Original research

Knowledge, attitudes and practices regarding respirable silica exposure and personal protective equipment use among brick kiln workers in Nepal

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ABSTRACT

Objectives Brick kiln workers in Nepal are a neglected population who are exposed to high respirable silica concentrations, and few use interventions to reduce exposure. We aimed to characterise the prevalence of respiratory personal protective equipment (PPE) use, understand knowledge and attitudes towards kiln dust and respiratory PPE and identify factors associated with respiratory PPE use.

Methods We conducted a cross-sectional study in Bhaktapur, Nepal. We used simple random selection to identify 10 out of 64 total kilns and stratified random sampling of 30 households to enrol workers aged ≥14 years within selected kilns. Field workers surveyed participants using structured questionnaires. Our primary outcome was to characterise the prevalence of current respiratory PPE use and secondary outcomes were summaries of knowledge, attitudes and practice of PPE use.

Results We surveyed 83 workers (mean age 30.8 years, 77.1% male). Of these, 28.9% reported current respiratory PPE use at work, 3.6% heard of silicosis prior to the survey and 24.1% correctly identified the best respiratory PPE (N95, compared with surgical masks and barrier face coverings) for reducing dust exposure. Respiratory PPE users had higher income (mean monthly household income US$206 vs US$145; p=0.04) and education levels (25% vs 5.1% completed more than primary school; p=0.02) compared with non-users.

Conclusions Respiratory PPE use was low. Workers had poor knowledge of kiln dust health effects and proper respiratory PPE. We highlight important barriers to PPE use, particularly knowledge gaps, which can guide future investigations to reduce the silicosis burden among brick kiln workers.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Brick kiln workers in Nepal are occupationally exposed to unsafe levels of respirable silica and experience a significant burden of respiratory symptoms. In the absence of workplace interventions, respiratory personal protective equipment (PPE) is a readily available intervention that can decrease silica inhalation and the lifetime risk of silicosis. However, little is known about the state of respiratory PPE use among brick kiln workers in Nepal.

WHAT THIS STUDY ADDS

⇒ Prevalence of respiratory PPE use was low. Although most workers agreed that kiln dust was unhealthy, many workers reported low concern with the health effects. Workers demonstrated limited knowledge of specific brick kiln dust health effects and proper respiratory PPE selection. The majority of workers stated they were willing to purchase respiratory PPE but could only afford a fraction of the cost.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study highlights knowledge, behavioural, financial and structural barriers to respiratory PPE use among brick kiln workers in Nepal. These findings can be used to develop targeted interventions to increase respiratory PPE use among workers and advocate for policies for this vulnerable occupational group.

INTRODUCTION

More than 42 million workers are exposed to respirable silica in China, India, Europe, Brazil and the USA; however, there are limited data on respirable silica exposure worldwide.[1] Inhaling respirable silica causes silicosis, lung cancer and chronic obstructive pulmonary disease.[1 2] In South Asia, one high-risk industry is brick manufacturing, which relies on manual labour and employs more than 16 million workers.[3–5] The manufacturing process involves digging and mixing soil, hand-moulding clay into bricks, baking bricks in a kiln at 800°C–1000°C, and manually hauling bricks.[3] Worldwide, the industry produces an estimated 1500 billion bricks annually.[3]

In Nepal, 200 000 workers are employed across 1200 brick kilns.[6 7] These workers are exposed to respirable silica concentrations 1.4–6.6 times higher than the US Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL).[8] These workers are a marginalised population and only 6.8% receive regular health checks.[9 10] Limited prior research has examined occupational exposures and health status of brick kiln workers.[6 8 11 12] One study

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found that mean exposures to total suspended particles and respirable suspended particles for brick kiln workers in the Kathmandu Valley in Nepal were 12.2 mg/m^3 and 2.6 mg/m^3, respectively.[6] A follow-up study found mean silica exposure was highest for workers involved in red brick loading/carrying (331 μg/m^3), but all worker exposures exceeded the US OSHA PEL of 50 μg/m^3.[8] Additional studies have demonstrated that brick kiln workers in South Asia experience a significant burden of respiratory symptoms, and spirometry suggests that they have impaired lung function.[6 13–15]

Despite these findings, few studies have evaluated interventions to reduce silica exposure in this population.[16–19] Structural interventions do not rely on individual-level behaviour change and are favoured over personal protective equipment (PPE) as a long-term strategy to protect worker health.[20] However, infrastructure changes are more costly and difficult to implement without proper political mechanisms to enforce adoption.[21] In many low-income and middle-income countries where political mechanisms are lacking, occupational health research and interventions may need to focus less on the workplace and more on the workers in their social context.[21] The implementation of PPE is a simple intervention that can be readily implemented with significant worker benefit while awaiting future workplace-level interventions.[22 23] When properly used, respirators decrease silica inhalation and the lifetime risk of silicosis.[24–26] US OSHA recommends respiratory PPE when engineering controls are not feasible or while awaiting implementation.[27] It is not mandatory for brick kiln workers to use respiratory PPE in Nepal, and no studies to date have explored respiratory PPE barriers and facilitators in brick kilns. Several studies have explored PPE factors in other silica-exposed workers in Singapore, the USA, Vietnam and India.[16 28–30]

