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Lung health in workers exposed to reed dust

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KEYWORDS
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Summary We conducted a cross-sectional survey in a cellulose plant among 109 reed workers, exposed to reed dust and 78 unexposed office workers, to investigate respiratory health effects of reed dust exposure. Investigations included dust measurements, serum total IgE, skin prick test, pulmonary function testing and questionnaire on respiratory symptoms. Total dust level in the reed processing unit was higher than the office (9.7 and 0.02 mg/m^3, respectively). Reed workers had a higher rate of current smoking (67% and 46%, respectively). After the adjustment for smoking status and age, reed dust exposure was significantly associated with wheezing, chronic cough, dyspnea, itching eyes and itching nose. Chest tightness and ODTS symptoms were only reported by reed workers (27.5% and 23.9%, respectively). After the adjustment for pack-years of smoking, percentage of predicted FEV_1, FVC, FEV_1/FVC and FEF_{25-75} in reed workers were significantly lower than office workers. Among reed workers, wheezing was associated with older age ($>$40 years) and ever smoking, and cross-shift decline in FVC and FEV_1 with shorter duration of work. Reed dust exposure in the workplace could provoke respiratory symptoms, possibly due to an irritating effect. Health selection bias is likely, and could have underestimated the health effects of reed dust exposure.

Introduction

Exposure in the paper and pulp industry includes various hazardous substances such as paper dust, wood dust, paper additives, fungal spores and chemical agents.[1] Some of the studies indicated loss of lung function and increased prevalence of

Abbreviations: CI, confidence interval; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; ODTS, organic dust toxic syndrome; OR, odds ratio

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respiratory symptoms related to the occupational exposures, while some others did not show any significant respiratory effect.[2,3] Accidental spilling of chlorine (gassing), used for bleaching is another potential hazard, which could lead to irritation in the throat and eyes and chronic airway disease.[4–7]

In developing countries, small-sized workplaces, which usually do not attain the regulations to control dust exposure, prevail in the industry. Hence, prevalence of the above-mentioned diseases and symptoms could be higher in the developing countries than that of developed countries.

We investigated the respiratory health effects of reed dust exposure in a cross-sectional study of workers in a plant manufacturing cellulose. Our main objective was to assess the prevalence and risk of asthma symptoms and airway disease due to reed dust exposure.

Materials and methods

We planned to investigate the respiratory symptoms and pulmonary function testing of the workers exposed to reed dust, after we had a patient, who developed asthma symptoms, while he was working in a cellulose plant. The patient received treatment with inhaled beclametasone 200 mcg, bid and inhaled salbutamol as needed. He was living in a village near the plant and was still working in the plant during our survey.

Reed plant was the only plant in Turkey, which was using stems of reed (*Phragmites communis*) found along the lake to produce cellulose. Straw was also used for the production of cellulose, when there was shortage of reed. During the survey, there was sufficient stock of reed and only reed was being used.

The plant was located in Cay, a town about 100 km far from Afyon, which is a city in the Western region of Turkey. The town had a dry inland climate, and a population of about 5000. Work in the plant was divided into transportation, cutting and grouping of the reeds in one big unit (reed-processing unit) and treating the prepared material with bleaching agents including caustic and hypochloric acid in a separate unit. Workers in the reed-processing unit had no exposure to the chemicals. Our interview with the plant physician did not reveal any occasion of accidental spill of chlorine. One hundred nine of the 150 (73%) male workers at the storage, transportation and cutting sections and 78 of the 116 male office workers (67%) gave informed consent and participated in the study. The informed consent stated that any medical problem that would be noticed during the survey would be reported to the plant physician so that he would inform the participant, and deal with the problem. There was neither a seasonal worker nor a history of another occupational exposure among the study participants.

Subjects

Workers in the reed-processing unit (reed workers) were mainly from the villages around the plant and had previous exposure to reed dust as they were collecting reeds to make baskets or rugs or to sell them to the plant. Office workers were mainly living in the town and had no previous exposure to reed dust. They were from a similar social and educational background, and earning wages comparable to the workers. Plant manager informed us about frequent transfer of workers between sections of the reed-processing unit according to the work demands. Thus, all the exposed workers were assumed to have similar exposure to reed dust.

