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RESPIRATORY, GASTROINTESTINAL, AND OTHER HEALTH EFFECTS AMONG WORKERS IN TWO REFUSE-DERIVED FUEL PLANTS

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This study was conducted to investigate health effects in workers at two refuse-derived fuel processing plants. Cross-shift pulmonary function testing and self reporting of symptoms from questionnaires formed the basis of a cross-sectional epidemiological study. Other topics addressed were exploration of the possibility of a hand to mouth component resulting in diarrhoea observed historically by the microbiological testing of skin. Symptoms of sinus trouble, headaches, nose irritation, and diarrhoea were reported by over 50% of the employees. Small, but statistically significant, cross-shift decrements of 1.50% and 2.01% were noted for forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1), respectively. Workers employed seven years or more had significantly larger cross-shift decrements in FVC and FEV_1 than those employed for a shorter period. No active cases of diarrhoea were observed. Low lung function decrements characterise the observed workforce. Elevated reporting of some symptoms and a cross-shift decrement that increases with length of employment indicate that further study is warranted.

Key words:
diarrhoea, headache, length of employment, nose irritation, pulmonary functions, questionnaire, solid waste

Workers' health throughout the refuse industry is a largely understudied subject. Research has been conducted to investigate emissions of viruses, bacteria, and fungi from processing solid waste (1, 2), but relatively few studies have looked at the health effects on the workers (3, 4).

There are several elements of the solid waste industry: waste generation, at-source waste separation, storage and processing, waste collection, waste separation, processing and transformation, waste transfer and transport; and waste disposal (5).

Every facet of solid waste management exposes workers to conditions that may cause injury or illness. Skin problems related to handling refuse were found by *Gellin and Zavon* (6) in their 1968 study of Cincinnati solid waste workers. Another report on respiratory effects in the solid waste industry quotes an increase in bronchitis among waste handlers (7).

The largest number of studies on the respiratory health effects of refuse handling have been conducted by *Sigsgaard and co-workers* in Denmark (8, 9). Their initial study followed the workforce of twelve at a newly opened solid waste sorting plant where eight of the workers became ill within eight months with initial symptoms of eye irritation and sore throat (10). The symptoms progressed to cough among the eight workers, exercise-related dyspnoea in seven, abnormal peak flow readings in seven, and chest tightness at work in four. The problems reportedly disappeared after the plant instituted better occupational hygiene controls. In their most recent study, *Sigsgaard and co-workers* (11) found no evidence of chronic respiratory effects among workers in resource recovery, but added a comment that there was a high turnover (50% in one year) due to respiratory symptoms. They also indicated that the industry was new with employees exposed for short periods, limiting the time for chronic diseases to develop.

Management and employee concerns regarding the workers' health in two refuse-derived fuel (RDF) processing plants provided the motivation for this study. The primary concerns among workers were a perceived increase in bronchitis, skin rashes, and a diarrhoeal condition termed the »RDF flu«, as well as concerns regarding possible long-term health effects. Cross-shift pulmonary function testing and self reporting of symptoms from questionnaires were used to investigate health effects in the workers and to form the basis of a cross-sectional epidemiological study. Concurrent environmental sampling for dust, endotoxins, and bioaerosols portion was carried out to establish risk factors among the environmental variables for observed respiratory decrements. The results, reported elsewhere, showed geometric mean values of personal air samples of 0.5 mg/m^3 for total dust, 29.0 EU/m^3 (2.9 ng/m^3) for endotoxin, and 6.8 x10^5 organisms/m^3 for bioaerosols. A microbiological skin contamination study was performed to investigate the possibility of a hand-to-mouth component to RDF flu. The relationships detected were to be used to identify strategies for controlling exposure and reducing adverse health outcomes. All willing RDF workers at two midwestern processing plants were included in the study.

The aims of this study were to establish the respiratory, gastrointestinal, dermal, and other possible effects in RDF workers, to determine whether there were any differences between groups of workers based on differing plants, work shifts, or jobs, and to examine the possibility of a hand-to-mouth component of diarrhoeal cases through microbiological testing of skin.

