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Frequency of respiratory symptoms among rice mill workers in Bangladesh: A cross-sectional study

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Abstract

Background and Aims: Rice mill workers are frequently exposed to rice dust specks containing bacteria, endotoxins, spores, and chemicals in workplaces. Consequently, they develop diverse respiratory symptoms that lead to increased disability and social burden. The present study was conducted to observe the frequency of respiratory symptoms among rice mill workers in Bangladesh.

Methods: This cross-sectional study was conducted at different rice mills in Rangpur district of Bangladesh. Three hundred and forty-six rice mill workers, both male and female of 18 years and above, with a job experience of at least 3 years, were selected as study subjects. An equal number of people who had never worked at rice mills were selected from the nearby locality as the nonexposed group. Enquiries were made regarding respiratory symptoms with the help of a preformed questionnaire which contained sociodemographic characteristics, occupational history, potential confounding factors, and physical parameters. A respiratory dust sampler was used to measure workplace dust concentration.

Results: The presence of one or more respiratory symptoms was significantly higher among rice mill workers than in the nonexposed group (52.3% vs. 17.6%). Rice mill workers who worked for more than 10 h and had a working experience of more than 15 years had a higher frequency of respiratory symptoms (41.3% and 39.8%, respectively). Rice mill workers with body mass index (BMI) <18.5 also exhibited more respiratory symptoms (25.4%). All working sections had a higher-than-average dust concentration level, with the milling section being the dustiest (PM 2.5 492.1 $\mu g/m^3$).

Conclusion: This study showed an increased frequency of respiratory symptoms among rice mill workers of Bangladesh. Longer working experience and working hours, low BMI and high dust concentration levels were strongly associated with that increase in frequency.

KEYWORDS

respiratory dust sampler (RDS), respiratory symptoms, rice mill workers

1 | INTRODUCTION

As a vital structure within the body, the lungs are pretty much susceptible to various types of infections. Other insults from the external environment due to persistent inhalation of specks of dust, fumes, and numerous organic substances at workplaces add further burden. These events affect not only the lung parenchyma but also have a hazardous effect on airways and pleura. In the field of respiratory medicine, occupational lung diseases have occupied an important field. Persistent exposure to organic dusts, inorganic dusts, pesticides, and agrochemicals lead to respiratory illness.[1] Different workers of various occupations have to work in an unsanitary environment which frequently causes lung problems. One such particular occupation group is the rice mill workers. Ranked fourth among the world's top rice-producing countries, Bangladesh is also one of the world's top rice-consuming countries.[2] The rice mill sector in Bangladesh has gone through revolutionary changes in harvesting, processing, and storage over the last few decades. There are three types of rice mills in Bangladesh: chatal (Traditional husking mill), semi-auto, and auto rice mill. Automatic rice-processing mills (ARMs) are essentially replacing "dheki" (a wooden device for husking paddy to make rice) and "chatals" (traditional sun-drying husking mills). All the activities in automatic rice mills are done through numerous mechanical processes that include categorization of rocks and unfilled grains, grain marinating, boiling, drying, milling, polishing, and bagging. Approximately 16,400 chatals, 420 semi-automatic rice mills, and around 400 fully automatic rice mills operate in Bangladesh, the highest concentration being in the Rangpur region.[3]

Rice dust is a complex substance that comprises a mixture of organic dusts, inorganic dusts, pesticides, micro-organisms (especially bacterial endotoxins), allergens, and mycotoxins.[4] Approximately 40% of its particles are less than 5 μm in mean diameter and represent a respirable piece that can penetrate the terminal airways.[5] This environmental dust has a long history of association with diseases of various organs such as eyes, nose, skin, lungs, and the airways. Workers exposed to rice dust have been reported to exhibit a variety of clinical manifestations like asthma, chronic obstructive airway diseases, conjunctivitis, allergy, and febrile reactions. Occupational asthma has been well documented as being a result of exposure. Various reports have suggested that unprotected dust exposures in agricultural settings may lead to pulmonary fibrosis.[4] Rice husk is known to have an abundance of silica content, and this biogenic silica may cause pulmonary diseases resembling asbestosis, namely pleural thickening, fibrosis, and possibly bronchial carcinoma.[6] Exposure to the rice dust may cause "organic dust toxic syndrome," a noninfectious febrile illness associated with chills, malaise, myalgia, dry cough, breathlessness, and nausea.[7] The frequency of the symptoms depends on the composition and nature of dust, duration of exposure, altered respiratory pathophysiology, immunity status and allergies, rice mills environment, use of protective devices, and many other factors. The components of rice dust mainly act as an endotoxin that can activate complement and initiate a vast array of inflammatory events within the bronchi. Exposure to organic dust and endotoxin at the workplace may cause several respiratory diseases, including asthma, allergic alveolitis, chronic bronchitis, hypersensitivity pneumonitis, and acute and/or chronic lung function impairment.[8] It also causes a sharp drop of airflow rate in sensitive individuals. Between 4% and 11% of rice mill workers showed a reduction of about 10% or greater in Forced Expiratory Volume in 1st second (FEV1).[7]

