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Prevalence of Work-Related Rhino-Conjunctivitis and Respiratory Symptoms Among Domestic Waste Collectors

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Abstract

Waste collectors may suffer from acute and chronic health effects caused by organic dust (bioaerosols). Pathophysiological symptoms may originate either from allergic or irritative pathomechanisms, but an explicit distinction of the etiology is often complicated although crucial for proper risk assessment and workplace prevention. In this cross-sectional study, a total of 69 male waste collectors from the Ruhr area in Germany underwent a customized testing protocol including a modified questionnaire, basic clinical examination, spirometry, and immunologic parameters. Subjects were classified according to their work tasks into loaders (n = 27), floaters (n = 29), and drivers (n = 13). We found that a high percentage of the workers had complaints (eyes 29.0 %, nose 39.1 %, and cough 34.8 %) which were strongly work-related. Multiple logistic regression analyses indicated that duration of employment in waste collection (per 10 years) was associated with an increased prevalence of cough (OR = 1.64, 95 %CI 0.81; 3.35) and chronic bronchitis (OR = 2.18, 95 %CI 0.80; 5.92). An association between rhinitis and cough (OR = 2.62, 95 %CI 0.94; 7.27) was found, which supports the association between the prevalence of upper and lower airway disease. Furthermore, when adjusting for smoking status, atopic subjects suffered more frequently from irritation of the lower airways as indicated by cough (OR = 2.71, 95 %CI 0.91; 8.08). In conclusion, the study demonstrates

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associations between the prevalence of upper and lower airway disease in waste collectors. Notably, an underlying allergic disease in waste collectors could be suspected more commonly than previously reported.

Keywords
Atopy • Bioaerosols • Occupational exposure • Risk assessment • Waste management

1 Introduction

In municipal solid waste collection, workers are inevitably confronted with fluctuating bioaerosol emissions from domestic waste. Associations between occupational bioaerosol exposure and adverse health effects have been demonstrated in several studies (van Kampen et al. 2012; Bünger et al. 2000; Ivens et al. 1999). Subjects exposed to biologic agents often state nonspecific complaints concerning upper and lower airways, skin conditions and digestive disorders (Ivens et al. 1999). While many investigations focus on compost workers or specific exposure assessment, research discussing adverse health effects in municipal solid waste collection is limited (Kuijer et al. 2010; Wouters et al. 2002; Yang et al. 2001).

Apart from temporary peaks during the loading process, emission levels detected outdoors in waste collection are, on average, lower than levels measured indoors, e.g., at composting plants (Wouters et al. 2006). Instead, external factors may have a bigger impact on the outcome. Different types of waste picked up by municipal solid waste collectors are residual and biological waste as well as recyclables. Up to now, investigations could not confirm a significant difference in bioaerosol emissions according to the type of waste (Neumann et al. 2002). Domestic waste is usually contaminated with fluctuating levels of microorganisms, predominantly bacteria and moulds. Conditions for cell growth in waste containers vary depending on duration of collection cycles and weather conditions. With rising cell counts, levels of harmful metabolites (e.g., endotoxins and beta-glucans) also rise in proportion to duration of storage (Wouters et al. 2006). Depending on the responsible municipal waste management company, collection cycles in the investigated area may vary from 7 to 28 days. In this context, there is no evidence for longer storage durations to bear significantly higher emission rates (Neumann et al. 2001).

When waste containers are moved or jolted, cellular particles are released into the air. Especially during the loading process of waste material, suspended solids may soar through the air in a short range around the loading area, affecting loaders standing close by (Poulsen et al. 1995). All these airborne particles may enter the human body in different ways including ingestion and skin contact, but most relevant are health effects triggered by inhalation (Kuijer et al. 2010; Wouters et al. 2002).

Sensitizing, irritative, or inflammatory pathomechanisms may cause adverse health effects depending on transmission path, atopic state, and lifestyle habits (i.e., smoking) of the affected individual. Rhino-conjunctivitis is a commonly observed effect of exposure to aerosolised biological agents. The defining complaints are burning and/or itching of the eyes, wheezing, runny nose, or nasal obstruction. Rhino-conjunctivitis is either a non-allergic reaction in terms of infection or mucous membrane irritation (MMI), but may also be modulated by atopy or result from an allergic response. Moulds may possibly cause a type I allergic disease, but environmental allergens are more likely (Bünger et al. 2007). In general, non-allergic reactions are assumed to overtake instead of beat allergy as a cause of rhino-conjunctivitis in bioaerosol-exposed workers (Eduard et al. 2001).

