Prevalence and Predictors of Respiratory Diseases Among Coal-Based Sponge Iron Plant Workers: A Cross-Sectional Study in Barjora, India

Kaushik Chattopadhyay

Background: During the last decade, coal-based sponge iron plants, a highly polluted industry, have grown rapidly in Barjora, India. The toxic effects of particulate matters and gaseous pollutants are often rapid and include respiratory diseases (such as asthma and rhinoconjunctivitis).

Objectives and Methods: A cross-sectional study was conducted among 258 coal-based sponge iron plant workers in Barjora to assess the prevalence of respiratory diseases (self-reported) and to determine the associated factors.

Findings: The percentage of participants with any chronic respiratory disease, asthma and rhinoconjunctivitis were 25.5%, 8.9%, and 17.1%, respectively. The odds of any chronic respiratory disease were lower in participants with family history of any chronic respiratory disease (odds ratio [OR] 0.47, 95% confidence interval [CI] 0.24–0.91, \( P = 0.024 \)). The odds of asthma were lower in participants living in a room with less than 3 people (OR 2.86, 95% CI 1.16–7.07, \( P = 0.023 \)) and with family history (OR 0.20, 95% CI 0.08–0.53, \( P = 0.001 \)). The odds of rhinoconjunctivitis were lower in illiterate participants (OR 0.34, 95% CI 0.12–0.94, \( P = 0.038 \)) and those with pucca/semipucca house type (OR 2.44, 95% CI 1.11–5.39, \( P = 0.027 \)).

Conclusion: Many coal-based sponge iron plant workers in Barjora report the presence of respiratory diseases, and the predictors such as overcrowding and poor quality housing were identified.
case, each question was shown and read to the participant who was asked to say and point out the answer. Each session was completed in one sitting. The data were entered on the day of its collection.

The questionnaire included the following sociodemographic and occupational variables: age (in years), sex, mother tongue (proxy measures for local ethnic origin, culture, and lifestyle), religion, social caste (general or scheduled caste [SC]/scheduled tribe [ST]/other backward class [OBC]), marriage, education (literate or illiterate), work type (nonmanual or manual), working hours per day (8 [normal] [5] or more than 8), salary per month (5395 Indian rupees [INR; minimum monthly wage of an unskilled worker] [5] or more, or less than 5395 INR), total duration of work in this type of factory (proxy measure for exposure time, in years), smoking, smokeless tobacco intake, alcohol drinking, house type (pucca/semipucca [at least some high-quality construction materials such as bricks, tiles, cement, and concrete] or kachcha [low-quality construction materials such as mud and thatch]) [6], people living in a room (less than 3, or 3 or more to indicate crowding) [6], pet animal at home, domestic cooking fuel (cleaner fuel [noncontinuous exposure to smoke: charcoal, coal/coke/lignite, kerosene, electricity, petroleum gas, and biogas] or biomass fuel [continuous exposure to smoke: wood/crop-residues and animal dung]) [6], separate room as kitchen at home, chimney/exhaust fan for cooking food at home, family history (presence of any chronic respiratory disease in biological father/mother/siblings), and health insurance. The presence of any respiratory disease was probed with the following question: Do you have any chronic respiratory disease, asthma or rhinoconjunctivitis, diagnosed by a medical doctor? The hint provided for the word asthma was symptoms like coughing, wheezing, chest tightness, and breathlessness [7]. The hint provided for the word rhinoconjunctivitis was symptoms like nasal congestion, runny nose, postnasal drip, sneezing, red eyes (conjunctivitis), and itching of the nose or eyes [8]. All the variables were dichotomous except age and total duration of work in this type of factory. The questionnaire was designed in English, translated into Bengali and Hindi, reviewed by a local primary school teacher, and pretested extensively on 6 local similar workers who were not involved in the study.

**Sample Size**

Because this was the first study on the prevalence of respiratory diseases among coal-based sponge iron plant workers, no information was available on which to base the sample size calculation. Instead, a web-based sample size calculator, Creative Research Systems [9], was used to calculate the sample size, using the following assumptions/information: confidence level (95%), margin of error (5%) and population size (662 information from the factory directors in Barjora). A random sample of 258 such workers was required, assuming a response rate of 95%. A numbered list of all 662 workers was created (worker #1, worker #2, worker #3, and so forth). A web-based randomizer, Research Randomizer [10], was used to generate 1 set of 258 unique, sorted numbers with a range from 1 to 662 (representing the workers’ assigned numbers).

