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The prevalence of respiratory symptoms among mushroom workers in Ireland

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Background	Respiratory conditions such as asthma, bronchitis, hypersensitivity pneumonitis and upper airways symptoms have been ascribed to fungal exposures. Mushroom workers may be at risk of these as a consequence.
Aims	To assess the prevalence of respiratory symptoms in mushroom workers.
Methods	A cross-sectional study assessed 4 weeks of respiratory symptoms among mushroom workers divided into four categories of exposure, using a self-administered respiratory questionnaire and spirometry.
Results	The population of 191 subjects was predominantly (66%) from Eastern Europe; 61% were women and 39% were under 30. It included 73 growers, 38 composters, 26 administrators and 52 packers. Among all workers, there was a high prevalence (67%) of one or more respiratory symptoms which did not appear to vary by age, gender, pack-years of smoking or duration of employment. There was a significant improvement in respiratory symptoms in workers during absence from the workplace ($P < 0.001$). Spirometry readings across all groups were within normal values. Symptom profiles suggest that as many as 22 workers had symptoms of airways disease; 18 (82%) of these were mushroom growers. Growers were significantly more likely to have symptoms consistent with airways disease than all other workers, odds ratio 9.2 (95% CI 3.0–28.4).
Conclusions	There was a high prevalence of respiratory symptoms among mushroom workers. Mushroom growers may be at high risk of airways disease, possibly from fungal antigens or related exposures.
Key words	Chronic cough; mushroom workers; respiratory symptoms.

Introduction

Work-related respiratory conditions such as asthma, bronchitis, hypersensitivity pneumonitis (HP) and upper airway symptoms (UAS) have been described in mushroom workers. Mushroom spores have been associated with asthma and HP [1–4], while bacteria such as *Saccharopolyspora rectivirgula* and thermophilic actinomycetes and fungi such as *Aspergillus fumigatus* have been found to cause HP [5]. Avian proteins have been implicated in one report of HP where poultry droppings were used in the production of mushroom compost [6]. Although the incidence of HP has declined in recent years [7], this does not obviate the need to consider other occupational causes of respiratory disorders. In recent studies of UAS in Japanese mushroom workers, cough variant asthma, eosinophilic bronchitis and organic dust toxic syndrome (ODTS) have been implicated as causes of work-related respiratory symptoms [8].

Modern mushroom processing plants may include the production of mushroom compost, growing, picking, grading and packaging of mushrooms and transporting the final product to market, all potentially exposed job tasks. Workers in these types of processing plants generally do not have cross-task exposure and are exposed to different work environments. The purpose of this study was to assess the prevalence of respiratory symptoms among different groups of workers within the same mushroom plant.

Methods

We carried out a cross-sectional study of respiratory health and symptoms in mushroom workers with different work environments and tasks within a mushroom

processing unit in Ireland. The grower exclusively cultured *Agaricus bisporus*, either as button mushrooms or 'flats' (breakfast mushrooms). The flats are the most mature form of mushroom in which the veils are fully open with consequent maximum exposure to the basidiospores. There were four categories of workers: growers (workers in an enclosed windowless environment controlled for humidity, light and temperature, responsible for selecting and picking mushrooms), composters (workers responsible for the production of phase I and II compost, composed of horse manure, poultry manure, gypsum, straw and inorganic nitrogen, working outdoors or in ventilated internal environments), packers (workers responsible for grading and packing mushrooms of varying quality and size, working in a well-lit internal environment with standard extraction systems and some exposure to a cold room) and administration ('admin') (clerical, administrative and technical staff with no direct exposure to mushrooms or compost). Workers were classified only by job title as environmental monitoring was not available for this study. An information day was held in all sections of the workplace 4 weeks before the start of the study and all workers on daytime shifts during the study period were invited to participate without obligation. All participants signed a written consent. All workers in the study completed a self-administrated MRC modified questionnaire which included questions related to symptoms of asthma, bronchitis, HP and UAS [9]. The questionnaire also covered work-related symptoms, duration of work, length of employment, smoking habits, previous work history and respiratory as well as medical history. In addition to English, questionnaires were translated into Russian, Lithuanian, Latvian and Polish.

