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GASTROINTESTINAL SYMPTOMS AMONG WASTE RECYCLING WORKERS*

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Abstract: It is expected that exposure to airborne microorganisms among waste recycling workers depends on type of plant (composting, biogas-producing, and sorting plant). Previous studies among waste recycling workers at selected plants indicated gastrointestinal symptoms related to bioaerosol exposure. This nationwide study reports findings of self-reported gastrointestinal symptoms by self-reported type of plant. A questionnaire based survey among Danish waste recycling workers (n = 432) at all composting, biogas-producing, and sorting plants collected data on occupational exposures, present and past work environment, the psychosocial work environment, and health status. Two hundred and seventy-seven participated and the response rate was 64%. Prevalence Proportion Ratios (PPR) adjusted for other possible types of job and relevant confounders were estimated by multivariate logistic regression with a comparison group of non-exposed workers. Sorting of paper was associated with reports of diarrhoea. Working with sorting of plastic was associated with nausea, and working with compost was associated with diarrhoea. Females reported more symptoms than males. This study confirmed the association between gastrointestinal symptoms and the type of recycling plant.

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INTRODUCTION

Waste recycling is of growing interest throughout the industrialized world. New recycling plants are likely to be built in an attempt to recycle increasing amounts of waste. It is a known problem that some types of recycling cause severe health problems among the employees [13]. However, more information is needed to prevent health problems in an expanding industry.

It is expected that exposure (mainly to bioaerosols) among waste recycling workers depends on type of plant (composting, biogas-producing and sorting plant), working routines, equipment, type of waste etc. Reported health problems among recycling workers have included gastrointestinal and respiratory symptoms related to bioaerosol exposure [2, 12, 17, 21].

The present nationwide study relates self-reported gastrointestinal symptoms to self-reported working conditions in an attempt to establish a relationship between the gastrointestinal symptoms and work at a recycling plant.

MATERIAL AND METHODS

Information on health problems and working conditions was collected via a telephone interview in 1995 among all employees at Danish recycling plants. The recycling plants included were:

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Table 1. Number of employees per type of recycle plant and gender. Study among Danish recycle workers (n = 277), 1995.

Type of plant	Male	Female	Total
Composting	27	1	28
Biogas-producing	14	1	15
Sorting, all kinds	170	64	234
Sorting, paper	88	15	103
Sorting, glass	58	38	96
Sorting, plastic	43	15	58
Total	211	66	277

The total number does not match the number of interviewed as some of the sorting plants are occupied with more than one type of sorting.

i) 6 biogas-producing plants where the biodegradable fraction of the household waste is transformed into biogas used for heating and the production of electricity,

ii) 7 composting plants where the biodegradable fraction of the household waste and garden waste is transformed into compost, and

iii) 46 sorting plants where presorted paper, glass and bottles, or plastic are sorted into a recyclable fraction. Moreover, 9 plants occupied with both sorting and composting were included.

Table 2. Prevalence of nausea and diarrhoea according to plant type and gender. Study among Danish recycle workers (n = 277), 1995.

Type of plant	Male	Female	Total
Nausea			
Composting	3 (11)	0 (-)	3 (11)
Biogas-producing	4 (29)	0 (-)	4 (27)
Sorting, all kinds	30 (18)	21 (33)	51 (22)
Sorting, paper	20 (23)	7 (47)	27 (26)
Sorting, glass	9 (16)	15 (39)	24 (25)
Sorting, plastic	9 (21)	4 (27)	13 (22)
Total	37 (18)	21 (32)	58 (21)
Diarrhoea			
Composting	3 (11)	1 (100)	4 (14)
Biogas-producing	1 (7)	0 (-)	1 (7)
Sorting, all kinds	22 (13)	10 (16)	32 (14)
Sorting, paper	16 (18)	4 (27)	20 (19)
Sorting, glass	8 (14)	5 (13)	13 (14)
Sorting, plastic	6 (14)	3 (20)	9 (16)
Total	26 (12)	11 (17)	37 (13)

Exact numbers and percent in parenthesis (rounded). The total number does not match the number of interviewed as some of the sorting plants are occupied with more than one type of sorting.

A total of 432 recycling workers were identified and of these around 64% (n = 277) agreed to participate in the telephone interview. Of the 277 persons, 5% worked at biogas-producing plants, 10% worked at composting plants, and the remaining 85% worked at sorting plants. A total of 27% of the sorting workers were women (Tab. 1).

The questionnaire. The questionnaire included the following main groups of questions: Present and former working conditions, the psychosocial work environment, background information, smoking- and drinking habits, and health status.

Present and former working conditions dealt with questions on duration of employment, physical activities during present and former employment, number of working hours per week/day, and type of payment (e.g. fixed wages, piecerate).