It is noteworthy that this occupational hazard can significantly be reduced by improving ventilation, good work practices, and personal protective equipment. In developed countries, they have proper working guidelines regarding the health and environmental safety of the rice mill workers. After observing the catastrophic consequences of asbestos exposure, more than 50 western countries banned asbestos handling in 1991, leading to reduced asbestos-related burden.[9] Unfortunately, in a developing country like Bangladesh, there is no specific guideline regarding the establishment of healthy and eco-friendly rice mills. The majority of the rice mill workers execute rice milling on crude machinery. Most rice mill workers do not use personal protective equipment, and most rice mills lack proper exhaust chimneys. Rice mills are a great source of pollution both on-site and in the surrounding locality. The sources of this pollution are dust released from the handling or processing of the paddy or its by-products.[10]

Despite being one of the significant contributors to the persistently flourishing economy of Bangladesh, the aspect of the respiratory health of the rice mill workers is neglected time and again. There is also a scarcity of data that correlates the burden of respiratory symptoms to rice dust exposure. The exact extent of this problem has not yet been adequately conceptualized. Keeping all these factors in mind, we conducted a study to observe the frequency of respiratory symptoms among rice mill workers in Bangladesh. We also observed the usual factors associated with the frequency of these symptoms. We also measured the dust concentration of various sectors of a rice mill.

2 | METHODS

2.1 | Study participants and data collection

The present study was conducted in different areas in Rangpur district of Bangladesh. A Cross-sectional model with an analytic approach was chosen as the study design. A standardized field questionnaire was formulated in consonance with the British Medical Research Council (BMRC) questionnaire on Respiratory symptoms.[11] As the subjects of this study were from rural communities, the research questionnaire was slightly modified[12] as per the study objectives and local needs and then translated

into Bengali for the convenience of data collection from the respondents. Forty-seven rice mills (34 chatals, 05 semi-auto, and 08 auto rice mills) were selected purposively for the convenience of data collection. Initially, the questionnaire was pretested on 10 individuals (five rice mill workers and five from the nonexposed group) from the study locations. Before commencement of actual data collection, the nature and intent of the study were explained to the participants in their vernacular language with the help of local collaborators. Confidentiality was assured, and informed written consent was taken from all of them before data collection. Participants were selected after completing careful enquiries about inclusion and exclusion criteria. Forty-two rice mill workers and 59 participants from nonexposed group were excluded from the study due to nonfulfillment of selection criteria. Finally, 346 rice mill workers and an equal number of nonexposed participants were selected as study population. Participants from the nonexposed group were those who had never worked at any rice mill, and they were selected to find out whether there was any actual detrimental impact of rice dust exposure among the population of that area or not. The data collection procedure from them was similar to that of rice mill workers. Data were collected by face-to-face interviews taken one by one using a predesigned, pretested questionnaire. About 30 peoples' interview were taken every day and each interview lasted for about 15 min.

Map of Rangpur district. Highlighted upazilas were selected for study purpose.

2.2 | Instruments

Our questionnaire-based interview had four parts. The first part was based on participant's sociodemographic profile, including name, age, sex, religion, marital status, educational status, monthly income. The second part included work-related history, including questions comprising all the details of present and past employment, including working time, working section, duration of employment, and use of personal protective equipment. The third part contained detail of smoking history, pack-years of smoking and passive smoking, the biomass fuel usage during cooking, and mosquito coil or aerosol usage. The final part covered different respiratory symptoms such as chronic cough, chronic phlegm, chest tightness, shortness of breath, wheeze, and runny nose. Physical measurements, including height, weight, body mass index (BMI) of each participant were recorded.

2.3 | Measurement of dust concentration

After finishing the interview, dust concentration as PM 2.5 and PM 10 was measured in different working sections of the mills, including parboiling and drying, milling, storage, and management by a portable respiratory dust sampler named "Temtop air quality detector." Air quality was checked in each section for 2 days on different occasions. The maximum value recorded among all the readings displayed on the monitor was taken.