SUBJECTS AND METHODS

The two plants included in this study process refuse from a large midwestern American metropolitan area into refuse-derived fuel. One plant produces 4–5 hundred tons

of RDF a day and has been operational since 1986. The other produces about 8–9 hundred tons of RDF per day and has been operational since 1988. Collection vehicles dump refuse onto the tipping floors of the plants where wheel loaders push the refuse to conveyors that bring the refuse into the plant for size reduction and non-combustible fraction removal operations. The finished RDF product and non-combustible fractions are loaded by compactors for removal from the plant by tractors. Plant workers direct traffic on the tipping floor, operate the wheel loaders, operate grapple cranes above the tipping floor conveyors to removing bulky items, and operate the compactors and tractors. Plant workers also operate, clean, and maintain the size reduction and non-combustible fraction removal machinery. All workers rotate jobs on a daily basis, save for shift supervisors, mechanics, and electricians, although these workers could also be called to perform any job for a given shift.

Seven workers participated in cross-shift pulmonary function testing in each shift. The selection was based on availability and willingness to participate. Protocols for the project were approved by the institutional review board and informed written consent was obtained from the subjects.

Workers at both plants were administered a comprehensive questionnaire to establish the levels of chronic and acute respiratory symptoms. A pre-shift and a post-shift questionnaire was self-administered to investigate acute symptoms and note any conditions that might interfere with pulmonary function testing. The subjects completed their pre-shift and post-shift questionnaires while they waited for pulmonary function tests. The first portion of the comprehensive questionnaire was adopted from the American Thoracic Society (ATS) respiratory disease questionnaire developed under the Epidemiology Standardization Project with additional ATS questions added pertaining to sinus problems, tuberculosis, and asthma (12). Additional questions were adapted for use from other studies and were added to the standard ATS questionnaire to elicit information on the frequency of symptoms, work habits, and skin rashes (13).

Pulmonary function tests were given to each participant before the work shift and after the work shift. Participants did not enter the work area without the pre-shift testing. The methods for pulmonary function testing followed ATS recommendations (14) using a MultiSpiro-SX Pneumotachometer (MultiSpiro Inc., Scottsdale, AZ). The spirometer was calibrated before each series of tests, pre-shift, and post-shift testing. Testing was performed by company health professionals with the exception of two days of post-shift testing, performed by one of the investigators. The participants performed the pulmonary function manoeuvres seated, without noseclips. Measurements were made of forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and forced expiratory flow ($FEF_{75–85}$).

The predictors for FEV_1 and FVC were taken from *Crapo and co-workers* (15), and the largest value for each measurement was used in their computation, independent of the test. Values were race-adjusted for black workers by multiplying the predicted values for white workers by 0.85 (16). A cross-shift decrement of 5% was used herein to indicate a physiologically significant cross-shift lung function decrement, a level adopted as indicative of »reactors« in the cotton dust standard (17).

The microbiological biota of workers' hands were measured before and after routine washing for meals by sterile glove immersion, a method commonly employed in such studies (18). The skin contamination study was conducted for each shift and for all participating workers.

The information collected was analysed with the SYSTAT® statistical analysis program (SPSS, Chicago, IL). The normality of data was tested by computing Lillefors' probabilities for Kolmogorov-Smirnov's one-sample tests against a normal distribution (19). Pearson's correlation coefficients were used to indicate the strength of association between normally distributed variables of interest, while Spearman's correlation coefficients were used with non-normally distributed variables. Pearson's chi-square test of homogeneity and Fisher's two-tail exact test were used to test for subgroup differences in symptoms. McNemar's test was used to test for cross-shift and seasonal differences in symptoms. Paired *t*-tests were used for variables normally distributed and Wilcoxon's signed-rank tests were used for paired variables not normally distributed. Unpaired variables (handwash enumerations) were tested by independent sample *t*-tests. A significance level of 0.05 was used in all tests.

