney test); ***($p < 0.001$; Mann-Whitney test); [a]Means of continuous variables, percentages of dichotomous variables; [b]Body mass index; [c]Calculated based on self-reported daily smoke of cigarettes, cigarillos, cigars and pipe tobacco.

RESULTS

Characteristics of waste collectors and comparison group members are given in Table 1. The waste collectors (mean age 39.4) were significantly younger than the comparison group members (43.5). Further, the waste collectors had a significantly shorter period of employment in their current job (9.4 years) compared to the comparison group (12.8 years). A significantly lower proportion of skilled workers was found among waste collectors (42%) than among park workers (56%). A significantly lower proportion of former smokers was found among waste collectors (18%) than among park workers (25%), whereas no significant differences appeared in proportions of current smokers (53% versus 51%) or in the mean amount of daily smoked tobacco (10.3 gram versus 9.1 gram).

Table 2 shows the prevalence percentage and the prevalence proportion ratios for the selected respiratory symptoms among Danish waste collectors. Except for asthma, increased PPRs are found for all the symptoms, although they appeared significantly elevated only for

Table 2. Prevalence proportion ratios[a] (PPR) of respiratory symptoms among waste collectors compared with park workers.

Disorder[b]	Prevalence (%)	PPR	95% CI	p-value
Cough	27.8	1.3	1.0-1.7	0.04
Phlegm	14.6	1.2	0.9-1.3	0.29
Chest tightness	3.9	2.1	0.9-4.9	0.06
Itching nose	11.5	1.9	1.0-3.5	0.04
Wheeze	23.2	1.4	1.0-1.8	0.03
Wheeze and breathlessness	12.7	1.4	0.9-2.1	0.09
Asthma	8.7	0.9	0.6-1.5	> 0.5
Chronic bronchitis	7.8	2.3	1.3-4.3	0.003

[a]Adjusted for age, tobacco smoking habits, exposure to irritant gases and fumes, exposure to inorganic dust, exposure to organic dust, and residential area; [b]Weekly or more often.

Table 3. Prevalence proportion ratios[a] (PPR) of chronic bronchitis among waste collectors compared to park workers (comparison) by waste, truck, collection unit and job characteristics.

Characteristic[b]	N	PPR	95% CI	p-value
Type of waste				
Garden	10	3.1	0.4-22.1	0.30
Paper and glass	102	2.6	1.1-6.2	0.03
Different types of waste[c]	240	2.5	1.2-5.2	0.01
Mixed household[d]	1173	1.9	1-0-3.6	0.04
Comparison	423	1		
Truck				
High loaded compactor	312	2.7	1.4-5.4	0.004
Platform vehicle	239	1.9	0.9-4.0	0.10
Low loaded compactor	804	1.6	0.9-3.1	0.13
Comparison	423	1		
Collection unit				
Bins without wheels	61	2.7	1.0-7.2	0.049
Different types of collection units	270	2.5	1.2-5.0	0.01
Sacks	828	2.0	1.1-3.9	0.03
Wheeled bins and containers	366	1.7	0.9-3.6	0.12
Comparison	423	1		
Job task[e]				
Runner	46	4.6	1.5-13.9	0.007
Loader	44	3.8	1.2-11.9	0.02
Mixed jobs	1251	2.0	1.1-3.8	0.02
Driver	33	-[f]	-	-
Comparison	423	1		

[a]Adjusted for age, tobacco smoking habits, exposure to irritant gases and fumes, exposure to inorganic dust, exposure to organic dust, and residential area; [b]Activity for more than 50% of the working day; [c]No single type exceeds 50% of working time; [d]Mixed household waste including biodegradable and residual fraction; [e]The main job function during the last month (>50% of working time); [f]None of the drivers have reported symptoms of chronic bronchitis.

Table 4. Prevalence proportion ratios[a] (PPR) of chronic bronchitis by different estimated levels of selected microorganism parameters.