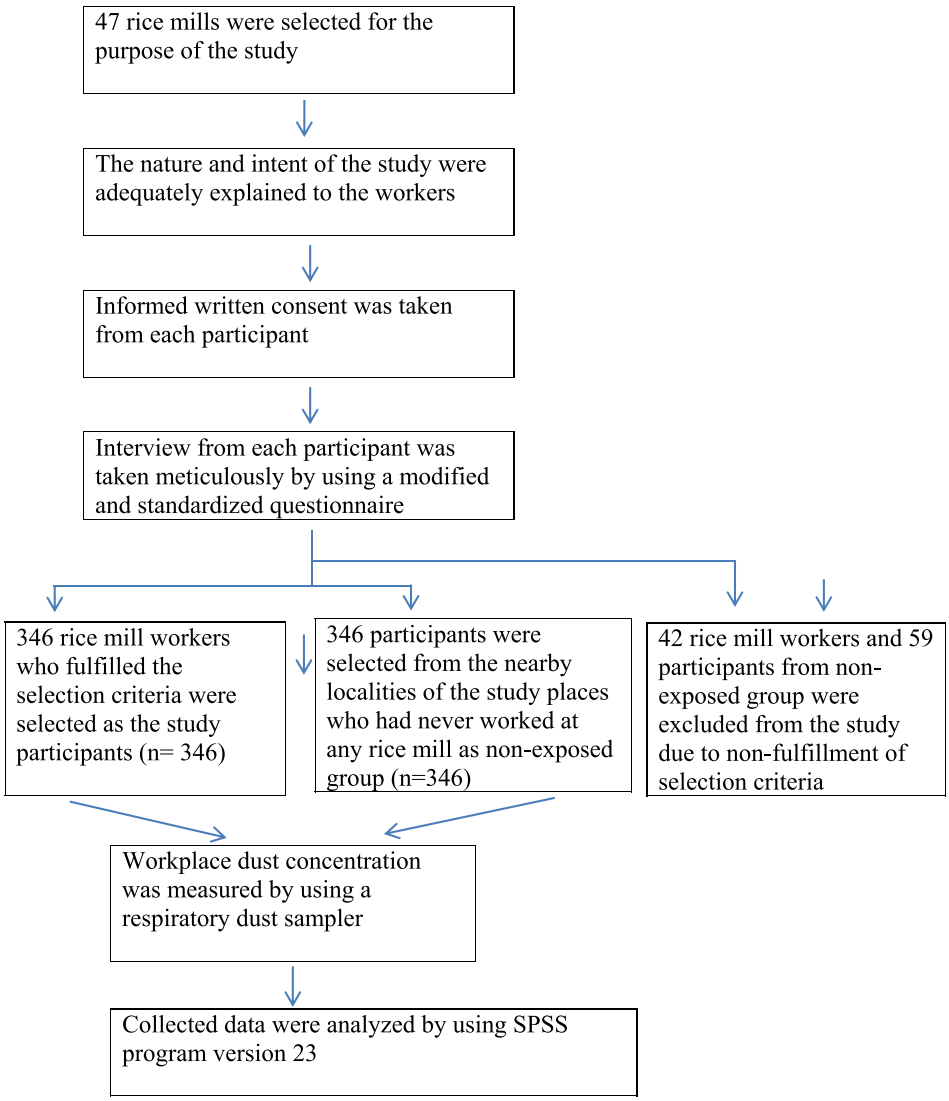
2.4 | Data analysis

Data were collected in a preformed questionnaire. After the collection of data, all data were checked, tabulated, and coded. Then the data were entered into the computer, and statistical analysis was done using the computer program SPSS (Statistical Package for the social science) version 23. After compilation, data were presented in tables, stacked columns, pie charts, and bar diagrams as necessary. Frequency was expressed in percentage. χ^2 test and unpaired t-test were used to find out the differences of different variables as per requirement. A $p < 0.05$ was considered statistically significant. Binary logistic regression analysis was done among the factors that were significantly associated with respiratory symptoms among the rice mill workers. Odds ratio and p-value were observed to find out the significance of those associations.

2.5 | Ethical approval

The proposal of this study was approved at the 208th meeting of IRB (Institutional Review Board) of BSMMU (Bangabandhu Sheikh Mujib Medical University), Bangladesh (NO.BSMMU/2020/9140). Before submitting the protocol for IRB clearance, recommendations regarding objectives and methodology were also taken from the department of respiratory medicine and the department of public health, BSMMU. After approval from IRB, we also got a recommendation letter from the department of respiratory medicine, BSMMU, asking for cooperation and collaboration from the local authority. Confidentiality was assured, and informed written consent was taken from all of them before data collection.

Study Flow Chart.