RESULTS

Demographics

Seventy-nine (73%) subjects of 108 persons in the workforce participated in the pulmonary function testing. The workers were predominately male (86%) and white (97%). There were no significant differences between the two plant populations with respect to age, sex, race, or smoking status. Demographic information from this group is presented in Table 1. Only 60 workers completed the ATS-derived questionnaire, 20 from Plant A, 40 from Plant B because of logistical problems in administering the questionnaire stemming from rotating shifts, vacations, etc. This subset had the same race and sex distribution and the same mean age as the larger group. Their demographics are shown in Table 2. A small (N=21) reference population was obtained for the ATS questionnaire from a district heating plant owned by the company. Participation in the reference group was voluntary and solicited through management request-

Table 1 *Study population demographics*

	Plant A	Plant B	Total
Employees, number (%)	38	41	79
Male	31 (82)	37 (90)	68 (86)
Female	7 (18)	4 (10)	11 (14)
Black	1 (3)	1 (2)	2 (3)
White	37 (97)	40 (98)	77 (98)
Smokers	9 (24)	14 (34)	23 (29)
Nonsmokers*	29 (76)	27 (66)	56 (71)
Mean age (SD)	35.8 (6.0)	35.0 (8.0)	35.4(7.0)
Mean years of employment (range)	5.0 (0.2–8)	4.5 (0.1–8)	4.7 (0.1–8)

*Never smoked and former smokers

Table 2 *American Thoracic Society questionnaire for the study population demographics*

	Refuse-derived fuel workers	Controls
Employees, number (%)	60	21
Male	50 (83)	14 (67)
Female	10 (17)	7 (33)
Black	2 (5)	0
White	58 (97)	21 (100)
Smokers	10 (17)	4 (19)
Nonsmokers*	50 (83)	17 (81)
Mean age (SD)	35.5 (6.0)	43.5 (10)

*Never smoked and former smokers

ing participation during regular work-related meetings. The reference population was all white, slightly older than the RDF workers, and had a higher percentage of females than the RDF group. As the reference population were administrative workers, any work-related exposure to dusts, bioaerosols, or endotoxins was likely to be minimal. The reference population demographics are also shown in Table 2.

Symptoms

The responses to the questionnaire administered before and after the shift were tested to determine if there were acute work-related symptoms. No significant differences were observed between pre-shift and post-shift responses. Tests for inter-plant differences in symptom occurrence in the ATS-derived questionnaire responses revealed no significant differences between the plants. Differences based on job could not be determined since workers rotate jobs and completed the questionnaire once. Significant elevations occurred in RDF workers relative to the reference population for diarrhoea at work, nasal irritation (without cold), and cough with phlegm (without cold). Reports of pneumonia and wheezing (without cold) were elevated in the reference population. Table 3 shows the ATS-derived questionnaire responses.

Skin rash symptoms were assessed from questionnaire responses, both on the pre-shift and post-shift questionnaire and from questions added to the ATS-derived questionnaire. The responses to skin-related questions added to the ATS-derived questionnaire appear in Table 4. There were no significant inter-plant differences. Some skin rash symptoms showed a significant elevation in RDF workers with respect to the reference population. Skin rash in the previous year and more than one skin rash in the previous year were both reported more often by RDF workers. Redness and itching of the arms was also reported more frequently by RDF workers.

