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OCCUPATIONAL HEALTH RISKS TO EMPLOYEES OF WASTE TREATMENT FACILITIES

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Abstract: In recent years, efforts have been made to reduce the volume of residual waste through sorting, recycling and composting. As in many other western countries, facilities designed to recycle materials collected from waste were established in Austria. Employees of such facilities are exposed to increased levels of bioaerosols. A total of 137 employees from 5 different facilities (2 composting facilities and 3 waste sorting plants) underwent medical examination. In addition to spirometry, allergy parameters (total IgE concentration, mold-allergen specific IgE concentration) and parameters of inflammation (C-reactive protein, blood count) were determined. A questionnaire recorded subjective observations and the immunization of the employees. No statistically significant increase of allergic diseases was found. Although IgE levels of employees in sorting facilities were increased, no causality between IgE concentrations and the length of employment in the facility could be established. The incidence of mold allergen-specific IgE was also not significantly higher among employees in waste treatment plants than among members of a control group. Spirometry showed no differences in the lung function, both within the facilities and in comparison with the control group. Obstructive changes of the respiratory organs which can be observed in allergic diseases were not even found among employees who had worked in sorting facilities for several years. Among the workers occurred subjective complaints such as hoarseness (38%), cough (35%), infections of the respiratory organs (23%), diarrhea (18%), disorders in joints and muscles (13%) and conjunctivitis (12%). Immunization of workers was shocking: Only 57% were properly vaccinated against polio, 42% against tetanus and 68% against HAV. The proportion of employees with increased blood sugar levels was conspicuously high. Although this cannot be interpreted as work-related, it should be taken into account when conducting initial medical examinations. In addition to regular medical check-ups, occupational medicine should place special emphasis on the initial medical examination. Routine examinations should determine immunizations, lung function, routine vaccinations, and biochemical parameters in order to prevent disorders in the metabolism (diabetes).

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INTRODUCTION

In the past two decades, domestic waste and domestic-type industrial waste have increased dramatically. The routine disposal of waste through dumping or incineration leads to a significant pollution of the environment. Various governments, especially in the industrialized world, have developed programs in order to minimize this environmental problem and to reduce the volume of waste through sorting and recycling.

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The capacity of the present dumps is slowly becoming exhausted thus steadily increasing the significance of alternative methods of waste disposal. In addition to prevention, sorting and recycling, composting of the biological waste components assumes special significance.

Presently, a large number of persons are employed in the disposal and manual sorting of waste. All of them are aware of the fact that work in the area of waste management may be associated with health risks [3-5, 7, 9-11]. Scientific studies must estimate the risks to those employed in this field but also to those of the general population living in the vicinity of the waste disposal industries. In defining the risk, we must clearly differentiate between hazard and risk. Hazard is a term, which describes the potential damages by a pollutant. It is a qualitative term which provides theoretical information on reaction of the toxic quality by a pollutant but which will not provide information on actually occurring adverse effects. Risk, however, is a quantitative term which provides a causal connection between definite damages and pollutants. It specifies the deducible damages and links them with the intensity of the exposure (dose) or calculates the probability of a damage occurring.

Several studies have described the hazard to those employed in waste sorting and recycling covering diseases of the lungs, the gastrointestinal tract, mucous membranes, skin and musculoskeletal system [1, 2, 5, 7, 8, 10-14].

This study is a contribution to the quantitative assessment of the health risk to employees.

MATERIAL AND METHODS

In this study, employees in different waste management facilities (composting plants, waste sorting plants) were examined and medically evaluated. The possible influence of microorganisms and pathogens on their condition was given special consideration. From the spectrum of potential diseases, infections of the respiratory tract, allergic diseases, infections of the mucous membranes, systemic mycoses, effects of mycotoxins and the organic dust toxic syndrome (ODTS) were given special consideration. Some aspects were evaluated as a result of the information furnished by the employees, others were determined by examining various laboratory parameters from the blood.

Examined population. A total of 117 employees from 5 different facilities in Southern Austria were examined. The median age of the 77 women and 40 men was 36.1 years (minimum = 16, maximum = 65). The average length of employment was 83.6 months (minimum = 1 month, maximum = 466 months). Figure 1 shows the cumulative relative frequency indicating clearly that 50% of the employees examined had worked less than 3.6 years in the facilities.