3 | RESULTS

3.1 | Baseline characteristics

The mean age of workers was 39.17 years. 82.9% of rice mill workers who participated in this study were male. Mean BMI was 20.79 ± 2.59. 35.3% of rice mill workers were smoker. Among smokers, 49.2% of rice mill workers smoked less than 10 pack-years. 22.1% rice mill workers who were smokers; smoked more than 20 pack-years. only 6.6% of workers used masks while working. 93.4% of workers did not use it (Table 1).

3.2 | Work-related characteristics of the study subjects

One hundred and sixty-eight workers of our study worked at the chatals, which was the highest (48.6%). It was followed by the auto rice mill workers (44%). Only 6.6% of workers in our study worked at the semi-auto rice mill (Table 2). A higher percentage of workers (33%) belonged to the storage section (Figure 1). The mean duration of working experience for the rice mill workers was 13.10 years (Table 3). 41.9% of rice mill workers worked more than 10 h (Table 4).

TABLE 1 Sociodemographic characteristics of the study population ($N = 346$).

Characteristics	*n* (%)
Mean (±SD)	39.17 ± 12.60 years
Gender	Male: 287 (82.9%)
	Female: 59 (17.1%)
Mean BMI (±SD)	20.79 ± 2.59
Mean working experience in years (±SD)	13.10 ± 8.96 years
Use of mask	Yes: 23 (6.6%)
	No: 323 (93.4%)
Smoking status	Nonsmoker: 189 (54.6%)
	Smoker: current: 122 (35.3%)
	Ex: 35 (10.1%)
	Pack year: <10:60 (49.2%),
	10–20:35 (28.7%)
	>20:27 (22.1%)

TABLE 2 Distribution of rice mill workers according to the type of rice mill ($N = 346$).

Type of rice mill	Number of workers	Percentage (%)
Chatal	168	48.6
Semi-auto	23	6.6
Auto	155	44.8
Total	346	100.0

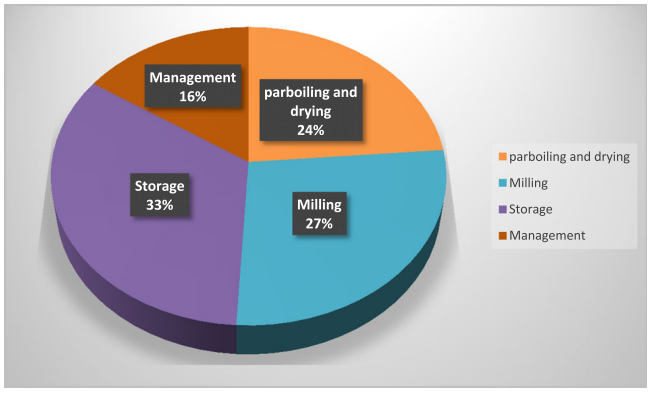


FIGURE 1 Distribution of rice mill workers according to working section.

3.3 | Respiratory symptoms

In our study, we found that 52.3% of rice mill workers had at least one respiratory symptom (Figure 2). On the other hand, only 17.6% of nonexposed group had at least one respiratory symptom. All types of respiratory symptoms were significantly higher among rice mill workers than the nonexposed group (Figure 3). Chronic cough was the predominant symptom in both groups (38.7% in rice mill workers vs. 14.7% in the nonexposed group). After cough, there was runny nose (37.6% vs. 5.5%), chronic phlegm (22.5% vs. 12.5%), chest tightness (19.9% vs. 4.6%), wheeze (13% vs. 2.9%), and shortness of breath (6.6% vs. 1.7%), respectively. Rice mill workers who worked at the chatals were adversely affected than the other rice mill workers. 21.4% chatal workers had chronic cough and chronic phlegm, 4.2% had chronic cough, chronic phlegm, and shortness of breath, 3.6% had runny nose, chest tightness, wheeze and shortness of breath, and 11.3% workers had any three of runny nose, chest tightness, wheeze and shortness of breath respectively (Table 5).