Here, we aimed to characterise the prevalence of current respiratory PPE use, understand knowledge and attitudes towards kiln dust and respiratory PPE and identify factors associated with current respiratory PPE use. This study builds on prior research characterising PPE use for occupational exposures and adds data for an understudied and vulnerable population: brick kiln workers in Nepal.[16 28–30]

METHODS

Study setting

Participants were recruited from brick kilns located in Bhaktapur, Nepal, a city located approximately 15 km east of Kathmandu.[31] The working season occurs from December to May when the weather is cold and dry the majority of the time. Workers migrate with their families from across Nepal and India and live in temporary households located at the brick kilns during the working season. The legal working age in Nepal is 14 years old. The brick kiln industry is prominent in Bhaktapur, with 64 kilns employing an estimated 24 000 workers. Workers have the following roles: preparing coal (coal crusher), maintaining the fire (fire man), moulding wet clay into bricks (green brick maker), stacking wet bricks (green brick stacker), covering them with ash and brick dust (rafies man) and hauling bricks (brick hauler).

Brick kiln workers in Nepal who load and carry red bricks (ie, haulers) are exposed to the highest mean silica concentrations (331 µg/m^3), but all working groups are exposed to unsafe levels.[8]

Study design

We conducted a cross-sectional study during the brick kiln season of December 2022–April 2023. Participants were recruited from 10 kilns using two-level random sampling (online supplemental E-Figure 1). First, we identified a total of 64 kilns in Bhaktapur and approached all. One kiln was permanently closed, and two kiln owners refused to participate. We then used simple random sampling to select 10 of the 61 kilns. Thereafter, we conducted a household census in the 10 kilns where we asked all kiln residents about their age, sex, type of job at the kiln, and number of seasons worked. Household census data were then used to conduct a stratified random sample and invite three types of workers aged ≥14 years with 10 or more seasons of work experience: brick haulers, green brick stackers and green brick makers. If there were no workers with 10 or more years of work experience for a particular work group, we modified the number of seasons worked down to ≥5. We also invited all household members who actively worked at the brick kiln to participate.

The primary outcome was the prevalence of current respiratory PPE use. Given limited data for our setting, we assumed a 30% prevalence of respiratory PPE use. This was based on prior literature estimating 33% respiratory PPE use among agate workers in India, a similar study population.[30] To estimate the prevalence of respiratory PPE at 30% with 10% precision and 95% confidence would require 81 participants.

Trained field workers obtained written informed consent and survey data from participants. For participants aged <18 years, field workers obtained parental/guardian informed consent and individual consent/assent and surveys were conducted in the presence of parents/guardians. Participants were excluded if their point-of-care urine pregnancy test was positive. We conducted surveys in private areas of participants' homes or workplace. Owners were not present during data collection. Participants were compensated US$15.

Data collection

Field workers administered structured questionnaires in Nepali, collecting data on sociodemographic characteristics, work history and medical history. A knowledge, attitudes and practices survey (see online supplemental file) was developed based on prior surveys among similar silica-exposed workers in India and Vietnam, and on Fishbein and Ajzen's Theory of Planned Behaviour model.[29 30 32] Field workers asked participants using closed-ended questions how concerned they were about brick kiln dust, if they had previously heard of silicosis and to identify symptoms and diseases associated with brick kiln dust from a list of options. After these questions, field workers provided participants with a brief description of silicosis: 'Silicosis is a lung disease caused by breathing in dust that contains silica. Brick kiln dust contains silica. Breathing this dust may lead to scarring of the lungs'. Field workers then proceeded to ask participants about their knowledge and attitudes regarding kiln dust health effects, prevention and respiratory PPE. Participants self-reported whether their brick kilns used prevention strategies and if they currently used respiratory PPE.

Definitions

Respiratory PPE included any of the following: N95 respirators, surgical masks and barrier face coverings. For clinical definitions, see online supplemental materials. We applied a conversion rate of US$1=NPR131.