The purpose of this study was to examine irritative and allergic reactions in waste collectors with different work tasks, exemplified by rhino-conjunctivitis and cough. We investigated the following topics in detail: (1) prevalence of irritation of the eyes, nose and lower airways; (2) contribution of allergy as the underlying pathomechanism of rhino-conjunctivitis in waste collectors; and (3) relation of upper and lower airway impairment.

2 Methods

In May 2012, the Ethics Committee of the Ruhr-University Medical School approved the implementation of all necessary examinations. All participants gave written informed consent and the study was performed in accordance to the Declaration of Helsinki.

2.1 General Study Design and Collection of Data

In this cross-sectional study, 69 current waste collectors (mean weekly working time: 39 h) were divided according to their work task into drivers and loaders. Drivers (n = 13) were workers exclusively occupied as drivers. Subjects exclusively involved in the loading process were referred to as loaders (n = 27). Subjects fulfilling both work tasks during employment were addressed as floaters (n = 29). All subjects were male. During 1 year of data collection from May 2012 to May 2013 (most interviews from May to September 2012), subjects from six municipal solid waste management companies of the Ruhr area in North Rhine-Westphalia, Germany, visited the Institute for Prevention and Occupational Medicine of the German Social Accident Insurance (IPA) for data assessment. To ensure realistic measurements, all workers were invited for testing on an afternoon during a working week after their shift.

The study protocol included a questionnaire, basic clinical examination, which was always performed by the same occupational health physician, spirometry and blood tests for immunologic parameters. The questionnaire was adapted from a previous study, which was performed in cooperation with the same companies under comparable conditions (Neumann et al. 2001). It contained items assessing personal data, working conditions, smoking habits, regular drug use, and perceived symptoms. Complementing items on the respiratory status of the study population (Pekkanen et al. 2005) were added for pulmonary disease assessment.

A full-body plethysmograph (Master Screen Body; Jaeger, Germany) was used for lung-function testing. Examination results were analyzed with the equations of the Global Lung Initiative (GLI 2012). Blood tests included specific immunoglobulin E (IgE) screening against multiple environmental allergens. The screening tool sx1 (Phadiatop; ThermoFisher Scientific, Uppsala, Sweden) contained house dust mite, cat dander/hair, dog dander, *Cladosporium herbarum*, pollen of timothy, rye grass, birch, and mugwort. Allergen-specific IgE values $\geq$0.35 kUA/L were considered positive and used to assess the subjects' atopy status.

2.2 Investigation of Health Effects

Work-related symptoms of eye and airway irritation in terms of conjunctivitis, rhinitis, cough, and chronic bronchitis (CB) were assessed for confirmation of irritative effects due to bioaerosol exposure. Common complaints, indicating an irritation of the eyes, were watering, itching and foreign body sensation (nose: congestion, runny nose, and dysfunction of olfactory sense). These symptoms were assumed according to the answers to the respective questionnaire items. CB was diagnosed in subjects stating cough with phlegm on most days during at least 3 months in two consecutive years (GOLD 2013). For eye and nose complaints, an allergic etiology was suspected in subjects with positive atopic status. A work-relation of symptoms was likely when at least two of the three following criteria were met: (1) absence of

symptoms before employment, (2) cumulative occurrence when working, and (3) remission during vacation.

2.3 Data Analysis

Median and inter-quartile range (IQR) were used to describe the characteristics of the study population. The groups were compared using the non-parametric Kruskal-Wallis test for continuous variables and Fisher's exact test for categorical variables. Unconditional logistic regression models were used to analyse the associations between occupational exposure and health effects.

To estimate the actual degree of occupational exposure of the study population, we considered two main factors. We took the work task (i.e., classification into drivers, floaters, and loaders) as a crude measurement of the magnitude of exposure. We then studied the impact on the outcome of the duration of employment as a continuous variable. Besides, the smoking status was considered as a confounding factor in the analyses.

3 Results

Drivers demonstrated the lowest percentage of current smokers compared to floaters and loaders (23.1 %, 51.7 %, and 55.6 %, respectively; $p = 0.134$). General anthropometric, occupational and immunologic data of the study population stratified by smoking status are shown in Table 1. No significant differences were observed concerning the anthropometric measures of employment. The duration of employment was similar in all groups with a median of 22 years. The number of workers with positive atopic status was comparable in never, former, and current smokers.