Table 3 *Responses to the American Thoracic Society-based questionnaire*

Symptom/Illness (Number of responding: Refuse-derived fuel workers, Controls)	**% Positive (N)**		
	Refuse-derived fuel workers	Controls	Probability*
Cough (59, 21)	17 (10)	5 (1)	0.272
Phlegm (60, 20)	27 (16)	5 (1)	0.057
Cough and phlegm (58, 21)	28 (16)	10 (2)	0.131
Wheezing, with colds (53, 20)	45 (27)	50 (10)	0.798
Wheezing, apart from colds (55, 20)	16 (9)	20 (4)	0.737
Wheezing, most days or nights (54, 18)	6 (3)	6 (1)	1.000
Breathlessness (58, 21)	10 (6)	0	0.186
Chest colds (60, 21)	37 (22)	43 (10)	0.605
Chest colds, debilitating (59, 21)	31 (18)	24 (5)	0.780
Bronchitis (60, 21)	17 (10)	38 (9)	0.065
Pneumonia (57, 17)	14 (8)	47 (8)	0.007
Hay fever (56, 17)	14 (8)	35 (6)	0.078
Sinus trouble (57, 18)	51 (29)	44 (8)	0.788
Pulmonary tuberculosis (57, 17)	0	0	
Chronic bronchitis (60, 21)	3 (2)	4 (1)	1.000
Emphysema (59, 19)	0	0	
Asthma (59, 19)	5 (3)	21 (4)	0.056
Allergies (60, 21)	32 (19)	33 (7)	1.000
Other chest illness (59, 21)	2 (1)	5 (1)	0.454
Heart trouble (60, 21)	3 (3)	14 (3)	0.107
High blood pressure (58, 19)	16 (9)	16 (4)	1.000
Diarrhoea (58, 20)	64 (37)	40 (9)	0.073
Diarrhoea, at work (36, 7)	92 (33)	43 (3)	0.008
Diarrhoea, current (35, 8)	31 (11)	13 (1)	0.407
Diarrhoea, confirmed by doctor (35, 8)	23 (8)	0	0.316
Dry cough, sans cold (60, 21)	22 (13)	10 (2)	0.331
Cough with phlegm, sans cold (58, 21)	33 (19)	10 (2)	0.046
Wheezing, sans cold (59, 21)	5 (3)	24 (5)	0.026
Chest tightness, sans cold (60, 21)	7 (4)	10 (2)	0.647
Shortness of breath, sans cold (59, 21)	12 (7)	10 (2)	1.000
Nose irritation, sans cold (57, 21)	51 (29)	24 (5)	0.041
Sore throat, sans cold (60, 21)	18 (11)	5 (1)	0.170
Sinus trouble, sans cold (59, 21)	53 (31)	33 (7)	0.203
Burning or stinging eyes, sans cold (59, 21)	29 (17)	14 (3)	0.247
Headache, sans cold (59, 21)	61 (36)	38 (8)	0.080
Nausea, sans cold (60, 21)	18 (11)	10 (2)	0.497
Fever, chills and malaise, sans cold (59, 21)	17 (10)	5 (1)	0.272
Earache, sans cold (59, 21)	10 (6)	0	0.332

*Fisher's exact test

Table 4 *Skin-related questionnaire responses*

Symptom/Illness (Number of responding: Refuse-derived fuel workers, Controls)	**% Positive (N)**		
	Refuse-derived fuel workers	Controls	Probability*
Eczema (58, 20)	5 (3)	5 (1)	1.000
Rash, current (59, 23)	17 (10)	4 (1)	0.168
Rash, previous year (51, 22)	35 (18)	0	0.001
Rash, > one in previous year (48, 22)	17 (8)	0	0.050
Redness and itching, > two days (59, 23)	34 (20)	0	0.001

*Fisher's exact test

Pulmonary function data

There were 79 pre-shift and post-shift measurements of these variables, all of which met the ATS testing acceptability criteria. The data were normally distributed when tested by Lillefors' probabilities for Kolmogorov-Smirnov's one-sample tests against a normal distribution, with the exception of post-shift FEV_1/FVC ratio, N=79, P=0.007. There were significant differences between pre-shift and post-shift measurements for FVC, FEV_1, and FEV_1/FVC, as shown in Table 5. Significantly different pulmonary function decrements were sought between subgroups (plant, first day of workweek, sex, smoking status, shift, and job) in the form of independent sample *t*-tests for dichotomous subgroups and ANOVA for subgroups with more than two classifications. Except for the subgroup classification of jobs for FVC (P=0.037), FEV_1 (P=0.019), and FEV_1/FVC (P=0.029), no subgroup was observed to have a significantly different decrement. No pairwise tests were found to be significant by *post hoc* Scheffe's tests. Table 6 shows the subgroups and the probabilities.