Table 1 Participant characteristics

	Total	Current respiratory PPE use	No respiratory PPE use	P value
Participants	83	24	59	
General characteristics				
Age (years), mean±SD	30.8 (11.1)	28.2 (10.5)	31.9 (11.2)	0.10
Male, n (%)	64 (77.1)	20 (83.3)	44 (74.6)	0.57
Country of origin				
Nepal, n (%)	64 (77.1)	21 (87.5)	43 (72.9)	0.25
India, n (%)	19 (22.9)	3 (12.5)	16 (27.1)	
Non-brick kiln season monthly household income (NPR)	19029 (14986)	24882 (17726)	16634 (13152)	**0.04**
Brick kiln season monthly household income (NPR)	27094 (15205)	23809 (14277)	28430 (15483)	0.16
Highest level of education, n (%)				
Did not attend school	23 (27.7)	3 (12.5)	20 (33.9)	**<0.001**
Class 1–5	31 (37.3)	4 (16.7)	27 (45.8)	
Class 6–8	20 (24.1)	11 (45.8)	9 (15.3)	
Class 9–10	8 (9.6)	5 (20.8)	3 (5.1)	
Class 11–12	1 (1.2)	1 (4.2)	0 (0.0)	
Bachelor degree or above	0 (0.0)	0 (0.0)	0 (0.0)	
Highest level of education, binary, n (%)				
Primary school or less (<class 9)	74 (89.2)	18 (75.0)	56 (94.9)	**0.02**
Secondary school or above (≥class 9)	9 (10.8)	6 (25.0)	3 (5.1)	
Number of kiln seasons worked, mean±SD				
Total	9.6 (7.7)	7.0 (6.4)	10.7 (7.9)	**0.05**
Coal crusher	0.2 (0.7)	0.29 (1.0)	0.16 (0.6)	0.61
Fire master	0.8 (4.3)	0.04 (0.2)	1.09 (5.0)	0.46
Green brick maker	3.8 (7.5)	0.88 (4.3)	5.00 (8.3)	**<0.01**
Green brick stacker	2.4 (4.6)	4.04 (5.5)	1.69 (4.0)	**<0.01**
Brick hauler	2.3 (4.5)	1.17 (3.0)	2.78 (4.9)	0.18
Rafies	0.2 (1.2)	0.50 (2.3)	0.03 (0.3)	0.15
Other role	0.04 (0.3)	0.04 (0.2)	0.03 (0.3)	0.54
Self-reported medical history, n (%)				
History of pulmonary tuberculosis	0 (0.0)	0 (0.0)	0 (0.0)	NA
History of asthma	1 (1.2)	0 (0.0)	1 (1.7)	1
History of chronic bronchitis	0 (0.0)	0 (0.0)	0 (0.0)	NA
History of COPD	0 (0.0)	0 (0.0)	0 (0.0)	NA
History of emphysema	0 (0.0)	0 (0.0)	0 (0.0)	NA
History of lung cancer	0 (0.0)	0 (0.0)	0 (0.0)	NA
History of silicosis	0 (0.0)	0 (0.0)	0 (0.0)	NA
Current smoking				
Daily, n (%)	27 (32.5)	11 (45.8)	16 (27.1)	0.29
Less than daily, n (%)	9 (10.8)	2 (9.3)	7 (11.9)	
None, n (%)	47 (56.6)	11 (45.8)	36 (61.0)	
Smoking in pack-years, mean±SD	4.4 (8.6)	2.4 (6.4)	5.6 (9.6)	0.23
Respiratory symptoms, n (%)				
Chronic respiratory medication use	1 (1.2)	0 (0.0)	1 (1.7)	1
Acute respiratory medication use	1 (1.2)	0 (0.0)	1 (1.7)	1
Cough	12 (14.5)	1 (4.2)	11 (18.6)	0.17
Phlegm	12 (14.5)	1 (4.2)	11 (18.6)	0.17
Wheezing	2 (2.4)	0 (0.0)	2 (3.4)	1

P values in bold are statistically significant at the 0.05 level.
COPD, chronic obstructive pulmonary disease; NA, not available; NPR, Nepalese rupees; PPE, personal protective equipment.

Data analysis

Quantitative variables were analysed as continuous variables in the analyses. We used t-tests or Mann-Whitney U tests to compare continuous variables and χ^2 or Fisher's exact tests to compare categorical variables between groups. Missing data occurred when participants did not complete full questionnaires or declined answering specific questions. In our analysis, we excluded participants who did not complete all questionnaires. We included participants who were missing data on specific questions. We compared whether there were differences in baseline characteristics between participants with and without complete data. Statistical analyses were conducted in R (www.r-project.org), V.4.2.1.[33]