The facilities examined were: (1) composting plant; (2), (3) and (4) waste sorting facilities; (5) dumping site and segregation facility. A sixth group, used as a control group for certain parameters, worked in: (6) an office of a food-processing plant (chicken farm). The median age of the 26 women and 18 men was 34.8 years (minimum = 16, and maximum = 65).

Spirometry. Spirometric testing was conducted with a portable spirometer (Jäger). The following parameters were tested: vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), maximum end-expiratory flow at 25% of the FVC volume (MEF25), maximum end-expiratory flow at 50% of the FVC volume (MEF50), and maximum end-expiratory flow at 75% of the FVC volume (MEF75) [14]. For the evaluation of lung function, the data were examined critically for the active participation of the subjects.

Total IgE concentration. Total IgE concentration was determined using the CAP-system (Pharmacia). This system consists of an immune assay and an information management software in order to determine total IgE concentration as well as the concentration of allergen-specific IgE from the undiluted serum or plasma. This system has the advantage that the linear range of a concentration extends from 0 to 2,000 kU/l. The upper limit of normal range for adults was determined as 100 kU/l.

Laboratory analyses of blood samples. 10 ml venous blood was drawn from each subject in order to determine several factors from the serum or the plasma. In order to rule out diabetogenic metabolisms, blood sugar was determined by means of an automatic analyzer (Boehringer-Hitachi). It is well known that increased blood sugar levels increase the susceptibility to infectious diseases.

In order to be able to rule out an acute infection, CRP (C-reactive protein) concentration was determined. The cut-off for exclusion was set at 1.2 mg/dl. The percentage of CO-Hb was also determined, but only non-smokers were included in the calculations. This investigation was carried out by means of gas check analysis (AVL-Graz).

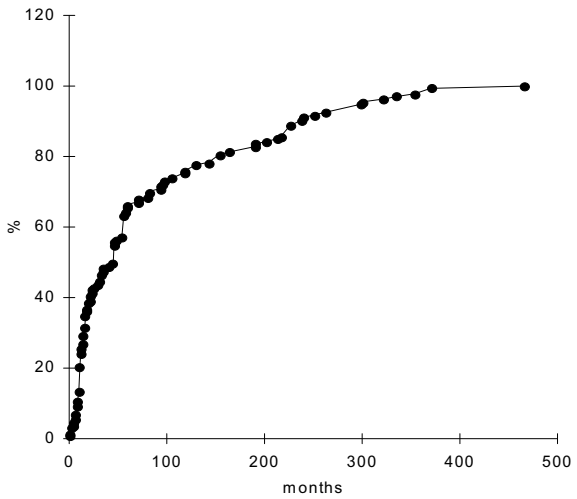

Figure 1. Cumulative relative frequency of the length of employment of workers.

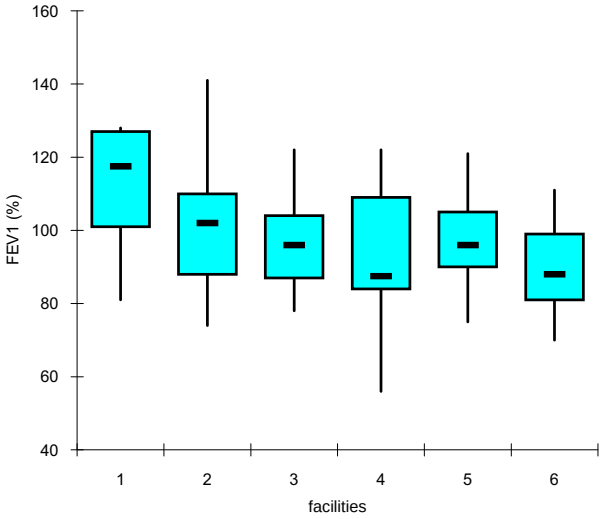

Figure 2. Box-plot of the lung function described by the forced expiratory volume in one second (FEV_1) in percent of the normal values. The central box covers the middle 50 percent of the data values, between the lower and upper quartiles. The whiskers extend out to the extremes, while the central line is at the median.