Microorganism parameter	Category	Aerosol concentration					Aerosol dose per working day[b]				
		Level	N	PPR	95% CI	p_{trend}	Level	N	PPR	95% CI	p_{trend}
Culturable fungi	Comparison		418	1		0.02		416	1		0.03
	Low	< 150 × 10^3 cfu/m^3	915	1.9	1.0-3.6		< 20 × 10^3 cfu	916	1.9	1.0-3.7	
	High	≥ 150 × 10^3 cfu/m^3	36	2.7	3.6-11		≥ 20 × 10^3 cfu	10	7.0	1.0-50	
Fungal spores	Comparison		418	1		0.03		416	1		0.07
	Low	< 300 × 10^3 cells/m^3	917	1.9	1.0-3.6		< 50 × 10^3 cells	900	2.0	1.0-3.8	
	High	≥ 300 × 10^3 cells/m^3	34	2.5	0.5-11		≥ 50 × 10^3 cells	26	1.4	0.2-10.0	
Total microorganisms	Comparison		418	1		0.02		416	1		0.03
	Low	< 300 × 10^3 cells/m^3	615	1.7	0.9-3.4		< 50 × 10^3 cells	427	1.9	1.0-3.6	
	High	≥ 300 × 10^3 cells/m^3	336	2.2	1.1-4.5		≥ 50 × 10^3 cells	202	2.4	1.1-5.5	

[a]Adjusted for age, tobacco smoking habits, exposure to irritant gases and fumes, exposure to inorganic dust, exposure to organic dust, and residential area; [b]The crude daily dose was calculated using information on concentration, ventilation rate, and self reported daily working hours.

cough (PPR = 1.3; p = 0.04), itching nose (1.9; 0.04), wheeze (1.4; 0.03) and chronic bronchitis (2.3; 0.003). Since the prevalence proportion ratio is most impressive for chronic bronchitis, and since this disorder previously has been found increased in a similar epidemiological study from Geneva, Switzerland [6], we focused only on this disorder in the further analyses of governing parameters.

The effects of type of waste, truck, collection unit and job task on prevalence of chronic bronchitis are shown in Table 3 together with the number of involved persons. Regarding the type of waste, most collectors spent most of their working time on collecting mixed household waste. The highest (non-significant) PPR appeared among relatively few workers mostly collecting garden waste (PPR = 3.1; n = 10). Although workers who were mostly collecting paper and glass (PPR = 2.6; n = 210), different types of waste (PPR = 2.5; n = 240) and mixed household waste (PPR = 1.9; n = 273) all had significantly elevated PPRs compared to the comparison group, no significant differences appeared between them. For the truck type only prevalence of using high loaded compactor trucks was significantly elevated (2.7; n = 312). The highest PPR for the collection unit was found among waste collectors using mostly bins without wheels (PPR = 2.7; n = 61). For workers mostly handling different types of containers, sacks or wheeled bins and containers the PPRs were 2.5, 2.0, and 1.7 (non-significant), respectively. Only few Danish waste collectors have a relatively permanent job task as either runner (n = 46), loader (n = 44) or driver (n = 33); most collectors (91%) have varying job tasks (n = 1251). The PPRs for the runner (4.6), loader (3.8) and mixed jobs (2.0) were significantly elevated compared to the park workers.

Table 4 shows the PPR for chronic bronchitis according to estimated aerosol concentrations or doses of culturable fungi, fungal spores and total microorganisms, respectively. For all selected microbial parameters significantly positive trends of increasing PPR with increasing exposure levels were found. The same situation occurred for doses except for fungal spores where a non-significant trend appeared. In general, the p-values for trend were somewhat lower for the concentration estimates compared to the dose estimates.

DISCUSSION

In the present cross-sectional study of waste collectors compared to park workers, we found moderate, but significantly higher prevalences of cough, itching nose, wheeze, and chronic bronchitis, together with non-significantly increased prevalences of phlegm, chest tightness, and wheeze and breathlessness.

Questionnaires were completed for around 76% of the waste collectors and 82% of the comparison group, which is comparable with results from similar studies [1]. As an attempt to detect differences between participating and non-participating persons, waste collectors and comparison group members who first refused to participate were contacted by telephone and requested to give only their age and answer one question about low back pain. No major differences appeared among the groups, indicating a good representativeness of the completed questionnaires.

A major problem in an occupational cross-sectional study is selection bias, especially the healthy worker effect [4, 13]. Since waste collection implies a demand on high physical activity, persons with respiratory problems will tend to leave this job earlier than the park workers, where the physical activity usually is lower. Since asthma is the most severe respiratory disorders under study, it is expected that the healthy worker effect is most pronounced for this disease. Actually, asthma was the only respiratory disorder in the present study which did not appear to be increased among the waste collectors, although all the acute symptoms were increased. To obtain more information on whether a possible healthy worker effect may have influenced the results, we

investigated 149 men who had filled in the questionnaire, but were excluded from the present study because they were no longer employed as waste collectors at the time they received the questionnaire. We found a significant PPR for asthma of 2.4 (95% confidence interval: 1.0-6.0), and a PPR for chronic bronchitis of 3.1 (1.4-7.1) in this group, which indicates the presence of a healthy worker effect. Thus, this phenomenon will tend to underestimate the true risk of respiratory problems among waste collectors.