Table 2 Knowledge and attitudes about brick kiln dust health effects

N (%)	Total	Current respiratory PPE use	No respiratory PPE use	P value
Participants	83	24	59	
Knowledge				
Identified brick kiln dust health effect				
Difficulty breathing	38 (45.8)	9 (37.5)	29 (49.2)	0.47
Cough	43 (51.8)	12 (50.0)	31 (52.5)	1
Weight loss	8 (9.6)	2 (8.3)	6 (10.2)	1
Feeling tired	32 (38.6)	10 (41.7)	22 (37.3)	0.90
Headache	14 (16.9)	3 (12.5)	11 (18.6)	0.75
None of the above	14 (16.9)	3 (12.5)	11 (18.6)	0.75
Do not know	7 (8.4)	2 (8.3)	5 (8.5)	1
Identified disease caused by brick kiln dust				
Silicosis	7 (8.4)	3 (12.5)	4 (6.8)	0.41
Tuberculosis	13 (15.7)	2 (8.3)	11 (18.6)	0.33
Lung cancer	27 (32.5)	9 (37.5)	18 (30.5)	0.72
Kidney disease	9 (10.8)	3 (12.5)	6 (10.2)	0.71
COPD	34 (41.0)	11 (45.8)	23 (39.0)	0.74
None of the above	16 (19.3)	1 (4.2)	15 (25.4)	**0.03**
Do not know	22 (26.5)	8 (33.3)	14 (23.7)	0.53
Previously heard of silicosis	3 (3.6)	1 (4.2)	2 (3.4)	1
Knew that silicosis can be prevented				
Yes	23 (27.7)	11 (45.8)	12 (20.3)	**0.01**
No	9 (10.8)	4 (16.7)	5 (8.5)	
Do not know	51 (61.4)	9 (37.5)	42 (71.2)	
Stated that silicosis can be cured				
Yes	29 (34.9)	13 (54.2)	16 (27.1)	**<0.01**
No	7 (8.4)	4 (16.7)	3 (5.1)	
Do not know	47 (56.6)	7 (29.2)	40 (67.8)	
Knew that brick kiln dust is unhealthy	67 (80.7)	20 (83.3)	47 (79.7)	1
Stated that co-workers knew that breathing brick kiln dust is unhealthy				
Yes	59 (71.1)	17 (70.8)	42 (71.2)	1
No	10 (12.0)	3 (12.5)	7 (11.9)	
Do not know	14 (6.9)	4 (16.7)	10 (16.9)	
Attitudes				
Concern about brick kiln dust on health				
Highly concerned	15 (18.1)	5 (20.8)	10 (16.9)	0.97
Moderately concerned	17 (20.5)	5 (20.8)	12 (20.3)	
Slightly concerned	16 (19.3)	4 (16.7)	12 (20.3)	
Not at all concerned	35 (42.2)	10 (41.7)	25 (42.4)	
Believe silicosis is a serious health issue				
Yes	25 (30.1)	14 (58.3)	11 (18.6)	**<0.01**
No	12 (14.5)	3 (12.5)	9 (15.3)	
Do not know	46 (55.4)	7 (29.2)	39 (66.1)	

P values in bold are statistically significant at the 0.05 level.
COPD, chronic obstructive pulmonary disease; PPE, personal protective equipment.

RESULTS

Participant characteristics

A total of 83 workers (94.3% of enrolled participants) were included in this study (online supplemental E-Figure 1). Mean (±SD) age was 30.8±11.1 years and 77.1% were male (table 1); 77.1% (n=64) of workers identified Nepal as their country of origin and 22.9% (n=19) identified India. Mean monthly income during the non-brick kiln season was NPR19 029 (US$145) and during the brick kiln season it was NPR27 094 (US$206). 10% of workers completed more than primary school education. Mean (±SD) number of kiln seasons worked was 9.6±7.7 seasons. Self-reported history of pulmonary diseases and respiratory medication use was low. Respiratory symptom burden was low, with the most frequent symptoms being cough (14.5%) and phlegm (14.5%). Daily current smoking was 32.5%. Mean (±SD) pack-years were low at 4.4±8.6 pack-years.

Respiratory PPE use

A total of 28.9% (24/83) of workers stated they currently wear respiratory PPE (including N95 respirators, surgical masks and barrier face coverings) while working at the brick kiln.

Knowledge and attitudes about health effects

Many workers (42.2%) reported that they were not concerned about the effects of brick kiln dust on their health