Table 5 *Pulmonary function measurements*

Test (N=79)	**Pre-shift** Mean (SD)	**Post-shift** Mean (SD)	% Change	Probability*
FVC	108 (12.2)	106 (12.3)	–1.50	0.039
FEV_1	104 (12.7)	102 (12.9)	–2.01	0.015
FEF_{75-85}	86 (24.1)	84 (25.5)	–2.94	0.050
FEV_1/FVC	80 (4.3)	79 (4.7)	–0.43	0.106

*Paired *t*-test for all except FEV_1/FVC, Wilcoxon's signed-rank test used since pre-shift values not normally distributed

No significant correlation was observed between personal sample environmental variables and pulmonary function decrements exceeding 5%, or with all values for pulmonary function decrements. No significant differences in age, sex, shift, plant of employment, and length of employment or exposure were observed between workers showing a decrement exceeding 5% and those showing a decrement below 5%.

Microbiological handwash data

There were 48 measurements made of biota before and after hand washing. Table 6 shows the geometric mean and geometric standard deviation of the enumerations in the 48 paired comparisons. A significant reduction in biota was observed for the enumeration of microorganisms on each of the three growth media; standard methods agar, inhibitory mould agar, and eosin methylene blue agar. Subgroups of workers with significantly different pre-wash enumerations were also sought. None of the subgroup comparisons had a probability indicating a significant difference. The culture analyst made notes of organism type where discernible. Fungi were the most commonly observed type of organisms annotated on the pre-wash hand elutions. Only two samples (2%) were noted as having coliforms present. None of the postwash elutions were noted as having coliforms present.

Table 6 *Hand elution data*

Media	Number of colonies, geometric mean (GSD)			
	Pre-wash	Post-wash	%Reduction	Probability*
Standard methods agar	4.53×10^7 (6.41)	1.17×10^7 (8.24)	74.2	<0.001
Inhibitory mould agar	520 (10.7)	118 (5.35)	77.3	<0.001
Eosin methylene blue agar	4.91×10^5 (59.6)	3.85×10^4 (40.3)	92.1	<0.001

*Wilcoxon's signed-rank test

Employment length

The mean length of time the workers were employed was 4.7 years (SD=2.7) The workers were classified by length of employment (greater/less than five, six, or seven years) to determine if length of employment had any bearing on the magnitude of cross-shift pulmonary function decrements. The mean decrements were greater in magnitude for workers with longer employment for all the variables, although the only significant differences (at 0.01) were found in workers with seven or more years of employment in cross-shift FVC decrement (P=0.068) and cross-shift FEV_1 decrement (P=0.071). Workers employed for less than seven years had a mean cross-shift decrement in FVC of 0.44% (SD=5.66) versus 2.98% (SD=5.72) in workers employed for seven years or more. Workers employed for less than seven years had a mean cross-shift decrement in FEV_1 of 0.76% (SD=7.27) versus 3.84% (SD=6.16) in workers employed for seven years or more. A significant correlation (-0.614, P=0.011) was observed between employment length and FVC decrement for the 25 workers employed for seven years or more. Table 7 shows cross-shift pulmonary function decrements by employment length. Pre-shift and post-shift pulmonary function variables were each

compared by the length of employment groupings and showed no significant differences. Symptoms were tested for differences based on length of employment; none of which showed a significant difference based on the length of employment groupings.

Table 7 *Cross-shift pulmonary function decrements by employment length*

Years of employment	N	Decrements (%)			
		FVC	FEV_1	$FEF_{75–85}$	FEV_1/FVC
<1	12	-1.19	-0.27	0.26	0.89
≥1<2	8	2.03	2.24	13.50	0.16
≥2<3	2	-0.60	-2.02	-7.38	-1.46
≥3<4	7	-2.06	-3.77	-16.90	-1.83
≥4<5	1	0.00	2.57	9.85	2.57
≥5<6	17	0.38	-0.61	0.231	-1.06
≥6<7	7	-2.38	-2.49	-2.69	-0.13
≥7<8	19	-1.42	-2.46	-7.04	-1.08
≥8	6	-7.94	-8.20	-4.67	-0.25

DISCUSSION

The failure to observe acute symptoms seems to agree with the low magnitude of cross-shift changes in pulmonary function variables. The medical history questionnaire revealed several symptoms which were significantly elevated.