Exposure

Reed was collected by the villagers and brought to the storage unit of the plant in bundles of 4–10. Bundles were transported to the cutting station to be mechanically sliced and grouped into lots before they were sent to the bleaching unit. Maximum capacity of the plant in a regular workday was 30 tons of reeds. A regular workweek included 5 workdays and each workday was divided into three shifts (8 a.m.–4 p.m., 4 p.m.–midnight, midnight–8 a.m.).

Concentration of respirable dust in the workplace and the office were measured using the Casella-London AFC 123 personal samplers. Three samples were taken from the plant from different sites (preparation, grouping, and cutting sections), in the morning 8 a.m., while the workers were doing their tasks. The door separating the cutting section from the storage section was open during the measurement, as there was transportation of the reeds. Duration of the sampling was 2 h.

Outcome variables

A physician from the investigation team administered a respiratory questionnaire, which included information on smoking status, occupation, respiratory symptoms, and diseases. Questions about cough and earlier diseases were adapted from British Medical Research Council questionnaire and supplemented by questions about phlegm, chest tightness, wheezing, dyspnea, itching eyes, and itching nose.[8] Symptoms were determined, when the subject gave "Yes" response to the question, which was asking if the subject often (more than one third of the time) had the symptom. "Yes" response to the following question: "Have you, during the last year, had episodes of influenza-like symptoms (fever, shivering, malaise, cough, tiredness, weakness, muscle and joint pains) in connection with dusty work?" was used to define ODTS. Smoking status was categorized as non-smoker (not regularly smoked one cigarette per day for a year), ex-smoker (quit smoking at least 1 year before the survey) and current smoker (smoking within 1 year before the survey). Amount of cigarettes smoked was calculated as pack-years, which is the product of the average number of packs (a commercial pack contains 20 cigarettes) smoked in a day by the number of years that the subject has smoked.

Pulmonary function testing was performed at the beginning and end of each shift according to the ATS guidelines.[9] A portable spirometer (Gold Pulmonary Analysis Computer, and Pulmograph, Holland) was used to measure the forced vital capacity (FVC), and forced expiratory volume in 1 s (FEV_1), and mid-maximal expiratory flow rate (FEF_{25-75}). Best of the three maneuvers was recorded. Predicted values of pulmonary function testing based on height and age, as adopted by Knudson et al., were used.[10] Calibration of the spirometer and leakage test was performed four times before each shift by a calibrated 3-l syringe at three different injection speeds, and found appropriate. Sera from the subjects were obtained and tested by an immunoassay method for total IgE level. Commercially available kits were used according to the instructions of the producer (Melja, Germany).

Skin prick testing was performed according to Österballe and Weeke[11] The panel included 18 common aeroallergens as follows: *Dermatophagoides pteronyssinus, D. farinae,* cockroach, *Phleum pratense, Artemisia vulgaris, Betula verrucosa,* hazelnut, *Olea europaea, Parietaria officinalis, tyrophagus Putrescentiae, Acarus siro, Lepidoglyphus destructor, Aspergillus fumigatus, Cladosporium herbarum, Alternaria alternata,* horse, cat and dog. Drops of allergen extracts were placed on the volar aspect of the forearm and penetrated by a lancet with a 1-mm point and the resulting wheals were measured after 15 min. The largest horizontal and perpendicular diameters were noted and their arithmetic mean was calculated. A mean diameter of 3 mm or more than that of the negative control was considered as positive. Atopy was considered in the presence of at least one positive reaction as defined above.

Statistical analysis

Respiratory symptoms and pulmonary function testing results were compared between the reed workers and the office workers. Student *t*-test was used for the comparison of continuous factors. Odds ratios were used to assess the association between reed dust exposure and potential risk factors. Multiple logistic regression analysis was used to adjust for smoking status and age to assess the independent association between respiratory and allergic symptoms and reed dust exposure.[12] Association between exposure to reed dust and the percentage of predicted FEV_1, FVC, and FEF_{25-75} was adjusted for pack-years of smoking and duration of work via general linear model, which provided the estimated means in different subgroups of the study population. As the control group had different background exposure than the workers exposed to reed dust, restricted analysis of the symptom wheeze and cross-shift difference in FEV_1 and FVC were conducted in the workers exposed to reed dust as stratified for age, atopy, section, smoking status and duration of work. Workers were categorized into cumulative exposure groups according to the median duration of work in the plant. Cross-shift FEV_1 change and and cross-shift FVC change were defined as: % of predicted $FEV_{1\,(\text{at the end of shift})}$ − % of predicted $FEV_{1\,(\text{at the beginning of shift})}$ and predicted % of FVC $_{(\text{at the end of shift})}$ − % of predicted FVC $_{(\text{at the beginning of shift})}$, respectively. Multiple linear regressions models adjusted for the potential risk factors, which were selected to the models by stepwise method with inclusion and exclusion criteria of 0.15 and 0.20, respectively. Statistical significance was assumed for *P* values less than 0.05. Ninety-five percent confidence intervals (95% CI) of the measures of association were calculated and reported. Statistical package of SPSS for windows (9.11 version) was used for the statistical analysis.