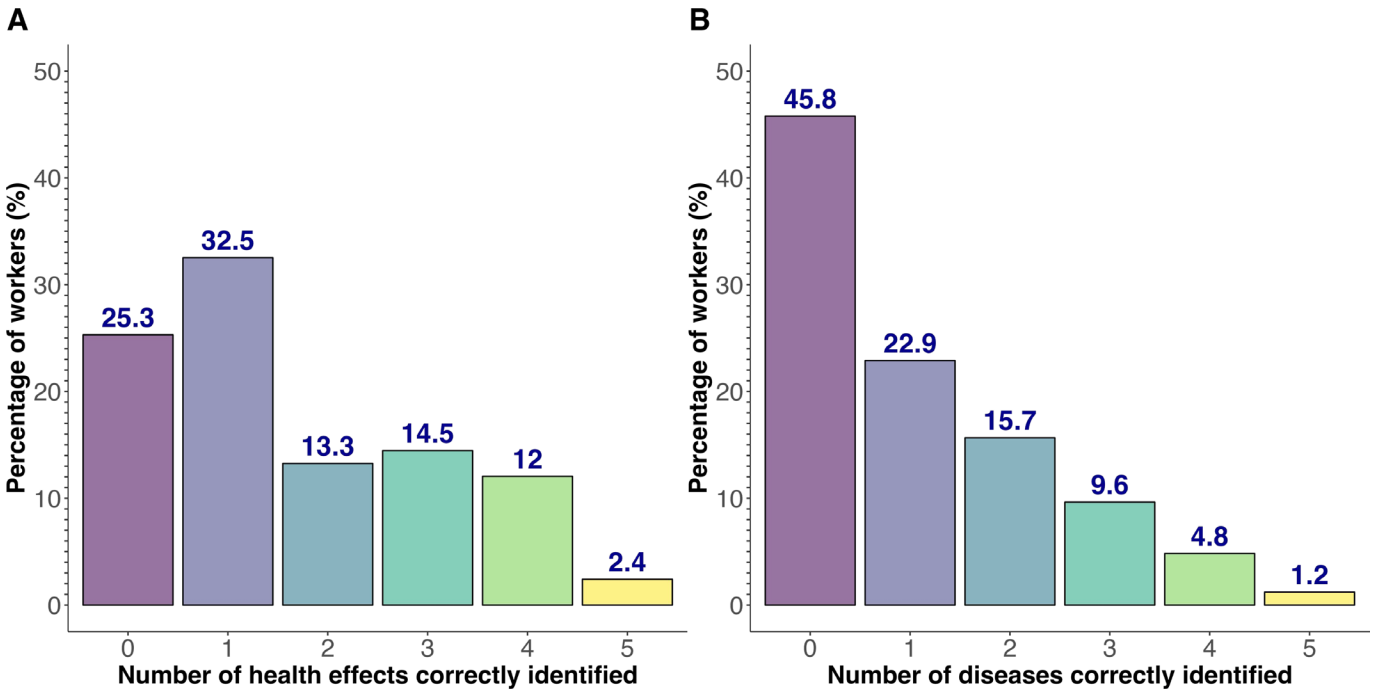

Figure 1 Worker knowledge. Workers identified brick kiln dust health effects (A) or diseases (B) from a list of options on a survey (see online supplemental file). Zero indicates no options were correctly identified, the lowest score. Five indicates all five options were correctly identified, the highest score.

(table 2). Overall knowledge of the health effects of brick kiln dust was low (table 2). When presented with a list of options, 25.3% of workers were unable to associate a single health effect (figure 1A) and 45.8% were unable to identify a single disease associated with brick kiln dust (figure 1B).

Only 3.6% of workers had heard of silicosis prior to the survey. After hearing a brief description of silicosis, most workers responded that they did not know whether silicosis could be prevented (61.4%) or cured (56.6%). Many workers agreed that brick kiln dust was unhealthy (80.7%) and thought their coworkers knew that brick kiln dust was unhealthy (71.1%).

A higher proportion of non-respiratory PPE workers (25.4%) did not identify any diseases associated with brick kiln dust, compared with those who wore respiratory PPE (4.2%, p=0.03). A higher proportion of workers who wore respiratory PPE answered correctly that silicosis could be prevented (45.8% vs 20.3%, p=0.01), incorrectly believed that silicosis could be cured (54.2% vs 27.1%, p<0.01), and thought silicosis was a serious health issue (58.3% vs 18.6%, p<0.01) compared with those who did not wear respiratory PPE.

Knowledge and attitudes about general prevention of exposures to brick kiln dust

Only 49.4% of workers stated that exposure to brick kiln dust could be prevented (table 3). Most stated that reducing brick kiln dust was a priority for owners (73.5%) and coworkers (75.9%). Workers reported that their kiln used the following strategies to reduce dust: spraying water on the ground (95.2%) or air (8.4%), and requiring workers to wear respiratory PPE (31.3%).

Among workers who currently wore respiratory PPE, 58.3% stated that their kiln required respiratory use, which is higher compared with those who did not wear respiratory PPE (20.3%, p<0.01); but workers from the same kiln had different responses on whether their kiln required respiratory PPE (online supplemental E-Figure 2). Among those who stated their kiln required respiratory PPE (n=26), only 53.8% (n=14) of participants reported currently using respiratory PPE.

Knowledge, attitudes and factors influencing respiratory PPE use

88% of workers agreed that wearing respiratory PPE provided protection from brick kiln dust (table 4). Most workers reported that they knew how to get (96.4%), select (88.0%) and properly wear respiratory PPE (96.4%). When asked to identify the best respiratory PPE for preventing exposure out of a list of respiratory PPE photos, only 24.4% correctly chose N95s (online supplemental E-Figure 3). Workers were more willing to wear surgical masks (60.2%) than N95 respirators (14.5%).