Smoking measured as grams of smoked tobacco per day, was found to be strongly associated with all the investigated respiratory symptoms (not shown). Differences in tobacco smoking habits are a major confounder for investigating occupational causes of respiratory problems. However, no major differences in smoking habits appeared among the waste collectors and park workers. Park workers tended to have had longer periods of previous occupational exposure to irritant gases, fumes, and inorganic and organic dusts than waste collectors even when taking account of the somewhat higher age among park workers compared to waste collectors. However, results have been adjusted for such confounders during the statistical modelling.

The use of self-reported exposures and health problems may result in recall bias and give differential misclassification. Moreover, confounding from e.g. hazardous exposures in previous jobs or passive tobacco smoke, are speculative sources of errors for which we are unable to estimate the possible effects [5].

Microorganisms (e.g. Gram-negative bacteria and fungi), vehicle exhaust and bad weather conditions may have contributed to the observed increase in respiratory problems. Since both waste collectors and park workers are exposed to approximately the same weather conditions, this factor may be of minor importance as explanation for the difference in prevalence between the two groups under study. Workers like waste collectors who are often working in the streets are more heavily exposed to traffic exhaust fumes than park workers [16]. Residence in the urban area is, compared to residence in the rural area, significantly associated with most of the respiratory disorders in this study, even when adjusting for tobacco smoking and occupational factors. It is therefore reasonable to believe that at least some of the increased prevalence for the respiratory disorders is caused by exposure to exhaust fumes.

In general most Danish waste collectors collected different types of waste, used different collection units, and changed job function during the work day (Tab. 3). Therefore, it is difficult to detect differences in occupational diseases and symptoms between the various exposure conditions, since most waste collectors are exposed to a mixture of these.

It has recently been measured that the concentrations of bioaerosols are significantly lower for waste collectors working with high loaded trucks compared to low loaded trucks [3]. However, the prevalence of chronic bronchitis has an opposite direction in this study, although the difference in PPR between the two types of trucks was not significant. This observation may be explained partly by chance, and partly due to little contrast in exposure. Another explanation could be confounding from inhalation of vehicle exhaust. However, differences in concentrations of such fumes have not been measured.

Since individual measurements were not available for all waste collectors, an *ad hoc* based four dimensional job exposure matrix has been used to estimate individual exposure levels. Since the matrix is based on relatively few measurements and since a large variation may exist for biological measurements within different job titles, some misclassification is inevitable and may tend to disguise a true increasing prevalence by increasing exposure [4, 8]. However, despite such limitations, the usefulness of the *ad hoc* constructed matrix was demonstrated by the indicated exposure-effect relationship, which was also found in a study of diarrhoea in the same group of workers [9].

The exposure level of waste collectors is normally lower than that found among workers engaged in e.g. agriculture, textile mills, or sewage treatment plants, who are among the occupational groups most frequently reported with respiratory problems [14, 17, 19]. This seems to be reflected in the present results of chronic bronchitis related to exposure to microorganisms, where in general no *major* differences in prevalences appeared between the low and high exposed groups.

In our attempt to calculate doses of aerosols from exposure concentration and ventilation rate, the PPRs and the p-values for trend declined, indicating a higher probability of chance contributing to the observed increase in disorder with increasing exposure level. This may reflect that the crudely calculated dose is not necessarily a valid measure for the actual amount of aerosol particles deposited in airways and lungs [4].

In two relatively small epidemiologic studies from Switzerland [6], and Croatia [12], some acute pulmonary disorders and chronic bronchitis were found in excess among waste collectors compared to other workers.

Since we found no obvious signs of positive bias in the study, and since the well-known associations between tobacco smoking and occupational exposures to other types of dust and irritant gases and respiratory symptoms were confirmed, there is no major reason to doubt the validity of the findings. Furthermore, since the observed increased prevalences of respiratory problems are biologically plausible and indicated in other epidemiological studies, it seems reasonable to believe that occupational exposures among waste collectors, i.e. exposure to vehicle exhaust and particularly inhalation of high concentrations of bioaerosol, play an important role in the development of respiratory problems.

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