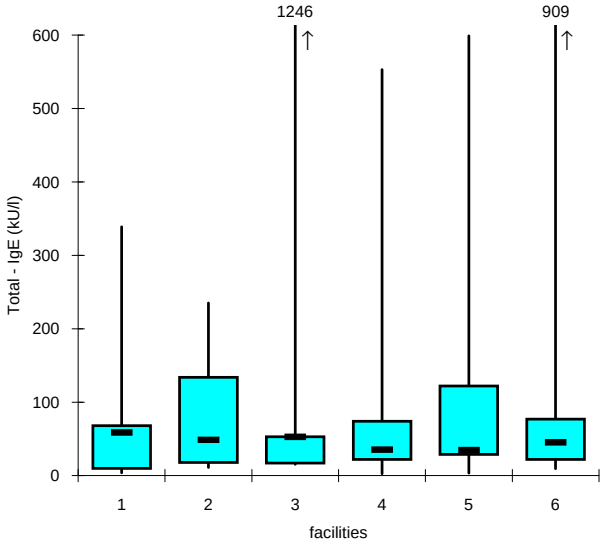

Figure 3. Box-plot of the concentration of the total IgE of employees in various facilities. The threshold limit value of adults was determined at 100 kU/l. The central box covers the middle 50 percent of the data values, between the lower and upper quartiles. The whiskers extend out to the extremes, while the central line is at the median.

Statistical analysis. All data were computed, tabulated and analysed using parametric (ANOVA, logistical and linear regression) and non-parametric tests (chi-square, Kruskal-Wallis [K-W], Spearman) with a statistical PC package (SPSS for Windows). The K-W test was used to compare means if there was heterogeneity of variance. Statistical significance levels were set at $p < 0.05$. Variables that were positively skewed were log-transformed for analysis.

Participation in the study was voluntary and confidentiality was assured. The study was also supported by the companies.

Table 1. Odds ratios with 95% confidence intervals of different health complaints. Irritation of mucous membranes demonstrated the highest values.

	Risk estimation	
Symptom (disorder)	OR	CI 95%
Asthma	0.817	0.75-0.88
Allergy	1.094	0.33-3.60
Nausea	1.558	0.57-5.20
Respiratory problems	2.087	0.74-4.64
Diarrhea	1.821	0.73-4.53
Eczema	1.304	0.40-3.83
Eye irritation	6.418	0.74-37.24
Flu-like symptoms	1.013	0.469-2.18
Articulation problems	2.769	1.25-5.217
Skin problems	1.043	0.34-3.15
Cough	1.452	0.594-3.54
Hoarseness	2.62	0.66-3.96
Allergic rhinitis	1.021	0.463-2.08
Smell problems	2.938	1.08-7.99

RESULTS

A number of studies point out an increased risk to workers in this industry, emphasizing especially allergic reactions and the ODTS. The present study found that the given conditions affected especially the mucous membranes of the upper respiratory tract and the conjunctivae. Table 1 shows the calculated odds ratios. It is conspicuous, that in comparison with the control group, the risk of eye irritation was highest in employees of the waste treatment plants. Allergic diseases, including asthma, play a rather minor role. It should be stressed that in waste sorting plants, employees suffer more frequently from disorders of the musculoskeletal system.

The respiratory tract was examined using spirometry, considering especially the allergic component. Allergic diseases manifest themselves in the respiratory tract by obstructive changes which leave clear signs in spirometry. Neither in garbage sorting plants nor in composting facilities, a statistically significant impairment of the lung function was found in the examined employees (Fig. 2). There was no linear causal relationship between the lung function and the length of employment. The spirometry results of the individual employees were transformed in analogical values (MEF50 60-80% = low lung function; MEF50 >80% = normal lung function) and the calculated relative risk shows an odds ratio of 1.5 which would suggest a clear influence on the lung function. This, in turn, correlates very well with the increased incidence of cough for which an odds ratio of 1.4 was calculated. Mucous membranes are therefore the system which is most sensitive to the effects of the pollutants in the waste treatment industry.