The questions on exposure included questions on type of plant, type of waste, working positions, type of work-processes and duration of time in each process.

The psychosocial questions were from the Whitehall studies [15] which relate to the demand-control-support model [7, 8]. From these questions the three psychosocial exposure measures demand, control and job-support were calculated [14].

Background information dealt with questions about gender, age, use of medicine, and general health.

The questions on gastrointestinal symptoms included: 'have you ever had nausea/diarrhoea' and the answer options were dichotomized so that no symptoms and symptoms some times per year were deemed as 'No' and symptoms some times per month or more frequent were deemed 'Yes' [22].

Statistical methods. To analyze the relationship between exposure level and nausea or diarrhoea, logistic regression models were fitted with proc logistic in SAS. Type of recycle plant (composting, biogas-producing, paper-sorting, glass-sorting, plastic-sorting) was used as an explanatory variable, and to prevent mutual confounding, all plant types were included in the same model. Other variables included were those which were almost statistical significant ($p < 0.10$) in univariate analysis.

All explanatory variables were included in the first model. Then the model was reduced depending on the Wald test and the relevance of the biological variables. If removal of one variable lead to a 10% change in one or several parameter estimates for the other relevant explanatory variables, the variable was maintained in the model no matter the p-value. No interaction terms were to be included.

Finally the risk estimates were fitted with proc genmod in SAS with binomial error and a log link-function. This analysis yields as a result the Prevalence Proportion Ratio (PPR) [1, 23]. For each PPR are shown 95% confidence limits and p-value for level of significance (Wald test).

The fit of the final model was analyzed with the Hosmer-Lemeshow test [5] and with the area under the ROC-curve [9].

RESULTS

Nausea. A total of 58 out of 276 (21%) reported of nausea some times per month or more frequent as seen from Table 2. Of these the group of females reported more symptoms compared to their male colleagues.

In the multivariate analysis of nausea, gender was of importance, and so were the psychosocial exposure measures demand and job-support, and migraine experienced more than 8 days a year. The results are presented in Table 3. For this model the Hosmer-Lemeshow test gave p=0.26 and the area under the ROC-curve amounted to 0.74 indicating good fit.

Working at a plastic sorting plant was associated with reports of nausea (PPR=1.8 (1.2-2.6)), and so was working at a biogas-producing plant, although the relation was not significant (PPR=1.4 (0.64-3.1)). Working at a composting plant, and at glass- or paper sorting plants was not associated with reports of nausea.

Females reported borderline more symptoms than males (PPR=1.1 (0.75-1.7)). High demands, low job support and migraine were associated with reports of nausea.

Diarrhoea. A total of 37 out of 274 (13%) reported diarrhoea some times per month or more frequent as seen from Table 2.

The analysis of reports of diarrhoea included information on gender, age group, the psychosocial exposure measure demand, average daily intake of alcohol and physical activity during former employments. The results are presented in Table 4. Concerning the fit of the model the Hosmer-Lemeshow test gave p=0.54 and the area under the ROC-curve amounted to 0.78 indicating good fit.

Working at a paper sorting plant was associated with reports of diarrhoea (PPR=2.7 (1.3-5.2)) and so was working at a composting plant. Working at a composting plant had however only a non-significant association (PPR=2.8 (0.90-8.8)). Working at a plastic sorting plant was slightly associated with diarrhoea (PPR=1.4 (0.72-2.7) and so was working at a glass sorting plant (PPR=1.2 (0.59-2.3). No association was found for workers at biogas-producing plants.

Females reported non-significantly more symptoms than males. Reporting of diarrhoea decreased with age, increased in connection with alcohol consumption and high job demands. A former heavy occupation seemed protective concerning diarrhoea.

DISCUSSION

In the present nationwide survey among workers at composting, biogas-producing, and sorting plants, an association was found between sorting paper and diarrhoea, between nausea and work at plastic sorting plants, and non-significantly between diarrhoea and work at composting plants. Only few studies exist on the relation between recycling work and gastrointestinal symptoms. The present study related self-reported exposure with self-reported health status. Further studies will

Table 3. Final multivariate model for nausea, (n = 276, cases = 57) in the study among Danish recycling workers, 1995.

Variable		PPR (95% CI)	p-value
Composting	E	0.60 (0.21;1.7)	0.35
	NE	1	-
Biogas-producing	E	1.4 (0.64;3.1)	0.38
	NE	1	-
Sorting, paper	E	0.96 (0.63;1.5)	0.84
	NE	1	-
Sorting, glass	E	0.82 (0.54;1.2)	0.32
	NE	1	-
Sorting, plastic	E	1.8 (1.2;2.6)	0.01
	NE	1	-
Gender	Female	1.1 (0.75;1.7)	0.56
	Male	1	-
Demand	Above or equal to mean	2.1 (1.3;3.2)	<0.01
	Below mean	1	-
Support	Below mean	1.7 (1.1;2.5)	0.02
	Above or equal to mean	1	-
Migraine, days/year	≥ 8	1.7 (0.65;4.6)	0.27
	< 8	1	-

E: Exposed means working at type of plant; NE: Non-exposed means not working at type of plant; PPR: Prevalence Proportion Ratio; 95% CI: 95% Confidence Interval.