The spirometric results for forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC) and the Tiffeneau-index (FEV_1/FVC) adjusted with the GLI equations are depicted in Table 2. Adjusted FEV_1 and FEV_1/FVC, were both highest for never smokers ($p = 0.025$; $p = 0.001$, respectively). An airflow limitation defined by GLI's age dependent lower limits of normal (LLN_{GLI}) could be found in seven current smokers (data not shown).

A high percentage of all workers reported health complaints (eyes 29 %, nose 39 %, and cough 35 %). A description of the stated complaints is shown in Table 3. Almost two thirds of all symptoms were work-related. Besides, one half of workers with eye complaints had an atopic status (nose: 41 %). In general, symptoms in atopic subjects were stronger associated with working conditions (eye: 70 %, nose: 82 %) compared with symptoms associated with MMI (eyes: 60 %, nose: 50 %). Furthermore, symptoms in atopic loaders and floaters were stronger associated with working conditions (eyes 78 %, nose 89 %) than in atopic drivers (eyes 0 %, nose 50 %). In contrast to this, the work-relation of rhino-conjunctivitis symptoms in non-atopic subjects showed an inverse gradient between drivers and loading workers (drivers: eyes 100 %, nose 75 %; loaders and floaters: eyes 50 %, nose 42 %). All subjects reporting cough and coexisting phlegm also suffered from these symptoms in terms of CB.

Univariate logistic regression was used to estimate the association of occupational exposure and conjunctivitis, rhinitis, cough, and CB (data not shown). Neither work task nor duration of employment showed a significant impact on these symptoms. With age, the risk of cough and CB was increased (OR = 1.51, 95 %CI 0.72; 3.19; OR = 2.69, 95 %CI 0.94; 7.68) and the risk of rhinitis was decreased (OR = 0.46, 95 %CI 0.21; 0.998). A significantly lower prevalence of conjunctivitis was seen in current smokers (OR = 0.25, 95 %CI 0.07; 0.87). Atopic subjects had a higher prevalence of cough (OR = 2.62, 95 %CI 0.91; 7.49), rhinitis (OR = 1.94, 95 %CI 0.69; 5.43), and conjunctivitis; the latter demonstrating statistical significance (OR = 3.08, 95 %CI 1.04; 9.19).

A multiple logistic regression model was applied to adjust for occupational exposure (Table 4). After adjustment, current smoking remained negatively associated with conjunctivitis,

Table 1 Characteristics of 69 waste workers stratified by smoking status

	All (n = 69)		Never smoker (n = 19)		Former smoker (n = 17)		Current smoker (n = 33)	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Age (years)	48	43; 51	48	44; 51	48	44; 56	47	42; 50
Height (cm)	178	173; 184	176	173; 180	178	171; 180	182	174; 187
Weight (kg)	90	82; 102	89	78; 102	85	82; 92	95	86; 104
BMI (kg/m^2)	28.1	25.9; 30.6	27.8	24.8; 31.2	29.4	24.9; 31.3	28.1	26.3; 30.2
Employment (year)	22	15; 25	22	14; 26	23	21; 27	21	15; 23
	n	%	n	%	n	%	n	%
Driver	13	18.8	4	30.8	6	46.1	3	23.1
Floater	29	42.0	7	24.1	7	24.1	15	51.7
Loader	27	39.1	8	29.6	4	14.8	15	55.6
Atopic (sx1 >0.35 kUA/L)	22	31.9	6	31.6	5	29.4	11	33.3

IQR Interquartile range, *BMI* Body mass index, *sx1* Specific environmental allergen screening

Table 2 Lung function of the waste collectors by smoking status, work task, and duration of employment in waste collection, regarding the reference values of the Global Lung Function Initiative (*GLI*)

		FEV_1 (%predicted$_{GLI}$)		FVC (%predicted$_{GLI}$)		FEV_1/FVC (%predicted$_{GLI}$)	
	n	Median	IQR	Median	IQR	Median	IQR
All	69	99.6	93.5; 106.9	101.1	93.8; 110.1	98.9	93.4; 102.7
Smoking status							
Never	19	106.5	97.0; 112.9	101.9	94.7; 108.6	103.0	98.7; 107.1
Former	17	97.3	91.6; 106.9	100.0	98.6; 106.4	97.0	93.7; 101.3
Current	33	97.8	89.4; 102.6	95.7	92.2; 111.1	95.1	89.2; 101.3
Work task							
Driver	13	102.3	91.2; 112.9	105.3	92.7; 111.3	93.0	86.2; 101.6
Floater	29	97.3	95.8; 104.4	101.1	94.6; 110.1	95.6	93.4; 101.5
Loader	27	99.6	91.6; 110.4	99.7	92.5; 109.8	101.4	94.5; 106.5
Employment							
≤20 years	28	102.1	95.1; 108.8	103.8	94.8; 112.1	97.1	92.6; 102.1
>20 years	41	98.1	91.2; 106.1	99.7	92.5; 107.6	99.4	93.9; 103.4