So far, immunoglobulin E concentration has been used as an important parameter for allergic diseases. However, increased immunoglobulin E concentration does not

Table 2. The proportion of correctly vaccinated employees.

Vaccination	
Vaccine	Correctly vaccinated employees (%)
Diphtheria	78.4
Hepatitis A	68.4
Hepatitis B	68.8
Polio	57.4
Tetanus	41.9

necessarily express an allergic disease. In Figure 3 total IgE concentration in the serum of employees is presented in the box-plot in the different facilities. The employees of a garbage sorting facility showed the highest total serum IgE concentration. Setting the value of the upper normal range at 100 kU/l, a large proportion of the employees had an IgE concentration which exceeds this limit. The concentration of IgE was set in relation to the length of employment, but no statistically significant dependence could be determined.

Determination of allergen-specific antibodies of the IgE type against the most important fungus allergens showed that there was no statistically significant difference between the employees and the general population.

Increased blood sugar is significant in the development of various infections. Routine examinations showed that 14.7% of the employees had a blood sugar concentration of more than 110 mg/dl. There was a significant correlation ($p < 0.01$) between glucose concentration and the occurrence of nausea, diarrhea and various skin manifestations.

Carbon monoxide is a gas which may occur as a result of chemical processes during decomposition and which forms a tight bond with human hemoglobin. Among employees of manual sorting facilities, a clearly elevated carbon monoxide load was found, although the values were still clearly within the normal range (the cut-off = 5% CO-Hb).

Immunizations of employees were also recorded. Table 2 shows the relative frequency of the individuals who were not or not sufficiently vaccinated against the most important infectious diseases. There was a high rate of insufficient protection against tetanus and poliomyelitis whereas the preventive measures against hepatitis, especially hepatitis B, were more correct.

DISCUSSION

The microorganism load, both bacteria and fungi, is dependent on the type of facility (closed or open system) and on the area within the facility itself. The differences in exposure can extend to several orders of magnitude. It is obvious that the microorganism load as well as the toxins are an essential criterium for the occurrence of specific clinical pictures. Since all characteristics develop independently from the length of employment, certain individuals are obviously genetically more predisposed for certain types of diseases or have started work with preexisting conditions in metabolism (diabetes) and are therefore at greater risk. Especially diabetics were highly threatened in this environment and had a much higher risk of nausea, diarrhea, eczema, inflammation of conjunctivae and skin irritations.

In spite of the elevated IgE concentration, allergic diseases were not represented to the expected degree. IgE is produced by B-lymphocytes and is controlled by different lymphokines (IL-4, IL-13) [6]. Pollutants such as PAH or heavy metals may interact with the surface structures of the lymphocytes and thus produce a 'switch' in the formation of immunoglobulins from IgM/IgG to IgE. This IgE found in the serum is non-specific and an increase of allergen-specific IgE could not be proven. Thus, the detection of IgE is a sign of an allergenic load but does not correlate with an increased incidence of an allergic disease.

In Austria and many other countries, routine occupational medical check-ups of employees are dependent on certain organizational criteria. Small businesses (below 80 employees) such as sorting facilities and composting facilities do not require a company physician. Moreover, it was found that the employees in this industry are for the most part (approx. 70%) foreigners which involves special problems for health care and prevention.

Based on the present study, the following recommendations are made:

1. The most important preventive measure is the initial check-up of employees. Individuals with increased blood sugar levels or increased IgE concentration or impaired lung function or recurring inflammations of mucous membranes should be excluded from this type of work.
2. There should be regular (annual) medical check-ups with special emphasis on lung function, total IgE concentration and blood sugar.
3. Vaccinations should be monitored routinely. "Required" vaccinations of employees in the waste management industry include vaccines against tetanus, diphtheria, polio, hepatitis A and B, and in endemic areas against tick-borne encephalitis.
4. The musculoskeletal system should also be critically examined and cases of severe aberrations excluded from work.
5. In jobs involving manual sorting, the workplace should be adapted to meet the size of the individual worker.
6. In spaces with increased loads of microorganisms, wearing of masks should be mandatory.

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