**Ethics**

Approval was received from the Barjora Block Development Office Committee (the committee was based on the Indian Council of Medical Research Ethical Guidelines for Biomedical Research on Human Participants, 2006) [11]. Information sheets and consent forms were available in English, Bengali, and Hindi. The study objectives were explained to all the eligible participants and written informed consent was taken from those interested in participating. Illiterate participants were requested to put their left-hand thumb impression on the consent form. Participants were not compelled and were free to participate in the study. They were assured regarding the anonymity, privacy, confidentiality, and data protection of their information.

**Statistical Analyses**

The presence of any chronic respiratory disease, asthma, or rhinoconjunctivitis was categorized into no and yes, and numbers and proportions were calculated being a
Results
The response rate was 100%. All the participants were men with a mean age of 35.4 years. The percentage of participants with any chronic respiratory disease, asthma, and rhinoconjunctivitis were 25.5%, 8.9%, and 17.1%, respectively. Table 1 reports the characteristics of coal-based sponge-iron factory workers with and without any chronic respiratory disease, asthma, or rhinoconjunctivitis. Family history (P = 0.017) was found to be associated with the presence of any chronic respiratory disease. People living in a room (P = 0.024) and family history (P < 0.001) were found to be associated with the presence of asthma. Table 2 shows the multiple backward stepwise regression analyses to determine factors independently associated with the presence of any chronic respiratory disease, asthma, or rhinoconjunctivitis. The odds of any chronic respiratory disease were lower in participants with family history (OR 0.47, 95% CI 0.24–0.91, P = 0.024). The odds of asthma were lower in participants living in a room with <3 people (OR 2.86, 95% CI 1.16–7.07, P = 0.023) and with family history (OR 0.20, 95% CI 0.08–0.53, P = 0.001). The odds of rhinoconjunctivitis were lower in illiterate participants (OR 0.34, 95% CI 0.12–0.94, 0.038) and those with pucca/semipucca house type (OR 2.44, 95% CI 1.11–5.39, P = 0.027). Sensitivity analyses showed similar results (i.e., the results were significant) except the association between the presence of rhinoconjunctivitis and education.

Discussion
The percentage of participants with any chronic respiratory disease, asthma, and rhinoconjunctivitis were 25.5%, 8.9%, and 17.1%, respectively. These findings are consistent with other studies conducted in different occupational settings where smoke and dust are common [13–18]. The odds of asthma were lower in participants living in a room with <3 people. This is consistent with other studies, and overcrowding is known to be a risk factor for asthma [19–21]. Overcrowding is common in Indian population and may be viewed as a marker for poor indoor hygiene and consequently increased exposure to various indoor allergens (such as house dust mites, animal dander, cockroaches, fungi, and molds) that are known to play an important role in the pathogenesis of asthma [19, 20]. The odds of rhinoconjunctivitis were lower in participants with pucca/semipucca house type. This is consistent with other studies, and poor quality housing is known to be a risk factor for rhinoconjunctivitis [19, 22, 23]. The odds of rhinoconjunctivitis were lower in illiterate participants. Intuitively, one would expect illiterates to have more rhinoconjunctivitis than literates. In this study, more illiterate participants may have reported the absence of rhinoconjunctivitis to field workers (who completed the questionnaire on their behalf) compared with self-completion by literate participants. In some studies, participants reported better health status during face-to-face interviews than in postal surveys [24, 25]. This issue requires further exploration. The odds of any chronic respiratory disease or asthma were lower in participants with family history. Intuitively, one would expect the opposite and this issue requires further investigation.

This study has a number of strengths and weaknesses. To the best of the author’s knowledge, this is the first study on the prevalence of respiratory diseases among coal-based sponge iron plant workers. All the workers who were approached to participate in the study responded (a 100% response rate and thus no nonrespondents). This indicates that the data collection methodology was appropriate and there is more certainty in the study findings (ie, it is more likely the results are representative of the population). In terms of generalizability, the study findings could be valid in settings with similar populations and health care systems (such as in other South Asian countries). The standard steps in questionnaire development (design, translation, and pretesting) were followed to ensure the validity and reliability of the questionnaire. The field workers used a standardized protocol for data collection. The field workers and the participants belonged to the same culture, which minimized the scope for cultural bias in the study. Missing data could lead to bias, but it was extremely low in this study. Multiple regression analyses included a sample with missing values for the adjusted variables. Participants who were absent from work on the dates of the survey were excluded, and this absence from work could be due to respiratory diseases, which could have underestimated the prevalence of respiratory diseases. Most of the data were self-reported, and recall error could have been a problem. Medical records might be a more reliable measure (for the presence of any respiratory disease), but these were not available or accessible in the study area. The study focused on confirmed cases and excluded undiagnosed cases, which could have underestimated the prevalence of respiratory diseases. Because of limited resources and budget, lung function or other diagnostic tests could not be performed. However, these tests could be used in future studies, which would cross-check these study findings and would provide a complete picture of the scenario. Some of the associations that were found in the study deserve further examination. For example, the odds of any chronic respiratory disease or asthma were lower in participants with family history. It is possible that these findings were the result of other confounding factors not adjusted for in the
Table 1: Characteristics of Coal-based Sponge Iron Factory Workers With and Without Any Chronic Respiratory Disease, Asthma, or Rhinoconjunctivitis.

