

Respiratory health of municipal solid waste workers

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Background	There is an increasing evidence that the incidence of work-related pulmonary problems is greater in waste collectors than in the general workforce.
Aims	To evaluate the respiratory health of municipal solid waste workers (MSWWs).
Methods	One hundred and eighty-four municipal employees of Keratsini (104 MSWWs and 80 controls) participated in a cross-sectional study. All participants were asked to fill in a slightly modified version of the Medical Research Council questionnaire. Lung function was evaluated by spirometry.
Results	Spirometry revealed reduced mean forced vital capacity (FVC) and forced expiratory volume in 1 s (as a percentage of predicted values) in MSWWs compared with controls. After adjustment for smoking status, only the decline in FVC was statistically significant ($P < 0.05$). Prevalence of all respiratory symptoms was higher in MSWWs than in controls. After adjustment for confounding factors, the difference reached statistical significance ($P < 0.05$) for morning cough, cough on exertion and sore throat.
Conclusions	The results of this cross-sectional study indicate a higher prevalence of respiratory symptoms and a greater decrease in lung function in MSWWs. A number of limitations such as the relatively small size of population and the 'healthy worker' effect should be taken into account.
Key words	Cross-sectional study; occupational exposure; occupational respiratory disease; pulmonary function; waste workers.

Introduction

Municipal solid waste handling and disposal is a growing environmental and public health concern. The collection of household waste is a hard job, which involves working on a vehicle that moves through traffic throughout the year. It also requires repeated heavy physical activity, such as the manual lifting and handling of heavy bins [1,2].

Municipal solid waste workers (MSWWs) are exposed to a number of pathogens (bacteria, fungi, viruses, parasites and cysts), toxic substances (endotoxins and beta-glucans), chemicals that come from the waste itself and from its decomposition, as well as vehicle exhaust fumes, noise, extreme temperatures and ultraviolet radiation [3,4]. As a result of their exposure to multiple risk factors, MSWWs suffer high rates of occupational health problems [2,5,6].

Bioaerosols generated by decaying organic waste, vehicle exhaust fumes and bad weather conditions may

all contribute to respiratory problems [7]. Bioaerosols contain several agents capable of inducing inflammation in the airways. The most widely researched of these are endotoxins, 1-3 beta-glucans, volatile organic compounds and fungi. Endotoxins are regarded as the most potent inflammatory component in bioaerosols [8,9].

There is increasing evidence that diseases caused by exposure to bioaerosols are mainly of a non-allergic inflammatory nature [8]. Bioaerosol exposure is also associated with health effects such as respiratory symptoms, influenza-like symptoms [10] and increased risk of chronic obstructive pulmonary disease (COPD) [11]. There is limited information on exposure levels of bioaerosols during waste collection [4,12]. However, it has been shown that moderate exposure to fungal spores and beta-glucans, and even low exposure to endotoxin during waste handling, induces upper airway inflammation characterized by neutrophil influx and activation (myeloperoxidase, eosinophil cationic protein and interleukin-8) [13].

The incidence of work-related pulmonary problems seems to be greater in waste collectors than in the general workforce [2]. This occupation is physically strenuous, resulting in workers breathing through their mouth rather than their nose. Individuals who breathe through their mouth have higher pulmonary ventilation rates when comparing to those who breathe through their nose [14].

Only a few studies have investigated the negative effects of work on the respiratory system of MSWWs. Some of these studies have indicated reduced lung function [1,9,15] and increased prevalence of respiratory symptoms and allergic diseases related to occupational exposure [2,7,10,12], while others did not show any significant respiratory effect [8]. Non-specific responses such as irritation effects and acute airway inflammation have also been reported [12].

This study was conducted to further examine the potential respiratory health effects among MSWWs.

Methods

The study was performed in the municipality of Keratsini, a suburb in the port city of Piraeus, Greece. In total, 184 municipal employees participated in the study, from March 2009 to May 2009. We randomly selected 104 MSWWs, as well as 80 office employees in the same municipality, who were not exposed to waste.