FEV_1 Forced expiratory volume in 1 s, *FVC* forced vital capacity, *FEV1/FVC* Tiffeneau index, *IQR* Interquartile range

Table 3 Stated complaints of the waste collectors stratified by work task

	Driver (n = 13)		Floater (n = 29)		Loader (n = 27)		All (n = 69)	
	n	%	n	%	n	%	n	%
Eyes								
Watering, itching, FBS	3	23.1	7	24.1	10	37.0	20	29.0
Thereof work-related	2	66.7	4	57.1	7	70.0	13	65.0
Nose								
Congestion, runny, DOS	6	46.2	12	41.4	9	33.3	27	39.1
Thereof work-related	4	66.7	8	66.7	5	55.6	17	63.0
Cough								
Complaints	4	30.8	12	41.4	8	29.6	24	34.8
Thereof work-related	1	25.0	8	66.7	5	62.5	14	58.3

FBS foreign body sensation, *DOS* Dysfunction of olfactory sense

Table 4 Multiple logistic regression analyses of the associations between occupational exposure and prevalence of conjunctivitis, rhinitis, cough, and chronic bronchitis

		Conjunctivitis (n = 20)		Rhinitis (n = 27)		Cough (n = 24)		Chronic bronchitis (n = 11)	
		OR	95%CI	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)
Work task	Driver	1		1		1		1	
	Floater	1.05	0.20; 5.60	1.14	0.26; 5.00	1.68	0.36; 7.91	4.19	0.36; 48.66
	Loader	2.38	0.46; 12.29	0.92	0.21; 4.13	0.98	0.20; 4.80	5.25	0.44; 63.19
Employment	(10 year)	0.99	0.47; 2.06	1.12	0.58; 2.17	1.64	0.81; 3.35	2.18	0.80; 5.92
Smoking status	Never	1		1		1		1	
	Former	0.51	0.11; 2.28	3.13	0.76; 12.98	1.34	0.29; 6.12	7.13	0.62; 82.53
	Current	0.20	0.05; 0.80	0.61	0.18; 2.12	1.78	0.49; 6.47	4.22	0.44; 40.69
Atopy	No	1		1		1		1	
	Yes	3.70	1.10; 12.43	2.20	0.73; 6.66	2.71	0.91; 8.08	2.35	0.57; 9.77

OR odds ratio, *CI* confidence interval

Table 5 Univariate logistic regression analyses of the associations between the prevalence of conjunctivitis and upper and lower airway disease

		Cough (n = 24)			Chronic bronchitis (n = 11)		
	n	n	OR	(95%CI)	n	OR	(95%CI)
Conjunctivitis							
No	49	15	1		8	1	
Yes	20	9	1.86	0.64; 5.41	3	0.90	0.21; 3.93
Rhinitis							
No	42	11	1		6	1	
Yes	27	13	2.62	0.94; 7.27	5	1.36	0.37; 5.00

OR odds ratio, *CI* confidence interval

but still had no obvious association with cough or CB. Like in univariate logistic regression, a higher prevalence of conjunctivitis, rhinitis, and cough could be seen in workers with positive atopic status. The association with conjunctivitis remained statistically significant (OR = 3.70, 95 %CI 1.10; 12.43). In this model, the duration of employment seemed to have an obvious, but still insignificant impact on lower airway disease.

Results of univariate logistic regression analysis on the association between the prevalence of upper and lower airway disease are shown in Table 5. A positive association between cough and rhinitis was found (OR = 2.62, 95 %CI 0.94; 7.73), while CB was not associated with symptoms of upper airway disease. Due to a limited number of subjects, multiple logistic regression was not applicable for adjusting specific characters, e.g., as already mentioned, airflow limitation was exclusively detected in current smokers.

4 Discussion

To our knowledge, this is the first study in municipal solid waste collectors that focuses on the upper and lower airways with respect to prevalence and association of irritative symptoms. Our data indicate that the duration of employment in waste collection, but not the work task was associated with increased prevalence of rhinitis, cough, or CB.