3.4 | Association of respiratory symptoms with other characteristics

Workers in the milling section had a higher frequency of respiratory symptoms than the other sections. 27.7% workers from the milling section had chronic cough and chronic phlegm, 7.4% had chronic cough, chronic phlegm, and shortness of breath, 4.3% had runny nose, chest tightness, wheeze, and shortness of breath, and 13.8% workers had any three of runny nose, chest tightness, wheeze and shortness of breath, respectively (Table 6). A significantly higher frequency (39.8%) of respiratory symptoms was observed among workers who worked more than 15 years (Table 7). Rice mill workers working more than 10 h were more prone to develop respiratory symptoms. 41.3% of workers who worked more than 10 h a day had a higher frequency of respiratory symptoms (Table 8). 55.2% of rice mill workers who worked at the chatals had a higher frequency of respiratory symptoms. Most of the auto rice mill workers did not have any respiratory symptoms (53.3%) (Table 9). A higher frequency of respiratory symptoms was observed among workers who had worked at the milling section (32.6%) (Table 10). The rice mill workers who had a BMI less than 18.5 (25.4%); a higher frequency of respiratory symptoms among them were found (Table 11). Both PM 2.5 and PM 10 levels were highest in the milling section (492.1 and 678.19 $\mu g/m^3$) and lowest in the management section (52.8 and 101.7 $\mu g/m^3$) (Table 12).

Binary logistic regression analysis that was performed to assess the impact of several factors on the respiratory symptoms among the rice mill workers. The strongest predictor of respiratory symptoms was long working experience (>15 years), reporting an odds ratio of 3.331 at 95% confidence Interval. This indicated that rice mill workers who worked >15 years were over 3.331 times more likely to have respiratory symptoms than those who had ≤15 years of working experience. Working for more than 10 h (odds ratio [OR]: 2.238, p-value: 0.001) and BMI < 18.5 (OR: 1.923, p-value: 0.036) were significantly associated with respiratory symptoms among the rice mill workers (Table 13).

Working experience (years)	Rice mill workers (n = 346) n (%)	Nonexposed group (n = 346) n (%)	X^2, df/t, df	p Value
≤15	245 (70.8)	270 (78.0)		
>15	101 (29.2)	76 (22.0)	4.37, 1	0.045[a]
Mean ± SD	13.10 ± 8.96	11.39 ± 9.04	2.50, 690	0.013[b]
Min–max	1–45	3–64		

[a]Chi-square test.
[b]Unpaired t test was done.

TABLE 3 Distribution of the study subjects according to working year (N = 692).

Working hour (hours)	Rice mill workers (n = 346) n (%)	Nonexposed group (n = 346) n (%)	X^2, df	p Value
Under 6 h	45 (13.0)	90 (26.0)		
6–10 h	156 (45.1)	203 (58.7)		
More than 10 h	145 (41.9)	53 (15.3)	63.9, 2	<0.001

Note: Chi-square test was done.

TABLE 4 Distribution of the study subjects according to working hour (N = 692).

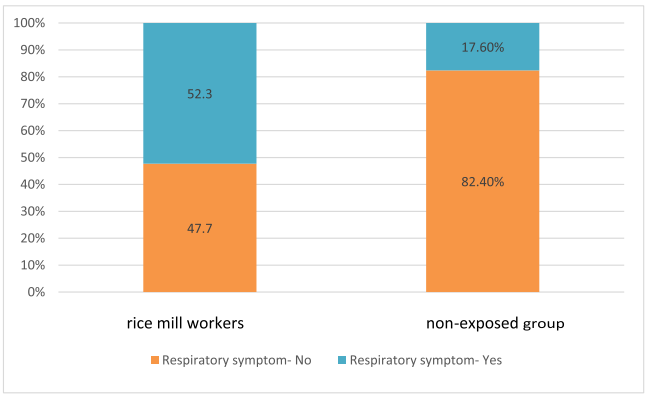


FIGURE 2 Frequency of respiratory symptoms between rice mill workers and the nonexposed group.

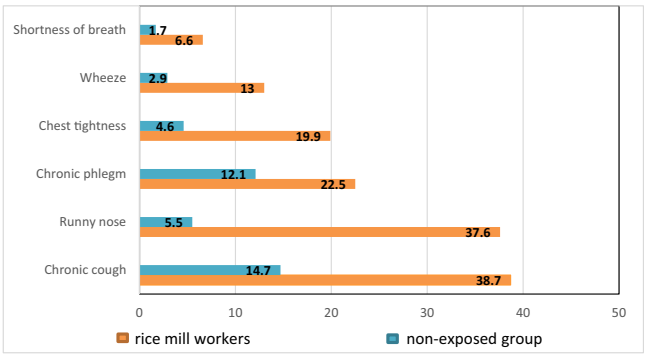


FIGURE 3 Frequency of different respiratory symptoms among rice mill workers and the nonexposed group.

4 | DISCUSSION

4.1 | Key findings of the study

This cross-sectional analytical study was conducted at Rangpur district, Bangladesh, with the objective to measure the frequency of respiratory symptoms due to rice dust exposure among 346 rice mill workers of 47 different rice mills and compare it with a nonexposed group containing an equal number of people who had not worked in the rice mills. In this study, we observed that 52.3% of the rice mill workers had at least one respiratory symptom compared to the nonexposed group (17.6%). This data corresponds to a study[6] which found that 52% of rice mill workers had at least one respiratory symptom compared to the nonexposed group (32%).