Table 4. Final multivariate model for diarrhoea, (n = 274, cases = 36) in the study among Danish recycling workers, 1995.

Variable		PPR (95% CI)	p-value
Composting	E	2.8 (0.90; 8.8)	0.07
	NE	1	
Biogas-producing	E	1.1 (0.16; 8.5)	0.89
	NE	1	
Sorting, paper	E	2.7 (1.3; 5.2)	<0.01
	NE	1	
Sorting, glass	E	1.2 (0.59; 2.3)	0.67
	NE	1	
Sorting, plastic	E	1.4 (0.72; 2.7)	0.34
	NE	1	
Gender	Female	1.4 (0.70; 2.7)	0.34
	Male	1	
Demand	Above or equal to mean	2.3 (1.2; 4.5)	0.01
	Below mean	1	
Age group, years	46-	0.37 (0.14; 0.97)	0.04
	31-45	0.73 (0.36; 1.5)	0.38
	-30	1	
Average alcohol consumption, drinks per day	1 or more	2.0 (1.0; 4.0)	0.04
	0	1	
Former physical activity	Heavy	0.48 (0.25; 0.94)	0.03
	Light	1	

E: Exposed means working at type of plant; NE: Non-exposed means not working at type of plant; PPR: Prevalence Proportion Ratio; 95% CI: 95% Confidence Interval.

evaluate the relationship between measured bioaerosol exposure and self-reported health problems in the same way as was done in studies among waste collectors [6].

The recycling trade is characterized by several small plants, each with only few employees. The low number of employees resulted in very broad 95% confidence limits for the PPRs and thereby several non-significant relationships. It can be discussed whether 90% confidence limits would have been more suitable in this study.

Despite the broad confidence limits, the tendency showed more gastrointestinal symptoms among females than among their male colleagues. This pattern was also reported in a study on musculoskeletal symptoms of the forearm-hand [4]. Here it seemed as if females were either assigned or chose tasks that involved higher exposure to some risk factors for work-related health problems.

Migraine as well as a high alcohol consumption are factors known to be associated with nausea and diarrhoea symptoms. The estimated PPRs were high for people with migraine and for those drinking alcohol. Finding again this tendency in our study indicates that the questionnaire reliably identified gastrointestinal symptoms [6].

This study indicates a difference in reports of nausea and diarrhoea according to type of plant. Working at composting plants was associated with reporting of diarrhoea some times per month or more frequent. Other studies found the gastrointestinal symptoms among employees at composting plants associated with exposure to airborne Gram-negative bacteria [10], especially endotoxin [3]. The same association of gastrointestinal symptoms and Gram-negative bacteria was reported in other occupations known to be exposed to high amounts of Gram-negative bacteria [11, 24]. It is assumed that the gastrointestinal symptoms among employees at biogas-producing plants also may be due to exposure to airborne Gram-negative bacteria, as both plants handle the biodegradable fraction of household waste.

Endotoxin, which is a part of the Gram-negative bacteria [18, 19], has been suggested as the cause of gastrointestinal symptoms [11]. However, in a study among waste workers, no clear pattern was found between gastrointestinal symptoms and exposure to endotoxin [21]. Moreover, studies in the USA found no relationship between health effects and the microorganisms contained in the waste [16]. It is therefore not likely that endotoxin in itself is a causal agent for gastrointestinal symptoms.

The highest prevalence of gastrointestinal symptoms was reported among workers at the paper sorting plants. This finding was surprising. Previous studies of paper sorting plants have focused on lung function impairment due to paper dust. One study found high concentrations of microorganisms in paper waste that came from mixed household waste [16], whereas the paper was a presorted fraction in our study. Gastrointestinal problems were reported among employees in a paper-mill [20]. However, this was in a wet working environment in contrast to the dry paper sorting environment in this study, so the results are not comparable.

No literature has been found concerning gastrointestinal problems among workers at plants sorting glass or plastic.

Thus, the causes of the gastrointestinal symptoms are still unknown, and more studies are needed to relate the health symptoms to the work-related exposures.

In conclusion, this nationwide cross-sectional study among waste recycling workers confirmed the association between gastrointestinal symptoms and work with recycling of waste. The present results are a step in the description of the causality of health problems and thereby a step in the prevention of occupational disorders in this trade.

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