Results

Total dust level in the reed processing unit and the office were 9.7 mg/m^3 and 0.02 mg/m^3, respectively. Respirable dust level in the reed processing sections of plant (preparation section: 4.1 mg/m^3, grouping section: 13.8 mg/m^3, cutting section: 11.3 mg/m^3) was much higher than that of the office (0.02 mg/m^3) (Table 1).

Personal characteristics and demographic information of the study population are presented in Table 2. Reed workers had a higher rate of current smoking than the office workers (67.9% vs. 46.2%). There was no significant difference in mean pack-years of smoking between the two groups. Atopic status as determined by skin prick testing (14.7% vs. 16.7%) or the total IgE measurement did not show a statistically significant difference between the two groups.

Comparison of respiratory and allergic symptoms in the office workers and reed workers is shown in Table 3. After the adjustments for smoking status and age, exposure to reed dust was significantly associated with wheezing (OR: 5.3, 95% CI: 2.3–12.4), chronic cough (OR: 5.5, 95% CI: 2.2–13.9), dyspnea (OR: 11.1, 95% CI: 4.0–30.5), itching eyes (OR: 2.5, 95% CI: 1.1–5.8), and itching nose (OR: 2.8, 95% CI: 1.2–6.4). Chest tightness and ODTS symptoms were only reported by the reed workers (27.5% and 23.9%, respectively).

Table 1 Dust measurements of the office and the reed plant.

Work sites	Respirable dust level (mg/m^3)
Office	0.02
Preparation section	4.1
Grouping section	13.8
Cutting section	11.3

Table 2 Personal characteristics and atopic status of office workers and reed workers.

	Office workers	Reed workers
N	78	109
Age (year), mean±SD (median)	39.5±5.4 (40)	40.7±2.8 (40)
Height (cm), mean±SD (median)	172.1±5.9 (172)	171.4±7.3 (172)
Smoking status *n* (%)		
Non-smoker	27 (34.6)	20 (18.4)
Ex-smoker	15 (19.2)	15 (13.8)
Current smoker	36 (46.2)	74 (67.9)*
Amount of cigarettes smoked (pack-year) mean ± SD (median)		
Ex-smoker	26.5±19.2 (23)	22.2±29.0 (12)
Current smoker	22.3±13.4 (21)	23.5±11.1 (22.5)
Duration of work (year), mean±SD (median)	12.0±6.0 (15)	15.4±4.7 (15)*
Atopy†	13 (16.7)	16 (14.7)
Total IgE, mean±SD	112.8±59.8	129.2±65.2
Logarithm of total IgE, mean±SD	2.0±0.4	2.0±0.3

Values are expressed as counts and percentages in parentheses, unless otherwise specified.
*$P<0.05$.
†Atopy was defined as at least one positive reaction to the aeroallergens tested.

Table 3 Comparison of respiratory and allergic symptoms in office workers and reed workers.

	Office workers *n* (%)	Reed workers *n* (%)	OR* (95% CI)
Diagnosis of asthma	4 (5.1)	5 (5.6)	0.9 (0.2–3.7)
Wheezing	8 (10.3)	47 (43.1)	5.3 (2.3–12.4)
Chest tightness	0 (0)	30 (27.5)	NA
Chronic bronchitis	12 (15.4)	27 (24.8)	1.7 (0.7–3.8)
Chronic cough	7 (9.0)	34 (31.2)	5.5 (2.2–13.9)
Dyspnea	5 (6.4)	46 (42.2)	11.1 (4.0–30.5)
ODTS	0 (0)	26 (23.9)	NA
Eczema	5 (6.4)	9 (8.2)	1.4 (0.4–4.4)
Itching eyes	9 (11.5)	28 (25.7)	2.5 (1.1–5.8)
Itching nose	10 (12.8)	30 (27.5)	2.8 (1.2–6.4)

*Odds ratios adjusted the association between reed dust exposure and the respiratory diseases and symptoms for smoking status (non-smoker as reference, ex-smoker and current smoker as dummy variables) and age (in years, continuous variable).