4.2 | Comparison of frequency of respiratory symptoms between rice mill workers and nonexposed group

This study found that the frequency of all types of respiratory symptoms was higher among the rice mill workers than in the nonexposed group. Comparative frequency analysis of respiratory symptoms between rice mill workers and the nonexposed group showed—cough (38.7% vs. 14.7) runny nose (37.6% vs. 5.5%), chronic phlegm (22.5% vs. 12.1%), chest tightness (19.9% vs. 4.6%), wheeze (13% vs. 2.9%), and shortness of breath (6.6% vs. 1.7%). These observations correlate with several previous studies. An Indian study[13] observed cough (39%) as the predominant symptom among rice mill workers, followed by shortness of breath (36.2%), wheeze (34.3%), and chest tightness (29.5%), which were higher than the nonexposed group. A cross-sectional study conducted in South India

TABLE 5 Presence of more than one respiratory symptoms among different types of rice mill workers (*N* = 346).

	Chatal (*n* = 168), *n* (%)	Semi-auto (*n* = 23), *n* (%)	Auto (*n* = 155), *n* (%)
Chronic cough + chronic phlegm	36 (21.4)	4 (17.4)	26 (16.8)
Chronic cough + chronic phlegm + shortness of breath	7 (4.2)	0 (0.0)	4 (2.6)
Runny nose + chest tightness + wheeze + shortness of breath	6 (3.6)	0 (0.0)	5 (3.2)
Any three of runny nose + chest tightness + wheeze + shortness of breath	19 (11.3)	2 (8.7)	14 (9.0)

TABLE 6 Presence of more than one respiratory symptoms among rice mill workers in different working section (*N* = 346).

	Parboiling and drying (*n* = 82), *n* (%)	Milling (*n* = 94), *n* (%)	Storage (*n* = 116), *n* (%)	Management (*n* = 54), *n* (%)
Chronic cough + chronic phlegm	9 (11.0)	26 (27.7)	22 (19.0)	9 (16.7)
Chronic cough + chronic phlegm + shortness of breath	0 (0.0)	7 (7.4)	3 (2.6)	1 (1.9)
Runny nose + chest tightness + wheeze + shortness of breath	1 (1.2)	4 (4.3)	5 (4.3)	1 (1.9)
Any three of runny nose + chest tightness + wheeze + shortness of breath	5 (6.1)	13 (13.8)	13 (11.2)	4 (7.4)

TABLE 7 Frequency of respiratory symptoms according to working year among rice mill workers (*N* = 346).

Working experience (years)	Respiratory symptoms: Positive (*n* = 181), *n* (%)	Respiratory symptoms: Negative (*n* = 165), *n* (%)	X^2, *df*	*p* value
≤15	109 (60.2)	136 (82.4)		
>15	72 (39.8)	29 (17.6)	12.73, 1	<0.001

Note: Chi-square test was done.

TABLE 8 Frequency of respiratory symptoms according to working hours among rice mill workers (*N* = 346).

Working hours (hours)	Respiratory symptoms: Positive (*n* = 181), *n* (%)	Respiratory symptoms: Negative (*n* = 165), *n* (%)	X^2, *df*	*p* Value
<6	34 (14.0)	101 (22.4)		
6–10	108 (44.6)	251 (55.8)		
>10	100 (41.3)	98 (21.8)	10.65, 2	0.004

Note: Chi-square test was done.

TABLE 9 Frequency of respiratory symptoms among rice mill workers according to the type of rice mill (*N* = 346).

Type of rice mill	Respiratory symptoms: Positive (*n* = 181), *n* (%)	Respiratory symptoms: Negative (*n* = 165), *n* (%)	X^2, df	*p* Value
Chatal	100 (55.2)	68 (41.2)	6.26, 1	0.012
Semi-auto	14 (7.7)	9 (5.5)	0.40, 1	0.527
Auto	67 (37.0)	88 (53.3)	2.29, 1	0.003

Note: Chi-square test was done.

TABLE 10 Frequency of respiratory symptoms according to working section among rice mill workers (*N* = 346).