A minority of workers stated that respiratory PPE was too expensive to buy (33.7%), uncomfortable to wear (32.5%), slowed down work efficiency (36.1%) and looked weird (21.7%). Most workers (92.8%) reported they would wear respiratory PPE if available free of charge, and a lower percentage (73.5%) stated they would wear respiratory PPE if they had to purchase it themselves. The mean amount that workers said they would be willing to pay daily for respiratory PPE was NPR12 (US$0.09) (online supplemental E-Figure 4). The price of N95s in local Nepal markets was NPR400 (US$3.01). Many workers (69.9%) stated that they would only wear respiratory PPE if required by law.

Workers who wore respiratory PPE had a higher monthly household income (non-brick kiln season income NPR 24 882±17 726; US$190±135 vs NPR 16 649±13 152; US$127±100; p=0.04); higher education levels (25% vs 5.1% completed secondary school or above; p=0.02); and worked fewer kiln seasons on average (7.0±6.4) than those who did not wear respiratory PPE (10.7±7.9; p=0.05) (table 1). There was no significant difference in brick kiln season household income between those who did and did not wear respiratory PPE.

Table 3 Knowledge, attitudes and practices regarding brick kiln dust prevention

N (%)	Total	Current respiratory PPE use	No respiratory PPE use	P value
Participants	83	24	59	
Knowledge				
Knew that brick kiln dust exposure can be prevented				
Yes	41 (49.4)	16 (66.7)	25 (42.4)	0.10
No	25 (30.1)	6 (25.0)	19 (32.2)	
Do not know	17 (20.5)	2 (8.3)	15 (25.4)	
Attitudes				
Reducing brick kiln dust is an important priority for owners and managers				
Yes	61 (73.5)	19 (79.2)	42 (71.2)	0.92
No	8 (9.6)	2 (8.3)	6 (10.2)	
Do not know	14 (16.9)	3 (12.5)	11 (18.6)	
Reducing brick kiln dust is an important priority for coworkers				
Yes	63 (75.9)	19 (79.2)	44 (74.6)	0.39
No	10 (12.0)	4 (16.7)	6 (10.2)	
Do not know	10 (12.0)	1 (4.2)	9 (15.3)	
Practices				
Brick kiln sprays water in the air				
Yes	7 (8.4)	3 (12.5)	4 (6.8)	0.38
No	71 (85.5)	21 (87.5)	50 (84.7)	
Do not know	5 (6.0)	0 (0.0)	5 (8.5)	
Brick kiln sprays water on the ground				
Yes	79 (95.2)	23 (95.8)	56 (94.9)	0.75
No	2 (2.4)	1 (4.2)	1 (1.7)	
Do not know	2 (2.4)	0 (0.0)	2 (3.4)	
Brick kiln requires respiratory PPE use				
Yes	26 (31.3)	14 (58.3)	12 (20.3)	**<0.01**
No	54 (65.1)	10 (41.7)	44 (74.6)	
Do not know	3 (3.6)	0 (0.0)	3 (5.1)	

P values in bold are statistically significant at the 0.05 level.
PPE, personal protective equipment.

A smaller proportion of workers who wore respiratory PPE (12.5%) agreed that respiratory PPE was uncomfortable, compared with workers who did not wear PPE (40.7%, p=0.02). A higher percentage of workers who wore respiratory PPE stated they would purchase respiratory PPE themselves (91.7% vs 66.1%, p=0.03) and that respiratory PPE was available to wear at brick kilns in the past (50.0% vs 11.9%, p<0.01), compared with workers who did not wear respiratory PPE.

DISCUSSION

We found that brick kiln workers in Nepal had limited knowledge of the symptoms and diseases associated with inhaling brick kiln dust and proper PPE selection. Respiratory PPE use was low. Although most workers agreed that kiln dust was unhealthy, many workers reported low concern with the health effects. The majority of workers stated they were willing to purchase respiratory PPE but could only afford a fraction of the cost of a disposable N95.

Approximately 50% of workers knew that brick kiln dust exposure could be prevented, which is significantly lower than Vietnamese workers, where 70% of workers knew how to prevent silicosis.[29] Despite poor awareness of specific health effects, most brick workers in Nepal agreed that brick kiln dust was unhealthy. A large proportion of workers (42.2%) reported not being concerned about brick kiln dust. Addressing knowledge gaps alone may not be sufficient to raise workers' awareness and action towards brick kiln dust exposure.