Waste workers worked an average of 6 h/day, 5 days/week, usually starting very early in the morning. In the municipality of Keratsini, waste handling is performed traditionally with most household and business waste being mixed together. MSWWs use compactor trucks with lifts for automatic emptying of waste bins and containers. They ride on footplates on the backs of the trucks and are exposed to the exhaust fumes emitted by the vehicle. Although strongly recommended, protective equipment is not regularly used.

The survey was conducted simultaneously in both groups, to eliminate the confounding effect of seasonal variation. All participants gave their informed consent. The Employees' Committee of Health and Safety at Work gave approval for the data analysis and presentation of study results, under the condition that personal data and medical confidentiality would be protected.

The subjects were interviewed using a slightly modified version of the extensively validated Medical Research Council Respiratory Questionnaire [16]. This included questions about personal data such as age, gender, tobacco smoking habits and previous diseases. It also enquired about acute symptoms, like irritation of the eyes, nasal congestion, sore throat and headache. A second set of questions focused on chronic respiratory symptoms such as coughing, phlegm production, wheezing and shortness of breath. The questionnaire was piloted in 15 MSWWs and 12 office employees.

Lung function testing was performed in a sitting position with the nose closed with nose clips, using a portable electronic spirometer (Spirobank MIR) and following the American Thoracic Society guidelines [17]. All tests were performed by the same person. Calibration of the spirometer was performed daily, before the tests, using a 2 l syringe.

Each subject undertook at least two tests. The curve with the largest forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV₁) was chosen as the best curve. Measurements were compared with individual predicted values based on age, sex, body weight, standing height and ethnic group. Besides FVC and FEV₁, the FEV₁/FVC ratio was also calculated. Spirometric airflow limitation was defined as a ratio of FEV₁/FVC <70% and/or a FEV₁ <80% of predicted value.

Statistical analysis was performed using SPSS software (version 17.0). An independent samples *t*-test was used for the comparison of continuous variables. Crude odds ratios (OR) were calculated using chi-square test. A multivariate logistic regression model was used to adjust for possible confounders (sex, age, smoking status and education level).

P-values <0.05 were considered as statistically significant. Ninety-five per cent confidence intervals (95% CI) for the measures of association were calculated and reported.

Results

The demographic characteristics of the study population are listed in Table 1.

The two groups were comparable with respect to mean age (45 years), but the exposed group had a significantly higher proportion of males (68 versus 36%, *P* < 0.001). The proportion of current smokers was similar in both groups (54 versus 43%). MSWWs had significantly lower education level compared with the office employees (*P* < 0.001).

Spirometric results are summarized in Table 2. The MSWWs had reduced mean FVC and FEV₁ values

Table 1. Demographic characteristics of the MSWWs and controls

Characteristic	MSWWs (%)	Controls (%)
Sex		
Male	71 (68)***	29 (36)
Female	33 (32)	51 (64)
Smoking status		
Non-smokers	34 (33)	36 (45)
Ex-smokers	14 (13)	10 (13)
Current smokers	56 (54)	34 (42)
Education level		
≥9 years	11 (11)***	49 (61)
<9 years	93 (89)	31 (39)

****P* < 0.001.

compared with the unexposed office workers (95.5 versus 100.2 for the FVC and 94.6 versus 96.9 for the FEV₁). After adjustment for smoking status, FVC as a percentage of predicted value was significantly lower in the MSWWs than that of the office workers ($P < 0.05$).

Comparison of influenza-like symptoms between the waste collectors and the office workers is shown in Table 3. Fifty-nine per cent of the MSWWs exhibited at least one influenza-like symptom in contrast to 54% of the office employees.

Waste collectors had a higher prevalence of influenza-like symptoms, which was not statistically significant. Analyses adjusting for probable confounders showed similar results in both groups for all influenza-like symptoms except for sore throat, for which the difference was statistically significant ($P < 0.05$).

A comparison of respiratory symptoms compatible with asthma or COPD in MSWWs and office employees is shown in Table 4. Except for coughing with phlegm, waste collectors had increased prevalence of all COPD symptoms, although they appeared significantly elevated only for coughing in the morning (OR = 3.0, 95% CI: 1.3–7.2), bringing up phlegm during the day (OR = 2.5, 95% CI: 1.1–6.1) and bringing up phlegm for as much as 3 months each year (OR = 3.0, 95% CI: 1.2–7.6).