Diarrhoea levels seem quite excessive. A study of irritable bowel syndrome conducted in Minnesota showed a prevalence of chronic diarrhoea of 17% in the 835 respondents to their questionnaire (whites with mean age 50, 46% male) (20). Another study conducted in Scotland indicated that about 12% of the individuals represented by their study population of 425 households reported diarrhoea in the preceding three months (21). Work-related vomiting or diarrhoea was reported in 27% of a garbage handling workforce (10) and work-related diarrhoea was reported in 36% of a garbage/sewage composting plant workforce by *Lundholm and Rylander* (22). A recent study of 1,747 Danish waste collectors showed prevalence proportions of 11% for nausea symptoms and 19% for diarrhoea (23). The 65% reporting diarrhoea herein and having 85% of those employees indicating having it at work is clearly higher than any of the above studies of residential or work populations.

Although the level of headaches in the RDF workers is high (61%), comparisons are difficult because headache prevalence estimates have been hampered by a clear case definition (24). A Danish postal questionnaire study of 4,000 randomly selected Danes found a point prevalence of headache of 11% in men and 22% in women (25). A study of workers in the UK showed nearly 31% experiencing at least one headache in the previous year that they considered »severe« (26). High levels of headache (45%) were also reported in garbage/sewage composting plant workers by *Lundholm and Rylander* (22).

The large proportion of workers reporting nose irritation without a cold (51%) does seem elevated, but not surprisingly so, given the odorous nature of the workplace. *Mustajbegović and co-workers* (27) observed an increase in nasal irritation in their study of sanitation workers, reporting a nasal catarrh prevalence rate of 36% compared to nearly 2% in controls. The study also reported a sinusitis prevalence of 24% in sanitation workers compared to nearly 2% in controls. Both of these are below the 53% of the RDF workers reporting sinus trouble without cold.

The levels of phlegm and cough and phlegm in RDF workers were also higher than values published for a group of nonexposed blue-collar workers, although the literature groups had higher percentages of smokers, females, and black workers (28, 29). None of the skin rash questionnaire responses approached the magnitude of the above responses. The level of rash in the previous year reported herein (35%) is close to *Gellin and Zavon's* 1968 study of Cincinnati solid waste workers (6). Their study found 30% of the workers to have folliculitis to the torso and 45% to have lower limb xerotic dermatitis.

There is not a large cross-shift decrement in pulmonary function values for the workforce as a group, despite the statistically significant differences between pre-shift and post-shift measurements for FVC and FEV_1. From a physiological standpoint, a 3% intrasubject variation is reported as normal for FVC or FEV_1 (30), although a variation of this magnitude would be interesting for a group. There are some workers who exhibited a decrease exceeding 10%: four workers (6%) for FVC and six workers (8%) for FEV_1. Three workers (4%) were in both groups. Despite the lack of a large decrement in cross-shift pulmonary function, correlations were sought between cross-shift pulmonary function decrements, environmental exposure variables from the concurrent environmental sampling study, and age and length of employment. None were found, except for the grouping of workers exposed for seven years or more.

The trend towards cross-shift pulmonary function decrement increasing with duration of employment compares with similar findings by *Donham and co-workers* (31). In that study, workers also showed a greater decrement in FEV_1 after six years of exposure (and a greater correlation of exposure with response). A recent Croatian study showed that FVC and FEV_1 were significantly lower than predicted values in sanitation workers with more than 10 years of employment (27). The large numbers of workers in the study of *Donham and co-workers* (31) greatly enhanced their ability to correlate exposure with effect, as they had 147 workers employed six years or more. In this study there were only 25 workers employed for seven years or more, the time grouping showing a significant difference in cross-shift pulmonary function variables.

The lack of a significant correlation between either age or length of employment and lung function decrements tends to downplay the importance of the differences in lung function based on groupings above or below seven years. The plants have been open for less than ten years, which is a time too short for a chronic disease or one with a latency period to manifest itself.