Spirometry (Micro Medical™; Microlab, Sword Medical, Ireland) was performed on a total of 120 workers according to the recommendations of the ATS/ERS [10]. Data were anonymized and single entered using Epidata 3.1 and analysed using Stat version 1.1, with two-way tabulation of exposure category with basic demographics, smoking and past medical diagnoses. Frequency distribution tables were developed for the total population. Fisher's exact test or the Kruskal–Wallis test were used as appropriate to assess statistical difference between the groups. To adjust for multiple comparisons, a P value <0.01 was considered significant. Logistic regression analysis adjusted for age and sex was used to compare the prevalence of basic respiratory symptoms. Symptom profiles were developed based on responses that were considered more likely to relate to a specific respiratory disorder. Of a total of 21 questions, there were 11 consistent with asthma, 8 with bronchitis, 10 with HP and 2 with UAS. Workers with profiles with >60% positive responses were classified as positive. We than compared the number of positive responders within each job category.

The study was approved by the Ethics Committee of the HSE Dublin NE in Ireland.

Results

The 191 mushrooms workers assessed included 73 growers (59% female), 38 composters (21% female), 52 packers (64% female) and 26 admin (58% female) (Table 1). There were significant ethnic differences between the groups with growers comprising predominantly Polish workers (49%) while packers predominantly came from Lithuania (62%). The majority of compost workers (76%) and administrative staff (92%) were Irish. The majority of growers were aged between 18 and 29 (48%) with a similar profile among packers (40%), while the majority of composters were older with 37% aged between 30 and 39. Almost all workers worked full time, between 37 and 50 h per week. Of the total population, 46% (88) had never smoked, while 37% (71) were current smokers. There were significant differences between the groups in smoking habits with growers and packers including the most current smokers. All groups apart from admin workers had smoking rates higher than the national average rate of 21% [11]. We found a high prevalence of respiratory symptoms, particularly in growers and packers (Table 2). Similarly, growers and packers had a high prevalence of headache, and aches and pains as well as nasal symptoms. There was a significant improvement in respiratory symptoms with absence from work for holidays in growers and packers (Table 3) although not for days off work. Despite differences between the groups in rates of smoking, no clear relationship was evident between current cigarette smoking or pack-years of smoking and respiratory symptoms. We also found no relationship between respiratory symptoms and duration of work (Table 4). On average, growers had worked for less time in the mushroom industry than other groups.

Despite the high rate of smoking, mean spirometry readings carried out in the four groups of workers were within normal limits. As shown in Figure 1, there was no significant difference in forced expiratory volume in one second or forced expiratory capacity between the four groups of workers. Peak expiratory flow rates were likewise equivalent in the four groups (results not shown). Profiles of workers with >60% positive responses to symptoms of airways disease were assessed. Nine workers scored between 8 and 11 on questions indicative of asthma. Eleven workers had scores between 6 and 9 for questions suggesting bronchitis and 20 had scores between 7 and 10 for questions indicative of HP. Overall, 22 workers' responses suggested the possibility of airways disease as there was an overlap in symptoms in 18 workers. Of these 22, 18 were growers, 1 was a composter and 3 were packers. Growers were more likely to have symptoms scores consistent with airways disease, yielding an odds ratio for growers of 9.2 (95% CI 3.0–28.4) when compared with all other workers.

Table 1. Basic demographic profile of mushroom workers by exposure category

Variable	Strata	Exposure category (n = 191)				P value (Fisher's test)
		Growers (n = 73)	Composters (n = 38)	Admin (n = 26)	Packers (n = 52)	
Sex, n (%)	Male	14 (19)	30 (79)	11 (42)	19 (37)	<0.001
	Female	59 (81)	8 (21)	15 (58)	33 (63)	
Preferred language, n (%)	English	2 (3)	29 (76)	24 (92)	10 (19)	<0.001
	Lithuanian	16 (22)	0 (0)	1 (4)	32 (62)	
	Russian	2 (3)	3 (8)	0 (0)	3 (6)	
	Latvian	17 (23)	3 (8)	1 (4)	6 (12)	
	Polish	36 (49)	3 (8)	0 (0)	1 (2)	
Age group, n (%)	18–29	35 (48)	10 (26)	12 (46)	20 (40)	NS
	30–39	21 (29)	14 (37)	9 (35)	8 (16)	
	40–49	11 (15)	9 (24)	3 (12)	9 (18)	
	50+	6 (8)	5 (13)	2 (8)	13 (26)	
Smoking status, n (%)	Never	26 (36)	22 (58)	20 (77)	20 (38)	<0.01
	Ex-smoker	16 (22)	4 (11)	3 (12)	6 (12)	
	Smoker	30 (42)	12 (32)	3 (12)	26 (50)	
Full/part-time work, n (%)	Full-time	73 (100)	35 (97)	26 (100)	50 (98)	NS
	Part-time	0 (0)	1 (3)	0 (0)	1 (2)	
Hours per week	Mean (SD)	43.3 (5.0)	45.7 (5.1)	42.8 (4.7)	46.6 (3.7)	–

P values calculated using Fisher's exact test for proportions. NS, not significant; SD, standard deviation.