Table 4 Comparison of percentage of predicted pulmonary function in office workers and reed workers.

	FEV_1	FVC	FEV_1/FVC	FEF_{25-75}
Office workers	99.2 (2.1)	106.1 (2.1)	77.4 (1.0)	87.5 (3.6)
Reed workers	88.3 (1.8)***	99.3 (1.8)*	73.8 (0.8)**	74.4 (3.0)**
Subgroups of reed workers				
Age (year)				
35–40	86.4 (2.6)	98.5 (2.6)	72.7 (1.2)	72.8 (4.1)
41–48	90.1 (2.9)	99.9 (3.0)	74.8 (1.4)	75.0 (4.6)
Duration of work				
$\leqslant$15 years	88.9 (2.3)	99.7 (2.3)	74.3 (1.1)	75.7 (3.6)
>15 years	85.6 (3.7)	97.6 (3.7)	71.8 (1.7)	68.7 (5.8)
Smoked				
Never	93.6 (5.3)	98.6 (5.4)	78.4 (2.5)	80.3 (8.3)
Current	86.8 (2.4)	99.5 (2.5)	72.4 (1.4)	73.2 (3.8)
Past	86.6 (5.3)	98.1 (5.3)	72.9 (2.4)	67.4 (8.3)
Atopy				
Negative	88.9 (2.1)	99.5 (2.1)	74.1 (1.0)	75.2 (3.3)
Positive	83.1 (5.1)	97.0 (5.2)	70.6 (2.4)	65.4 (8.0)
Dust section				
No	88.7 (2.2)	100.1 (2.2)	73.5 (1.0)	72.9 (3.4)
Yes	85.2 (4.5)	94.9 (4.5)	74.1 (2.1)	77.3 (7.0)

Percentage of predicted pulmonary function was adjusted for pack years of smoking in the comparison of office workers and reed dust exposed workers, and for pack years of smoking and duration of work in the comparisons of subgroups of reed dust exposed workers.

*$P<0.05$.

**$P<0.01$.

***$P<0.001$.

Percentage of predicted pulmonary function measurements were compared between the office workers and reed workers (Table 4). After the adjustment for pack-years of smoking percentage of predicted FEV_1, FVC, FEV_1/FVC and FEF_{25-75} were all significantly lower in the workers exposed to reed dust than that of the office workers. Subgroup analysis among the workers exposed to reed dust after the adjustment for pack-years of smoking and duration of work did not reveal any significant difference, but a tendency to decrease with increased duration of exposure to reed dust in the plant, smoking and atopy.

Table 5 shows the association between wheezing and reed dust exposure in different subgroups of reed workers. Current wheeze was significantly associated with older age (above 41 years) and ever smoking. Workers who had atopy or who were in the sections with higher dust measurements (cutting and grouping sections) had higher prevalence of wheeze, which did not reach statistical significance. Workers, who had exposure to reed dust for more than 15 years had a trend for lower prevalence of wheeze as compared to workers, who had exposure to reed dust for 15 years QJ;or less.

Cross-shift change in percentage of predicted FEV_1 and FVC among the reed workers is shown in Table 6. A negative value of cross-shift change in FEV_1 and FVC means cross-shift decline in FEV_1 and FVC, respectively. Cross-shift decline in FEV_1 and FVC were found in the workers, who were atopic, never smoked and exposed to reed dust for 15 years or less than that of the corresponding comparison groups ($P<0.05$ for duration of work and cross-shift change in FVC, and $P>0.05$ for other comparisons). Adjustment for the relevant risk factors (pack-year of smoking for FEV_1, and age, atopy and work in the dust section during the survey for FVC) revealed an increase in both the cross-shift FEV_1 and FVC per each year of work exposure to reed dust.