Section	Respiratory symptoms: Positive (*n* = 181), *n* (%)	Respiratory symptoms: Negative (*n* = 165), *n* (%)	X^2, *df*	*p* Value
Parboiling and drying	39 (21.5)	43 (26.1)	0.74, 1	0.389
Milling	59 (32.6)	35 (21.2)	5.09, 1	0.024
Storage	62 (34.3)	54 (32.7)	0.09, 1	0.862
Management	21 (11.6)	33 (20.0)	4.01, 1	0.115

Note: Chi-square test was done.

showed a significantly greater proportion of the rice mill workers complained of phlegm (40.8%), dyspnea (44.2%), chest tightness (26.7%), cough (21.7%), and runny nose (27.5%).[4]

4.3 | Association of frequency of respiratory symptoms with work-related characteristics

Fifty-five percent of the chatal workers exhibited respiratory symptoms, which was statistically significant. The most plausible explanation may be due to faulty ventilation systems and outdated milling machines, which generated more dust. We also observed that workers in the milling section were most adversely (32.6%) affected by rice dust exposure. This finding is in agreement with a previous Indian study which showed an increased frequency of respiratory symptoms among workers from the milling section.[6] During milling, a large amount of rice dust generates that

TABLE 11 Frequency of respiratory symptoms according to BMI among rice mill workers ($N = 346$).

BMI	Respiratory symptoms		X^2, df/t, df	p Value
	Positive ($n = 181$), n (%)	Negative ($n = 165$), n (%)		
<18.5	46 (25.4)	21 (12.7)	8.1, 1	0.004
18.5–22.9	101 (55.8)	101 (61.2)	0.83, 1	0.362
≥23.0	34 (18.8)	43 (26.1)	2.24, 1	0.134
Mean ± SD	20.45 ± 2.75	21.13 ± 2.42	-2.44, 344	0.015

Note: Chi-square test and unpaired t test was done.
Abbreviation: BMI, body mass index.

TABLE 12 PM 2.5 and PM 10 levels at different working sections of the rice mills.

Section	PM 2.5	PM 10
Parboiling and drying	104.0	278.1
Milling	492.1	678.19
Storage	207.0	303.7
Management	52.8	101.7

Note: unit = $\mu g/m^3$.

TABLE 13 Binary logistic regression of factors separately associated with the presence of respiratory symptoms among the rice mill workers.

Factors	OR	95% CI for OR		p Value
		Lower	Upper	
BMI (<18.5)	1.923	1.045	3.537	0.036
Type of mill (Chatal)	1.271	0.776	2.083	0.341
Working hour (>10 h)	2.238	1.385	3.616	0.001
Working section (milling)	1.520	0.895	2.582	0.121
Working experience (>15 years)	3.331	1.924	5.766	<0.001

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

is rich in protein constituents, silica, and micro-organisms, including fungal spores. These airborne pollutants enter the lungs bypassing the upper airway defence mechanism (those with particle size less than 10 μm) and induce an inflammatory response resulting in diverse respiratory symptoms. The reaction is dose-dependent and if the exposure persists, then chronic inflammatory response leads to distortion of lung parenchyma and alteration of pulmonary elasticity. As a consequence, functional impairment of the lungs ensues.

We found that workers who had working experience of more than 15 years (39.8%) were more affected by rice dust exposure. We also observed that working more than 10 h was strongly associated with increased respiratory symptoms. An Egyptian study[14] observed that flour workers with a longer duration of employment had a greater frequency of respiratory symptoms (96.2%) than those with shorter duration (83.3%).

4.4 | Association of frequency of respiratory symptoms with other characteristics

Our study found no statistically significant association between smoking and increased frequency of respiratory symptoms. The probable reason may be that most of the workers in our study were nonsmokers, and most of them smoked below 10 pack-years (40.9%).

We found that low BMI (<18.5) was significantly associated with an increased frequency of respiratory symptoms (25.4%, p-value: 0.004). The low value of BMI in our study indicated malnourishment and the development of compromised immune function among rice mill workers. As a result, they were more vulnerable to respiratory morbidity related to rice dust exposure.

4.5 | Dust concentration in the rice mills

During the inspection of the rice mills, we observed milling section was filled with visible dust, which looked dense and cloudy. This is probably due to increased airborne particulate maters from rice husk that was contaminated with dust and emissions from machines during milling, particularly from the outdated and poorly maintained machines. The concentration of dust as PM 2.5 and PM 10 was found higher in the milling (492.1 and 678.19 $\mu g/m^3$), followed by storage section (207.0, 303.7 $\mu g/m^3$) parboiling and drying (104.0, 278.1 $\mu g/m^3$) and management section (52.8, 101.7 $\mu g/m^3$). In light of those findings, it may be assumed that there is a close association between different working sections of rice mills with their dust concentration and frequency of respiratory symptoms among the workers of those working sections.