|                      | Any chronic respiratory disease (n = 258, includes 11 unknown) | Asthma (n = 258) | Rhinoconjunctivitis (n = 258) |
|----------------------|-------------------------------------------------------------|------------------|-------------------------------|
|                      | No (n = 181)       | Yes (n = 66)     | P                             | No (n = 235) | Yes (n = 23) | P                             | No (n = 214) | Yes (n = 44) | P                             |
| Age                  | 35.5 (8.5)*       | 35.0 (7.4)*      | 0.710†                        | 35.5 (8.2)*  | 34.5 (7.7)*  | 0.582†                        | 35.8 (8.3)*  | 33.5 (7.3)*  | 0.085†                        |
| Mother tongue        | 0.803             | 0.490            | 0.287                         |               |               |                               |               |               |                               |
| Bengali              | 155 (85.6)        | 58 (87.9)        | 200 (85.1)                    | 22 (95.7)    | 186 (86.9)   | 36 (81.8)                     |               |               |                               |
| Other                | 21 (11.6)         | 7 (10.6)         | 28 (11.9)                     | 1 (4.3)      | 22 (10.3)    | 7 (15.9)                      |               |               |                               |
| Unknown              | 5 (2.8)           | 1 (1.5)          | 7 (3.0)                       | 0            | 6 (2.8)      | 1 (2.3)                       |               |               |                               |
| Religion             | 1.000             | 0.256            | 0.406                         |               |               |                               |               |               |                               |
| Hindu                | 173 (95.6)        | 63 (95.5)        | 226 (96.2)                    | 21 (91.3)    | 206 (96.3)   | 41 (93.2)                     |               |               |                               |
| Islam                | 8 (4.4)           | 3 (4.5)          | 9 (3.8)                       | 2 (8.7)      | 8 (3.7)      | 3 (6.8)                       |               |               |                               |
| Social caste         | 0.195             | 0.354            | 0.458                         |               |               |                               |               |               |                               |
| General              | 109 (60.2)        | 45 (68.2)        | 145 (61.7)                    | 16 (69.6)    | 137 (64.0)   | 24 (54.6)                     |               |               |                               |
| SC/ST/OBC            | 69 (38.1)         | 19 (28.8)        | 86 (36.6)                     | 6 (26.1)     | 75 (35.1)    | 17 (38.6)                     |               |               |                               |
| Unknown              | 3 (1.7)           | 2 (3.0)          | 4 (1.7)                       | 1 (4.3)      | 2 (0.9)      | 3 (6.8)                       |               |               |                               |
| Marriage             | 0.638             | 0.196            | 0.150                         |               |               |                               |               |               |                               |
| Yes                  | 157 (86.7)        | 54 (81.8)        | 204 (86.8)                    | 17 (73.9)    | 186 (86.9)   | 35 (79.6)                     |               |               |                               |
| No                   | 24 (13.3)         | 10 (15.2)        | 30 (12.8)                     | 5 (21.7)     | 26 (12.2)    | 9 (20.4)                      |               |               |                               |
| Unknown              | 0                 | 2 (3.0)          | 1 (0.4)                       | 1 (4.4)      | 2 (0.9)      | 0                             |               |               |                               |
| Education            | 0.568             | 1.000            | 0.171                         |               |               |                               |               |               |                               |
| Literate             | 156 (86.2)        | 59 (89.4)        | 205 (87.2)                    | 21 (91.3)    | 190 (88.8)   | 36 (81.8)                     |               |               |                               |
| Illiterate           | 24 (13.3)         | 7 (10.6)         | 29 (12.4)                     | 2 (8.7)      | 23 (10.7)    | 8 (18.2)                      |               |               |                               |
| Unknown              | 1 (0.5)           | 0                | 1 (0.4)                       | 0            | 1 (0.5)      | 0                             |               |               |                               |
| Work type            | 0.239             | 0.318            | 0.372                         |               |               |                               |               |               |                               |
| Nonmanual            | 34 (18.8)         | 17 (25.8)        | 50 (21.3)                     | 7 (30.4)     | 45 (21.0)    | 12 (27.3)                     |               |               |                               |
| Manual               | 146 (80.7)        | 49 (74.2)        | 184 (78.3)                    | 16 (69.6)    | 168 (78.5)   | 32 (72.7)                     |               |               |                               |
| Unknown              | 1 (0.5)           | 0                | 1 (0.4)                       | 0            | 1 (0.5)      | 0                             |               |               |                               |
| Hours/day            | 0.452             | 1.000            | 1.000                         |               |               |                               |               |               |                               |
| 8                    | 161 (89.0)        | 62 (93.9)        | 212 (90.2)                    | 21 (91.3)    | 193 (90.2)   | 40 (90.9)                     |               |               |                               |
| >8                   | 18 (9.9)          | 4 (6.1)          | 21 (8.9)                      | 2 (8.7)      | 19 (8.9)     | 4 (9.1)                       |               |               |                               |
| Unknown              | 2 (1.1)           | 0                | 2 (0.9)                       | 0            | 2 (0.9)      | 0                             |               |               |                               |
| Salary/month         | 0.886             | 0.975            | 0.367                         |               |               |                               |               |               |                               |
| ≥5395 INR            | 45 (24.9)         | 17 (25.8)        | 62 (26.4)                     | 6 (26.1)     | 54 (25.2)    | 14 (31.8)                     |               |               |                               |
| <5395 INR            | 136 (75.1)        | 49 (74.2)        | 173 (73.6)                    | 17 (73.9)    | 160 (74.8)   | 30 (68.2)                     |               |               |                               |
| Total duration       | 9.9 (13.7)*       | 9.4 (11.6)*      | 10.2 (14.7)*                  | 7.9 (3.1)*   | 10.5 (15.3)* | 7.7 (3.3)*                    |               |               |                               |
| Smoking              | 0.541             | 0.438            | 0.373                         |               |               |                               |               |               |                               |
| No                   | 106 (58.6)        | 36 (54.5)        | 133 (56.6)                    | 15 (65.2)    | 120 (56.1)   | 28 (63.6)                     |               |               |                               |
| Yes                  | 74 (40.9)         | 30 (45.5)        | 101 (43.0)                    | 8 (34.8)     | 93 (43.4)    | 16 (36.4)                     |               |               |                               |
| Unknown              | 1 (0.5)           | 0                | 1 (0.4)                       | 0            | 1 (0.5)      | 0                             |               |               |                               |