Discussion

In this cross-sectional survey of workers in a plant manufacturing cellulose, exposure to reed dust was associated with both respiratory symptoms and

Table 5 Association between wheezing and characteristics of the reed workers.

	n	*Wheezing (%)*	Crude OR (95% CI)	Adjusted* OR (95% CI)	Adjusted† OR (95% CI)
Age (year)					
35–40	61	*36*	1	1	1
41–48	48	*52*	1.9 (0.9–4.2)	2.0 (0.9–4.5)	2.4 (1.1–5.6)
Duration of work					
⩽15 years	79	*46*	1	1	1
>15 years	30	*37*	0.7 (0.3–1.6)	0.6 (0.3–1.5)	0.5 (0.2–1.4)
Smoked					
Never	20	*20*	1	1	1
Ever	89	*48*	3.7 (1.2–12.1)	4.7 (1.4–16.0)	4.7 (1.4–16.0)
Atopy					
Negative	93	*41*	1	1	1
Positive	16	*56*	1.9 (0.6–5.4)	1.6 (0.6–4.9)	1.5 (0.5–4.6)
Dust section					
No	88	*41*	1	1	1
Yes	21	*52*	1.6 (0.6–4.1)	1.6 (0.6–4.2)	1.6 (0.6–4.5)

Dust section included cutting and grouping tasks.
*Adjustments were made for age and duration of work.
†Adjustments were made for age, duration of work and ever smoking.

Table 6 Cross-shift change of percentage of predicted FEV_1 and FVC among the reed workers.

	Cross-shift FEV_1 change mean (SD)	Adjusted cross-shift FEV_1 change† beta (SEM)	Cross-shift FVC change mean (SD)	Adjusted cross-shift FVC change‡ beta (SEM)
All	0.24 (19.64)		0.65 (21.12)	
Age (year)				
35–40	0.53 (20.00)	0	–0.23 (21.30)	0
41–48	–0.13 (19.38)	–0.85 (3.76)	1.77 (21.06)	2.49 (3.95)
Atopy				
Negative	0.97 (20.05)	0	1.69 (22.34)	0
Positive	–4.00 (16.95)	–4.89 (5.25)	–5.38 (10.22)	
Dust section				
No	–0.49 (20.49)	0	0.33 (22.07)	0
Yes	3.28 (15.64)	4.01 (4.73)	2.00 (16.91)	0.77 (4.99)
Smoking status				
Never	(17.63)	0	–3.65 (18.92)	0
Ex	(16.12)	(7.29)	0.20 (16.45)	(7.70)
Current	1.44 (20.84)	0.35 (5.85)	1.90 (22.54)	(6.18)
Duration of work				
⩽15 years	(18.10)	—	(19.49)*	—
>15 years	5.87 (19.64)	—	8.03 (23.68)	—
Per 1 year	—	0.87 (0.40)*	—	1.20 (0.42)**

*$P<0.05$.
**$P<0.01$.

†Cross-shift FEV_1 change: % of predicted $FEV_{1\ (\text{at the end of shift})}$-% of predicted $FEV_{1\ (\text{at the beginning of shift})}$. Cross-shift FEV_1 change was adjusted for duration of work (years) and pack-year of smoking of current smokers in different groups of workers.

‡Cross-shift FVC change: % of predicted $FVC_{\ (\text{at the end of shift})}$−% of predicted $FVC_{\ (\text{at the beginning of shift})}$. Cross-shift FVC change was adjusted for duration of work (years) in different groups of workers. Adjustment in the "per year of work" group was made for atopy, age and dust section as categorized in the table.

diminished pulmonary function testing. Multiple regression analysis was used to adjust for the potential confounding factors. Temporal relationship and, thus causality interpretation of the associations is questionable due to the cross-sectional design.[13] However, cross-sectional studies are well justified in the context of a primary investigation of a work exposure.[14] To our knowledge, this was the first study, which has investigated the respiratory effect of exposure to reed dust.

Problems relevant to our study includes the following: "exposures are often mixed, disease outcomes may be quite non-specific...; and potential subjects available for study move in and out of the workforce, in part depending on health status."[15]

As this study included active workers in the reed plant, we could not include a possible group of workers, who had left the job due to respiratory health effects of reed dust exposure. Thus, it should be noted that, results of our study could only be generalizable to active workers exposed to reed dust.