The technique used to sample the microbial contamination on workers' hands is a common method for enumeration of microbial contamination. There are, however, no regulations regarding the amount or type of organisms that should be present on workers' hands and little data on what would be considered normal (32). The current handwashing practices at the plants do reduce significantly the amount of viable organisms on workers' hands, although large numbers of organisms remain. Another

favourable indicator regarding handwashing techniques is the absence of coliforms on post-handwash samples. Coliforms are commonly used as indicator organisms for human faecal contamination and have been associated with gastrointestinal illnesses such as diarrhoea. The large numbers of workers reporting diarrhoea was thought to be an indicator of the hand-to-mouth ingestion of gastrointestinal pathogens. The reporting of diarrhoea symptoms noted in the historical questionnaire was not noted in the cross-shift questionnaire. We cannot tell whether this is an artefact of the reductions in biota counts of the current handwash practices or not.

CONCLUSIONS

The primary motivation for the study was management and employee concern regarding worker health in two RDF processing plants. Reporting of several symptoms was significantly elevated in the RDF workers relative to other workers; diarrhoea at work, headache (without cold), nasal irritation (without cold), cough with phlegm (without cold), and phlegm were all elevated compared to a small control group. No current cases of diarrhoea were observed, which may relate to the efficacy of current handwashing practices. Having one or more skin rash in the previous year and having redness and itching of the arms was also reported more frequently in RDF workers than in the small reference group. Cross-shift lung function decrements were found for FVC and FEV_1, although not appreciably so from a physiological standpoint. The small sample size reduced the power to detect significant small differences in cross-shift lung function. Despite the lack of a large reference population and the small sample size, this is the largest and most in-depth look at worker health in the refuse-processing industry in the US.

The trend towards increased lung function decrements with time, evidenced by the larger decrement in those employed for more than seven years, indicates that the annual lung function testing should be continued. The administration of a health-symptom questionnaire, on an annual or biannual basis, would help track the symptoms that were found to be elevated in RDF workers and identify trends in other symptoms. The lack of active diarrhoea cases during the study should not reduce the emphasis of personal hygiene in the workplace. The current handwashing practices do reduce the microbiological contamination on workers' hands, but considerable contamination remains and should be an ongoing concern.

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Sažetak

RESPIRACIJSKI, GASTROINTESTINALNI I DRUGI ZDRAVSTVENI UČINCI U RADNIKA NA PRERADI OTPADA U GORIVO

Istraživanjem su se željeli ispitati zdravstveni učinci u radnika dvaju pogona za preradu otpada u gorivo. U tu je svrhu testirana plućna funkcija radnika u svim smjenama. Radnici su, osim toga, ispunjavali i upitnik koji je sadržavao pitanja o simptomima uočenim samopromatranjem. Mikrobiološkim testiranjem uzoraka kože s ruku procijenjena je mogućnost dobivanja proljeva preko prljavih ruku. Više od polovice radnika žalilo se na tegobe sa sinusima, glavobolju, nadraženu sluznicu nosa te proljev. Malen, ali statistički značajan pad u plućnim funkcijama zamijećen je u forsiranom vitalnom kapacitetu (1,5%) i forsiranom ekspiratornom volumenu u prvoj sekundi (2,0%). Radnici sa stažem duljim od sedam godina iskazali su značajniji pad ovih vrijednosti od radnika s manjim stažem. Nije zamijećen niti jedan slučaj proljeva za trajanja istraživanja. To se, međutim, može pripisati vrlo učinkovitom pranju ruku za koje je utvrđeno da značajno smanjuje broj mikroorganizama na rukama radnika. Mali pad plućnih funkcija obilježje je promatrane skupine radnika. Učestale žalbe na neke simptome te smanjenje plućnih funkcija koje se pogoršava s godinama rada upućuju na potrebu daljnjeg istraživanja.

Ključne riječi:
duljina zaposlenja, glavobolja, kruti otpad, nadražena nosna sluznica, plućne funkcije, proljev, upitnik

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