Discussion

In this cross-sectional study of workers in a modern mushroom processing plant, we found a high prevalence of work-related respiratory symptoms among workers with direct contact with compost or mushrooms. This is the largest survey to date of respiratory symptoms in mushroom workers and the first that compares respiratory symptoms between groups of workers within the plant. There was a high prevalence of work-related respiratory symptoms such as cough, chest tightness, wheeze and sputum, particularly among growers with a concomitant high attribution of symptoms to work. All groups apart from admin noted improvement in respiratory symptoms when they were away from the workplace. Although the prevalence of smoking was high, we found no clear relationship between respiratory symptoms and cigarette smoking, although quantification of pack-years may not be sufficiently accurate in a self-reported questionnaire to exclude cigarette smoking as a contributing factor. Interestingly, despite the high prevalence of cigarette smoking in the working population, mean spirometric indices were within normal limits. This may reflect the younger age of the population and consequently shorter duration of cigarette smoking among the growers and packers. Similarly, the duration of tenure within the jobs did not appear to be an important factor in the prevalence of respiratory symptoms. The pattern we note suggests that growers who worked for shorter periods had more symptoms than those with longer employment duration, which may indicate that many of these workers did not remain in these jobs for long. This suggests a rapid onset of symptoms in this job with the possibility of a healthy worker effect or merely early departure from an unpleasant job. The opposite was seen with compost workers who developed a greater number of symptoms the longer they remained in the workplace, which may indicate a longer lead-in period for sensitization if their respiratory symptoms have an immunological basis. We were unable to obtain work histories of the number of employees who left in the preceding years. Clearly also differing work environments could affect the different pattern of respiratory symptoms among the various groups. While the gender profile of both groups differed significantly, there is nothing to suggest that female workers answered the questionnaire differently compared with male workers.

The number of workers with at least one work-related respiratory symptom in this industry was very high. This in itself may reflect previous data which demonstrated that respiratory questionnaires have a high sensitivity but low specificity for detecting respiratory disease [12]. Despite this, questionnaires are the most sensitive and effective method of detecting early onset work-related respiratory disease [13]. Although aggregating scores of groups of symptoms most related to specific respiratory conditions is likely to increase the specificity, it should be borne in mind that these methods are primarily for surveillance case definitions rather than diagnostic of disease. The questionnaire results suggest there is a significant prevalence of respiratory morbidity which requires more detailed assessment. Spirometry readings were normal in all workers assessed; however, spirometry may be limited in its ability to discriminate respiratory

Table 2. Worker responses to the respiratory questionnaire by category

Question	No. (%) 'Yes' by exposure category				Combined 'Yes'	Total answered
	Growers	Composter	Admin	Packer		
5: Do you ever feel you have a:						
a) Dry cough	45 (67)	5 (14)	3 (12)	18 (36)	71 (40)	179
b) Tight chest	36 (59)	6 (16)	2 (9)	11 (25)	55 (33)	165
c) Difficulty breathing	27 (44)	2 (6)	4 (16)	7 (18)	40 (25)	161
d) Wheeze	19 (35)	1 (3)	1 (4)	7 (17)	28 (18)	153
e) Cough with phlegm	37 (60)	4 (11)	3 (13)	12 (28)	56 (34)	164
9: If you run or climb stairs fast do you ever:						
a) Cough	12 (25)	3 (10)	0 (0)	3 (7)	18 (12)	149
b) Wheeze	8 (19)	4 (13)	2 (8)	0 (0)	14 (10)	141
c) Get tight chest	22 (41)	3 (10)	3 (12)	8 (17)	36 (23)	158
10: Is your sleep ever broken by						
a) Wheeze	7 (11)	0 (0)	2 (8)	1 (2)	10 (6)	176
b) Difficulty breathing	18 (26)	0 (0)	0 (0)	1 (2)	19 (11)	177
11: Do you ever find you wake up in the morning (or from your sleep if a shift worker) with						
a) Wheeze	8 (13)	1 (3)	0 (0)	0 (0)	9 (5)	172
b) Difficulty breathing	17 (26)	0 (0)	0 (0)	3 (6)	20 (11)	174
12: Do you ever have difficulty in breathing						
a) if you are in a smoky room	26 (39)	6 (17)	5 (21)	10 (21)	47 (27)	174
b) if you are in a very dusty place	29 (44)	14 (39)	8 (31)	16 (33)	67 (38)	176
13: Following work, have you often (more than a third of the time) felt						
a) Feverish	6 (15)	0 (0)	0 (0)	1 (2)	7 (5)	144
b) Headache	39 (61)	6 (17)	4 (15)	12 (23)	61 (34)	178
c) General aches/pains	23 (43)	3 (8)	2 (8)	10 (21)	38 (24)	161
d) Difficulty with breathing	22 (42)	1 (3)	0 (0)	3 (7)	26 (17)	156
16: Have you, during the last year, ever had episodes of 'flu-like' symptoms (fever, shivering, cough, malaise, tiredness, weakness, muscle and joint pains) in connection with dusty work?						
a) Yes/No	49 (70)	7 (20)	4 (17)	28 (55)	88 (49)	180
17: Has your nose ever been blocked, itchy, runny or sneezing? (Do not count the time you were ill with a cold or flu)						
a) Yes/No	49 (69)	6 (16)	6 (24)	32 (64)	93 (51)	183
18: Have your eyes ever been itchy or runny? (Do not count the time you were ill with a cold or flu)						
a) Yes/No	42 (59)	7 (19)	4 (16)	20 (40)	73 (40)	183