4.6 | Implications of the study

The rice mill workers in our country belong to a particular occupational group, one of the major constituents of the backbone of Bangladesh's economy. So, their occupation-related respiratory problems demand special attention. We also observed that the rice mill workers were more affected in comparison to the nonexposed group. Cough was the most predominant symptom. Traditional husking mills (chatals) and milling section were more affected. From our study point of view, we can draw inferences that increased

indoor air pollution by rice dust is mainly responsible. Lack of latest technologies, excess dust emission from the out dated machines, improper exhausting system, and periodic cleaning of the facilities are the prime reasons for excessive dust generation.

4.7 | Strength and limitations of the study

Very few studies in our country have been conducted regarding the frequency of respiratory symptoms among rice mill workers. No study was conducted that included workers from all types of rice mills. No previous study in our country was conducted which observed the differences of frequency of respiratory symptoms according to working section. To control the confounding factors, we took the same number of people who were not exposed to the rice dust as a nonexposed group, which increased the statistical power of the study. We measured workplace dust concentration that provided valuable information regarding the impact of dust concentration among different working sections on the respiratory health of the rice mill workers. As it was a cross-sectional study, data were collected at only a single point in time. The study subjects could not be followed up. We could not measure the toxin level, including Mycoflora mixed with rice dust. The study population was selected from four upazilas of Rangpur district, so the results of the study may not reflect the whole picture of the country. Randomization could not be done, which might result in selection bias. Designed as cross-sectional, this study could give a clue about possible associations. Actual causation can be perceived based on assumption only.

4.8 | Future scope

This study was a cross-sectional study where qualitative characteristics were analyzed to have an assumption about the burden of respiratory symptoms among the rice mill workers of our community. Based on the findings of this study, there may be scope for future studies which will be focused on evaluating the burden of a particular respiratory disease among the rice mill workers in our community. The findings of this study may also contribute to find out the Population Attributable Fraction (PAF), which is the indicator of the frequency of a disease that develops in response to a particular exposure. If the PAF of a particular disease can be measured, it will be possible to reduce the burden of that particular disease by eliminating the exposure risk.

4.9 | Recommendations

1. Formulation of proper guidelines regarding the eco-friendly establishment of rice mills and surveillance of the working condition by the government. Our neighboring country India has a rice mill act for setting up a rice mill in accordance with the law. We also need a proper legal framework to ensure the health safety of our workers.
2. Application of ergonomics to improve the workplace environment. Use of protective devices such as respiratory masks and goggles by the workers to reduce occupational exposure to dust.
3. Replacement of the old and outdated machines as they emit an excessive amount of dust.
4. Dust reduction measures in the mill environment by installing proper ventilating systems.
5. Regular cleaning of the floor of the milling and storage section after work.
6. Provision of occupational health services to the workers before entering the job, including pre-placement clinical check-ups.
7. Periodic clinical examination, chest radiography, and pulmonary function tests of the rice mill workers should be done.
8. Workers showing increased respiratory symptoms should be readjusted in other sections of the mill where exposure to industrial dust is relatively low.
9. All employees with coughs for more than 2 weeks should be counseled to undergo sputum testing.
10. Provision of health education and rationalization of the work methods to improve the workers' health and safety.
11. Encouragement of the workers to reduce or stop smoking to prevent the development of harmful effects of smoking to themselves and to others.
12. Longitudinal or Intervention studies should be conducted in the future to find out the temporal association between respiratory symptoms and various characteristics, increase the knowledge and awareness among workers on health hazards based on observations.

5 | CONCLUSION

This study showed an increase of respiratory symptoms among the rice mill workers, with cough being the most predominant symptom. Also the respiratory symptoms were significantly higher among the rice mill workers than the nonexposed group. Longer working experience, extended working hours, low BMI, and high dust concentration levels were strongly associated with the rice mill workers' increased frequency of respiratory symptoms.

AUTHOR CONTRIBUTIONS

Shah A. R. A. Choudhury: conceptualization; data curation; formal analysis; investigation; methodology; validation; writing—original draft; writing—review and editing. **Abu Rayhan**: data curation; investigation. **Shamim Ahmed**: methodology; supervision; validation; visualization. **Rajashish Chakrabortty**: supervision; validation; visualization. **Mohammed A. Rahman**: project administration. **Abdullah A. Masud**: writing—review and editing. **Susanta K. Paul**: writing—review and editing. **Ahmed Sami Al Hasan**: writing—review and editing. All authors have read and approved the final version of the manuscript. The corresponding author had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

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CONFLICT OF INTEREST STATEMENT

The authors declare there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

TRANSPARENCY STATEMENT

The lead author Shah Ashiqur Rahman Ashiq Choudhury affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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