Exposure to dust in the agricultural setting is complex and variable.[16] Workers in our study had no exposure to chemicals including chlorine used to process reed, but had previous exposure to reed dust and other potentially harmful dusts in the villages, where they were living. This might be one of the reasons for the lower pulmonary function testing measurements in the exposed workers. The office workers had no prior exposure to reed dust. Dust level in the reed processing units was almost 500 times higher than that of the office. Therefore, we attributed the differences in pulmonary function and respiratory and allergic symptoms between the reed workers and office workers to reed dust exposure. We could not develop a work exposure matrix and examine the dose–response relationship in different sections of the plant, as the tasks in storage, cutting, and transport units were not specialized. Workers, who worked in the cutting section or grouping section during the survey, had higher exposure to respirable dust, but there was no statistically significant association between working in these sections and prevalence of asthma symptoms or pulmonary function testing. Frequent change of the sections among the workers is a possible explanation for this finding.

Inhalation of endotoxin has been related to acute and chronic respiratory symptoms.[14,17] Therefore, possible role of endotoxin in the occurrence of respiratory symptoms cannot be excluded, since endotoxin level was not measured in the plant. Measurement of endotoxin and the allergen(s) in the workplace would elucidate the cause of the respiratory symptoms due to reed dust exposure.

Occupational asthma has been defined as "a disease characterized by variable airflow limitation and/or airway hyperresponsiveness due to causes and conditions attributable to a particular occupational environment and not to stimuli encountered outside the workplace."[18] Wheezing has been validated and proposed as a definition for asthma, and used in occupational epidemiology.[19,20] In this study workers exposed to reed dust and office workers had almost the same prevalence (5%) of asthma diagnosed by a physician. Reported diagnosis of asthma is likely an underestimation of the prevalence of occupational asthma, as the relationship of many illnesses with occupational exposure may be unnoticed in medical practice.[21] Furthermore, workers might have a tendency to avoid seeking medical help for their symptoms due to fear of losing their jobs.

Increased prevalence of itching nose and itching eyes, chest tightness and diminished pulmonary function testing in the workers exposed to reed dust, compared to the office workers group could be related to allergy, asthma, ODTS or allergic alveolitis. In a study of 37 workers in a soft paper mill exposed to paper dust, Hellgren et al. found increased prevalence of nasal blockage and crusting, but no evidence of increased nasal inflammation as compared to controls.[22]

Among the workers exposed to reed dust, atopy was not associated with wheezing. This finding suggests an irritating effect of reed dust exposure. Sensitization due to reed dust could be tested by preparation an allergen extract of reed dust, which could better characterize the respiratory effect of reed dust.

Development of febrile reaction on dust exposure has been described for ODTS and the initial stage of allergic alveolitis. Our study protocol did not include physical examination or any other test for the differential diagnosis of ODTS and allergic alveolitis. Distinction is not always possible even with chest X-ray, physical examination and advanced tests, as ODTS could represent a transition to allergic alveolitis.[23]

High prevalence of smoking among the workers makes it difficult to investigate the independent effect of occupational exposure on respiratory health. Smoking might be enhancing the airway inflammation due to inhalation of sensitizing agents.[24] For the interaction between smoking and exposure to reed dust on wheezing, interaction term was not significant in the logistic regression analysis.

A study of tissue paper-producing factories in Germany found mean concentration of respirable dust level as 12.4 mg/m^3 and significantly lower FEV_1

and FVC in the highest cumulative dust exposure group as compared to the control group.[25] In our study cumulative exposure to reed dust were not significantly related to lung function test measurements, despite the similar concentrations of respirable dust level to that of the study from Germany.

Analysis restricted to exposed workers suggested that smoking and older age was associated with wheezing. Duration of work, which is a proxy for cumulative exposure, had a negative association with wheezing, that did not reach statistical significance. There was no significant decline in cross-shift FEV_1 and FVC in the overall reed workers. After the adjustment for the relevant risk factors, duration of work exposure to reed dust was associated with cross-shift increase in FEV_1 and FVC. These findings suggest a weak effect of reed dust exposure on the respiratory health and/or health selection among the reed dust exposed workers.

Summary

Exposure to reed dust in the workplace can provoke respiratory symptoms and ODTS, and cause airway disease, possibly due to an irritating effect. Smoking might increase the risk of wheezing among the workers, who were exposed to reed dust. Health selection bias is likely in the plant, which could have underestimated the health effects of reed dust exposure. Follow-up studies of the workers are required to assess the relationship between reed dust exposure and development of chronic airway disease.

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