Table 3. Summary of the association between absence from work and respiratory symptoms

Exposure category	Grower	Composter	Admin	Packer
Change in symptoms on days off (P = NS)				
Better	28	3	0	9
Same	9	2	3	8
Worse	3	0	0	0
Change in symptoms on holidays of 1 week or longer ($P < 0.001$)				
Better	33	2	0	11
Same	2	2	3	7
Worse	3	0	0	0

P values calculated using Fisher's exact test for proportions.
NS, not significant.

disease in a cross-sectional study, since many ill or symptomatic workers may have left the workforce.

Early case reports of workers in the mushroom industry have variously described respiratory conditions such as asthma or HP caused by differing varieties of mushrooms and various fungi found in compost. However, while reporting on a series of workers with mushroom workers lung, Sanderson *et al.* [14] noted chronic respiratory symptoms in a significant number of American mushroom workers not diagnosed with HP. In a series of studies on Japanese Bunashimeji mushroom workers, Tsushima *et al.* [15] assessed 114 employees and found significantly higher levels of respiratory symptoms in the pickers than office staff with a much smaller number (only four) diagnosed with HP. Having previously shown that over a 3 year period, 40% of Japanese mushroom workers had to quit their job because of symptoms of cough without any formal diagnosis of a specific respiratory complaint, Tanaka *et al.* [16] went on to assess a group of workers with respiratory symptoms not due to HP and attempted to define the nature of their symptoms. Of the 69 mushroom workers assessed, they demonstrated an increase in the level of airway hyper-responsiveness to methacholine in 42 compared to controls and considered 15 of these workers to have

Table 4. Summary of the association between duration of employment and respiratory symptoms

Question	No. (%) 'Yes' for working years group				Total 'Yes'	Total answered	*P* value (Fisher's test)
	0–1 years	1–3 years	3–7 years	7+ years			
5: Do you ever feel you have a:							
a) Dry cough	17 (43)	10 (26)	19 (54)	7 (21)	53	147	NS
b) Tight chest	17 (41)	12 (34)	8 (31)	7 (21)	44	135	NS
c) Difficulty breathing	7 (18)	8 (23)	8 (30)	6 (18)	29	133	NS
d) Wheeze	7 (19)	1 (3)	8 (30)	2 (7)	18	125	NS
e) Cough with phlegm	13 (33)	9 (25)	13 (46)	4 (13)	39	133	NS

NS, not significant.