Multiple logistic regression was used to adjust for possible confounders (smoking status, education level, age and sex). After the adjustment, collection of municipal solid waste was found to be associated with an increased prevalence of coughing in the morning ($P < 0.05$).

Waste collectors also had increased prevalence of all symptoms compatible with asthma, although they appeared

significantly elevated only for coughing on exertion (OR = 3.1, 95% CI: 1.2–8.3). After adjustment for probable confounders, the prevalence of coughing on exertion remained significantly elevated for MSWWs ($P < 0.05$).

Comparison of self-reported disease history between MSWWs and controls showed no significant difference (Table 5). The subjects were also asked about any chest symptoms that may have kept them away from work for up to 1 week. According to Roche *et al.* [18], the numbers of missed working days is associated with chronic airflow obstruction and poorer quality of life. Eleven per cent of MSWWs appeared to have at least one such illness in contrast to 12% of controls. This difference was not statistically significant.

Discussion

In this cross-sectional survey of MSWWs, exposure to household waste was associated with both increased prevalence of respiratory symptoms and worse lung function testing results. To our knowledge, this is the first study in our country investigating the respiratory health of MSWWs.

Spirometry tests in MSWWs revealed a reduction in lung function parameters. The difference was statistically significant for the FVC. After adjustment for smoking status, the difference remained statistically significant.

Similar significant reductions in lung function parameters have been reported in waste collectors in other studies [1,9,19]. In a cross-sectional study, Gea de Meer *et al.* [20] found that dose–response slope (i.e. % fall in FEV₁ per milligram methacholine compared to the post-saline value) increased in MSWWs with a history of respiratory symptoms over a working week and decreased in control subjects, indicating an exaggeration of pre-existing airway inflammation during the working week in MSWWs with regular respiratory symptoms.

In our study comparing MSWWs to office employees, we found a moderate but statistically higher prevalence of sore throat, coughing in the morning, coughing on exertion and phlegm production in MSWWs, along with non-significant increases in the prevalence of headache,

Table 2. Spirometric lung function measurements

	MSWWs	Controls
FVC%	95.5*	100.2
FEV ₁ %	94.6	96.9
FEV ₁ /FVC	82.7	81.9
FEV ₁ /FVC%	104.1	102.2

* $P < 0.05$.

Table 3. Influenza-like symptoms

	MSWWs (%)	Controls (%)	Crude OR ^a (95% CI)	Adjusted OR ^b (95% CI)
Headache	32 (36)	22 (33)	1.1 (0.6–2.3)	1.8 (0.7–2.8)
Sore throat	15 (17)	5 (8)	2.6 (0.9–7.5)	4.1 (1.2–11.9)*
Rhinitis	30 (33)	18 (27)	1.3 (0.6–2.7)	1.2 (0.6–2.8)
Conjunctivitis	16 (18)	9 (13)	1.5 (0.6–3.7)	1.4 (0.5–3.7)

^aCalculated using chi-square test.

^bCalculated using a multivariate logistic regression model.

* $P < 0.05$.

Table 4. Respiratory symptoms compatible with asthma or COPD

	MSWWs (%)	Controls (%)	Odds ratio (95% CI)
Breathlessness	45 (50)	27 (41)	1.5 (0.8–2.8)
Coughing in the morning	26 (29)	8 (12)	3.0 (1.3–7.2)*
Coughing during the day	14 (16)	7 (10)	1.6 (0.6–4.3)
Coughing for 3 months/year	14 (16)	4 (6)	2.9 (0.9–9.3)
Phlegm in the morning	25 (28)	16 (24)	1.2 (0.6–2.5)
Phlegm during the day	23 (26)	8 (12)	2.5 (1.1–6.1)*
Phlegm for 3 months/year	23 (26)	7 (10)	3.0 (1.2–7.6)*
Cough with phlegm	20 (22)	15 (22)	1.0 (0.5–2.1)
Coughing on exertion	22 (25)	7 (10)	3.1 (1.2–8.3)*
Wheezing on exertion	20 (22)	14 (20)	1.1 (0.5–2.6)
Waking up with wheeze	13 (15)	5 (8)	2.1 (0.7–6.3)
Wheezing in a dusty room/smoky place	14 (16)	6 (9)	1.8 (0.7–5.2)