Especially loaders are exposed to bioaerosols when volatile particles from decomposing biomass are aerosolised during handling, lifting, and emptying of waste bins and containers (Poulsen et al. 1995). However, even though in less magnitude, drivers are also substantially exposed to organic dust, because waste collection is processed at the back of the waste truck, proportionally close to the driver's cabin. Also, high biologic agent emissions occur at waste disposal sites. Bioaerosols comprise dust, bacteria and fungi and may contain various toxic components like endotoxins.

Previous investigations of the bioaerosol exposure in German municipal solid waste collection revealed inhalable dust quantities of about 2.6 mg/m^3 (respirable dust: 0.41 mg/m^3) in the air around the loading area (Neumann et al. 2005). Bacteria levels fluctuated between 10^3 CFU/m^3 and 10^5 CFU/m^3 (Neumann et al. 2002). Endotoxin levels up to 100 EU/m^3 but mostly below 40 EU/m^3 and mould levels between 10^3 CFU/m^3 and 10^5 CFU/m^3 were detectable (Neumann et al. 2005). By comparison, drivers were usually exposed to mould and bacteria levels slightly above background levels with values between 10^2 CFU/m^3 and 10^3 CFU/m^3 (Neumann et al. 2002). Mould levels of $<10^3$ CFU/m^3 may already suffice to induce MMI (Herr et al. 2010). Therefore, health effects provoked by organic dust inhalation are a realistic threat – for drivers as well as for loaders.

Most frequently reported symptoms were related to the eyes, nose, and lower airways according to the workers' self-assessment given in the questionnaire. These complaints could predominantly be attributed to working conditions. We found a relatively higher prevalence of above mentioned symptoms than described in previous reports on the hazards of the exposure to bioaerosols (Yang et al. 2001).

There is moderate evidence that waste collectors are at increased risk of developing respiratory complaints (Kuijer et al. 2010), e.g., bronchitis. Even though our statistical analyses were limited by the number of subjects, we found evidence for an association of cough and CB with the duration of employment. In this context, we demonstrated an increased odds ratio for cough and CB. Likewise, the prevalence of common non-productive cough in our study population was 35 %. Recurrent non-productive cough points to an irritation of the lower airways. All subjects additionally complaining about phlegm (16 %) fulfilled the criteria for having CB. The prevalence of respiratory symptoms in our study is in line with previous data on respiratory health in waste workers (Wouters et al. 2002). In general, it is conceivable that CB may be caused by occupational exposure (Blanc and Torén 2007). An airflow limitation with respect to adjusted reference values (GLI 2012) could be demonstrated in current smokers and long-term employed workers. This might point to a combined effect of personal and occupational exposure resulting in an increased risk of developing an obstructive lung disease. This has previously been suggested for occupational exposure to particulate matter (Eisner et al. 2010).

Notably, an underlying allergic disease could be suspected in 44 % of loaders (and 38 % of drivers) reporting symptoms in terms of rhino-conjunctivitis. These calculations are based on the assumption that symptoms of conjunctivitis in subjects with atopy were indicative of an allergic aetiology. In contrast, we addressed irritation of eyes or nose without an underlying allergy as MMI. However, it is to stress that only a nasal provocation test with the potential allergen can reveal a causative link between sensitization and rhino-conjunctivitis in terms of an allergic disease. Thus, atopy might solely be a condition triggering mucous membranes for an enhanced response towards nonspecific irritative hazards.

Municipal solid waste collection is an 'outdoor activity', which is necessarily performed along the circumscribed road network of municipal communities. Waste collectors are directly exposed to traffic-related air pollution including diesel exhaust, as well as background levels of airborne allergens like pollen and moulds (from other sources than domestic waste). Furthermore, we must not forget other sources of air pollution (e.g., industrial exhaust). This contamination may contribute to work-related health effects and might explain a lacking relation between symptom prevalence and work task. In contrast, it may emphasize the detected associations between the symptoms and the duration of employment. Moreover, healthy worker effects were previously observed in workers handling biological waste (Bünger et al. 2007) and have to be considered. Our data analyses were hampered by a relatively small number of subjects. However, the results indicate a high prevalence of work-related rhino-conjunctivitis in long-term exposed domestic waste collectors. This study supports associations between the prevalence of upper and lower airway disease. Finally, when adjusting for smoking status, our data suggest that atopic waste collectors have an increased risk for irritation of the lower airways as indicated by cough.

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