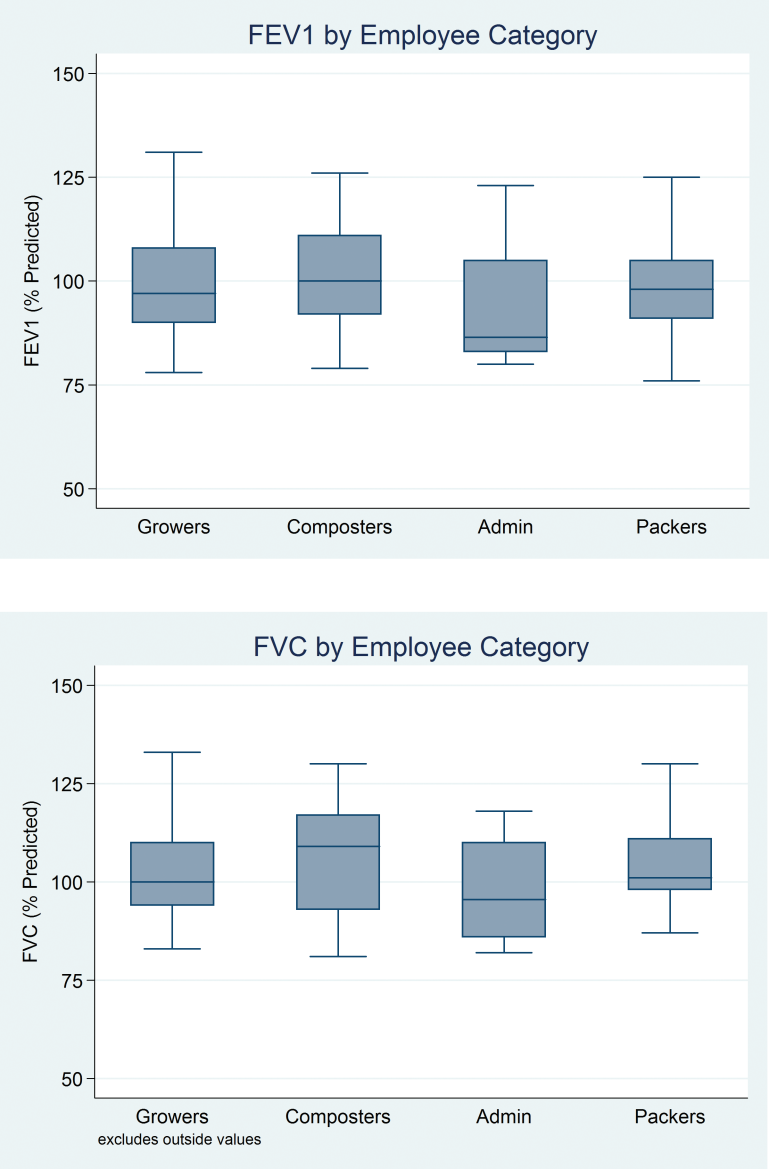

Figure 1. Spirometric values (FEV1 and FVC, mean ± SE) among job categories of mushroom workers. Closed circle indicates a single outlier. FEV1, forced expiratory volume in one second; FVC, forced expiratory capacity.

cough variant asthma and a further three to have eosinophilic bronchitis (defined as sputum eosinophils >3% in workers without airway obstruction). In other groups of workers, symptom profiles consistent with ODTS were present in as many as 6% of those with cough symptoms using standard definitions including negative chest X rays.

They also found that as many as 18 workers had symptoms of upper airways disease. No direct relationship could be found between the level of airborne dust measured in the Japanese plant and the prevalence of respiratory symptoms. As in our study, no relationship between cigarette smoking and symptoms was noted although the level of smoking exposure was not quantified. Similar to our study, no relationship was noted between basic lung function and symptoms nor indeed any specific lung condition to which the authors attributed symptoms. This study clearly demonstrated a significant degree of respiratory symptoms among mushroom workers with symptom profiles consistent with a number of respiratory conditions related to the workplace including asthma, upper airways disease, bronchitis, HP and ODTS.

Our findings are consistent with these previous studies which confirm a high prevalence of respiratory morbidity among mushroom workers. It is interesting to speculate whether much of the symptomatology is due to irritation to the upper and lower airways related to combined cigarette smoking and organic dust exposure rather than airway sensitization. Further definition of these work-related respiratory symptoms could allow early intervention such as modification of the work environment and efforts to reduce cigarette smoking which may reduce the prevalence of work-related chronic respiratory conditions such as asthma [17] and HP [18] as well as other conditions such as bronchitis [19] and ODTS.

Although we cannot define the precise nature of respiratory disorders that may give rise to the high symptom prevalence, we observed it is likely that many mushroom workers are symptomatic from work-related airways disease. Further studies would be required in this group of workers to define the nature of the respiratory symptomatology and the environmental exposures responsible for the high level of respiratory morbidity.

Key points

- This study found a high prevalence of respiratory symptoms among workers at an Irish mushroom production plant.
- The study compared respiratory symptoms among different job tasks and found the highest prevalence of symptoms in mushroom growers and packers, with a significant improvement in symptoms with absence from work for holidays.
- The study found a high prevalence of cigarette smoking among this group of workers, which may also contribute to the reported symptom prevalence.

Conflicts of interest

None declared.

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