Workers from the same kiln had different responses on whether their kiln required respiratory PPE, and this inconsistency raises questions about accuracy or suggests that respiratory PPE enforcement is lax. 29% of workers stated they currently wear respiratory PPE while working at the kiln, although we suspect that actual respiratory PPE use was lower based on anecdotal observations from our field team. The prevalence of respiratory PPE use among brick kiln workers in Nepal is lower than the 88% found in silica-exposed workers in Vietnam.[29] However, it is similar to the 32%–33% respiratory PPE use found among similar silica-exposed workers in India and Bangladesh.[30 34 35]

Most workers reported that they knew how to find, select and properly wear respiratory PPE. However, when asked to identify the best respiratory PPE for preventing brick kiln dust exposure, only 24.1% of workers correctly identified N95s. This suggests that workers perceive their respiratory PPE knowledge to be better than their actual knowledge. Alternatively, this could suggest acquiescence bias, with workers wanting to portray a higher level of knowledge. Proper selection of PPE is a knowledge gap that has previously been identified among workers exposed to occupational dust.[28]

Fewer workers than hypothesised reported concern about respiratory PPE cost, comfort, look and impact on work efficiency. Unexpectedly, most workers stated that they have looked and were able to find respiratory PPE, suggesting that supply is not a significant barrier for workers. Perhaps workers were thinking about any face covering when answering these

Table 4 Knowledge, attitudes and practices regarding respiratory PPE

N (%)	Total	Current respiratory PPE use	No respiratory PPE use	P value
Participants	83	24	59	
Knowledge				
Knew that wearing respiratory PPE provides protection from brick kiln dust	73 (88.0)	20 (83.3)	53 (89.8)	0.47
Knew where to get respiratory PPE	80 (96.4)	23 (95.8)	57 (96.6)	1
Knew how to select the right type of respiratory PPE (self-reported)	73 (88.0)	23 (95.8)	50 (84.7)	0.27
Knew how to wear respiratory PPE properly	80 (96.4)	24 (100.0)	56 (94.9)	0.55
Identified N95 as best respiratory PPE for preventing brick kiln dust exposure	20 (24.1)	6 (25.0)	14 (23.7)	0.15
Attitudes				
Willing to wear the following respiratory PPE type at work				
Cloth/scarf	21 (25.3)	7 (29.2)	14 (23.7)	0.81
Surgical mask	50 (60.2)	15 (62.5)	35 (59.3)	0.98
N95	12 (14.5)	3 (12.5)	9 (15.3)	1
None	1 (1.2)	0 (0.0)	1 (1.7)	1
Believe that respiratory PPE are too expensive to buy	28 (33.7)	6 (25.0)	22 (37.3)	0.41
Believe respiratory PPE are uncomfortable to wear	27 (32.5)	3 (12.5)	24 (40.7)	**0.02**
Believe respiratory PPE slow down work efficiency	30 (36.1)	7 (29.2)	23 (39.0)	0.55
Believe wearing respiratory PPE looks weird	18 (21.7)	4 (16.7)	14 (23.7)	0.57
Would only wear respiratory PPE if required by law	58 (69.9)	16 (66.7)	42 (71.2)	0.89
Would wear respiratory PPE if available at work free of charge	77 (92.8)	23 (95.8)	54 (91.5)	0.67
Would wear respiratory PPE if had to purchase	61 (73.5)	22 (91.7)	39 (66.1)	**0.03**
Amount willing to pay daily for respiratory PPE (NPR), mean±SD	12.0 (12.5)	14.5 (15.5)	11.0 (11.1)	0.47
Practices				
Respiratory PPE available to wear at brick kilns in the past	19 (22.9)	12 (50.0)	7 (11.9)	**<0.01**
Currently wear respiratory PPE while working at the brick kiln	24 (28.9)	24 (100.0)	0 (0.0)	NA
Have looked for respiratory PPE	62 (74.7)	24 (100.0)	38 (64.4)	**<0.001**
Able to find respiratory PPE	79 (95.2)	24 (100.0)	55 (93.2)	0.32
Forget to wear respiratory PPE	15 (18.1)	4 (16.7)	11 (18.6)	1
Factors encouraging respiratory PPE use				
Knowledge about the health effects of brick kiln dust	79 (95.2)	24 (100.0)	55 (93.2)	0.32
Training on how to wear respiratory PPE properly	66 (79.5)	23 (95.8)	43 (72.9)	**0.02**
Respiratory PPE are supplied at workplace	76 (91.6)	24 (100.0)	52 (88.1)	0.10
Reminders at workplace to wear respiratory PPE	67 (80.7)	24 (100.0)	43 (72.9)	**<0.01**
Co-workers are wearing respiratory PPE	62 (74.7)	20 (83.3)	42 (71.2)	0.28
Respiratory PPE is comfortable to wear	77 (92.8)	23 (95.8)	54 (91.5)	0.67
Respiratory PPE does not interfere with work efficiency	73 (88.0)	21 (87.5)	52 (88.1)	1

P values in bold are statistically significant at the 0.05 level.
NPR, Nepalese rupees; PPE, personal protective equipment.

questions. Most workers stated they would only wear respiratory PPE if required by law, highlighting the importance of advocating for mandatory laws in Nepal.