* $P < 0.05$.**Table 5.** Disease history and absence from work due to respiratory illness

	MSWWs (%)	Controls (%)	Odds ratio (95% CI)
Absence >1 week from work	10 (11)	8 (12)	0.9 (0.3–2.4)
Chest injury ^a	5 (6)	0 (0)	–
Heart trouble ^b	9 (10)	12 (18)	0.5 (0.2–1.2)
Bronchitis	19 (21)	11 (16)	1.3 (0.6–3)
Pneumonia	7 (8)	12 (18)	0.4 (0.2–1.1)
Pleurisy	4 (4)	0 (0)	–
Asthma	7 (8)	11 (16)	0.5 (0.2–1.3)

^aSelf-reported history of an injury or operation affecting the participant's chest.^bSelf-reported history of a heart disease.

rhinitis, conjunctivitis, breathlessness and wheeze. Questionnaires were completed for ~87% of the MSWWs and 84% of the comparison group, which is comparable with results from similar studies [21].

An increased prevalence of influenza-like symptoms has also been shown in other studies [7,8]. Yang *et al.* [2] found that MSWWs have an increased risk of developing chronic respiratory symptoms (cough, phlegm production and wheezing).

One limitation of this study is that a temporal relationship cannot be determined due to the cross-sectional design of our study. A further limitation is that data pertaining to specific bioaerosol or chemical exposures were not available in this study. However, the authors believe that the MSWWs in this study are exposed to noxious agents similar to those encountered by MSWWs employed in other countries [22,23].

Since a specific exposure assessment and air pollution measurements were not part of this study, there is some uncertainty over the generalizability of our results. Nevertheless, the system of municipal solid waste collection and therefore waste collectors' occupational exposure are similar in different regions of Greece. Consequently, there is no reason to consider that the results are not representative for the whole country.

Differences in tobacco smoking habits are a major confounder in investigating occupational causes of respiratory problems. For this reason, multiple logistic regression analysis was used to adjust for smoking habits and other potential confounding factors.

A major problem in an occupational cross-sectional study is selection bias, especially the 'healthy worker' effect [24]. Since waste collection implies highly demanding physical activity, persons with respiratory problems will tend to leave this job earlier than the office employees, where the physical activity demand is lower. Coughing with phlegm for 3 months a year is one of the more functionally significant respiratory symptoms under study. According to the Employees' Committee of Health and Safety at Work policy, MSWWs with significant respiratory symptoms are temporarily or permanently transferred to other municipal departments where the physical activity demand is lower. If the respiratory health problems are severe enough to render the employee completely incapable of work, then the possibility of taking a disability pension is considered. That is probably the reason why coughing with phlegm for 3 months a year was the only symptom in our study that was not increased among the MSWWs. Yet, the more frequent reporting of previous chest diseases among controls, although not

statistically significant, could suggest a healthy worker effect.

Since the observed increased prevalence of respiratory problems is biologically plausible and indicated in other epidemiological studies, it seems reasonable to believe that occupational exposure to bioaerosols, dust, exhaust fumes and bad weather conditions play an important role in the development of respiratory problems.

The findings of this study suggest that occupational physicians should deal more actively with the occupational health of MSWWs. The workers should be motivated to quit smoking. Screening tests prior to hiring together with annually screening tests (physical examination and spirometry tests) are recommended. People with respiratory health problems or significant decline in lung function parameters should be transferred to other municipal departments. Initiatives are needed to encourage the use of safe waste management techniques and the appropriate use of personal protective equipment.

Key points

- Municipal solid waste workers are exposed to bioaerosols generated by decaying organic waste, dust, vehicle exhaust fumes and bad weather conditions, which may all contribute to respiratory problems.
- In this cross-sectional survey of municipal solid waste workers, solid waste collection work was associated with both respiratory symptoms and diminished lung function testing.
- After adjustment for confounding factors, spirometry tests in municipal solid waste workers revealed statistically significant decline in the forced vital capacity.

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Conflicts of interest

None declared.

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