Higher income, higher level of education and fewer kiln seasons worked were associated with current respiratory PPE use. Our finding that higher education level was associated with current respiratory PPE use aligns with studies from Vietnam and India.[29 30] However, more years worked were associated with frequent respiratory PPE use in Vietnam, which is different from what we found in Nepal.[29] Perhaps as workers in Nepal spend more years at the kiln, they become more desensitised to dust and adjusted to the norm of not wearing respiratory PPE, compared with Vietnam where respiratory PPE use is the norm.

Beliefs that silicosis could be prevented and was a serious health issue were associated with current respiratory PPE use. Interestingly, a higher proportion of workers who wore respiratory PPE thought that silicosis could be cured, which is incorrect and emphasises the need to educate all workers. Those that reported kilns required respiratory PPE use and that respiratory PPE were available at past kilns had higher use, which highlights the influence of kiln-wide respiratory PPE policies.

Our study has some strengths. We collected data on multiple factors that could influence knowledge, attitudes and practices. We developed our study survey based on Fishbein and Ajzen's Theory of Planned Behaviour that attitudes (eg, concern about brick kiln dust), subjective norms (eg, coworkers wearing respiratory PPE) and perceived behavioural control (eg, able to find respiratory PPE) influence intentions to perform a behaviour (eg, wearing respiratory PPE). We also modelled our survey on previous surveys among silica-exposed workers in India and Vietnam.[29 30]

Our study also has some potential shortcomings. Our sample size was small although adequate for our primary objective of estimating respiratory PPE prevalence. We recruited participants from 10 brick kilns, and workers from these kilns may differ from those from other kilns, affecting external validity. We sampled participants by household, and workers who lived together may have similar characteristics, leading to possible

clustering of results and over-representation of certain knowledge, attitudes and practices. A true random sample of workers at the kilns would have been a better design. We defined silicosis early in the survey, as we suspected that workers were not familiar with the disease and wanted to probe into their perceptions but doing so may have influenced workers' responses to subsequent questions. Field workers surveyed participants, who self-reported answers to the surveys. Responses could have been subject to recall bias. Acquiescence and social desirability bias could have occurred, with workers wanting to portray favourable attitudes or higher level of knowledge. Workers' reported behaviours are likely different from their actual behaviours. We did not directly measure actual respiratory PPE use, duration of use, type of respiratory PPE used and actual purchasing behaviour, which would better quantify proper respiratory PPE use and affordability. We did not collect data on the influence of COVID-19 on respiratory PPE use.

PPE places the onus of protection on the worker and requires individual-level behaviour change. PPE is the lowest intervention on the hierarchy of controls, and given variable proper use, workers who wear PPE may still be exposed above the PEL.[20] Worker health should be the responsibility of businesses and government through enforcement of structural interventions.[20] However, workplace-level interventions work well in countries where there are strong regulatory policies in place.[21] Advocacy and social justice efforts are needed to develop and enforce laws that protect brick kiln worker health in Nepal. In the meantime, PPE is a non-invasive intervention that can be readily implemented and may provide immediate protection and benefits while awaiting structural changes in Nepal. Increasing PPE uptake is feasible through distribution and promotion and has improved health outcomes.[36] Although structural interventions are more cost-effective, PPE provides cost–benefit.[37] Policies are needed to improve PPE affordability for workers in Nepal.

Despite these limitations, our study adds important data on the knowledge, attitudes and practices surrounding brick kiln dust health effects and prevention methods for a novel vulnerable population: brick kiln workers in Nepal. To our knowledge, this is the first study to date to characterise factors associated with PPE use in this population. Our findings can guide future investigations to reduce the burden of silicosis among brick kiln workers. Moving forward, our study team will gather qualitative data to better characterise factors influencing PPE use, and then design and pilot a PPE intervention to improve use among brick kiln workers in Nepal.

CONCLUSION

In this study, we found that only 28.9% of sampled workers wore respiratory PPE while working at the kiln. Workers knew that inhaling brick kiln dust was unhealthy but had poor knowledge of the specific symptoms and diseases associated with brick kiln dust and were unable to select proper respiratory PPE. Despite poor baseline knowledge, workers generally had favourable attitudes towards wearing respiratory PPE. Higher income, higher level of education and fewer kiln seasons worked were associated with respiratory PPE use. Overall, our research highlights important barriers to respiratory PPE use which should be considered when developing PPE interventions among brick kiln workers. While less effective than structural interventions, PPE remains cost-effective and can save lives.

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