(Contd.)
Any chronic respiratory disease (n = 258, includes 11 unknown) | Asthma (n = 258) | Rhinoconjunctivitis (n = 258)
---|---|---
| No (n = 181) | Yes (n = 66) | P | No (n = 235) | Yes (n = 23) | P | No (n = 214) | Yes (n = 44) | P |
Smokeless tobacco | 0.444 | 0.659 | 0.755 |
No | 89 (49.2) | 29 (43.9) | 113 (48.1) | 10 (43.5) | 101 (47.2) | 22 (50.0) |
Yes | 91 (50.3) | 37 (56.1) | 121 (51.5) | 13 (56.5) | 112 (52.3) | 22 (50.0) |
Unknown | 1 (0.5) | 0 | 1 (0.4) | 0 | 1 (0.5) | 0 |
Drinking | 0.086 | 0.809 | 0.081 |
No | 119 (65.8) | 36 (54.6) | 146 (62.1) | 15 (65.2) | 139 (64.9) | 22 (50.0) |
Yes | 60 (33.1) | 30 (45.4) | 87 (37.0) | 8 (34.8) | 74 (34.6) | 21 (47.7) |
Unknown | 2 (1.1) | 0 | 2 (0.9) | 0 | 1 (0.5) | 1 (2.3) |
House type | 0.925 | 0.858 | 0.220 |
Pucca/semipucca | 88 (48.6) | 32 (48.5) | 116 (49.3) | 11 (47.8) | 102 (47.6) | 25 (56.8) |
Kachha | 91 (50.3) | 34 (51.5) | 117 (49.8) | 12 (52.2) | 111 (51.9) | 18 (40.9) |
Unknown | 2 (1.1) | 0 | 2 (0.9) | 0 | 1 (0.5) | 1 (2.3) |
People in a room | 0.115 | 0.024 | 0.672 |
<3 | 63 (34.8) | 16 (24.2) | 69 (29.4) | 12 (52.2) | 66 (30.8) | 15 (34.1) |
≥3 | 118 (65.2) | 50 (75.8) | 166 (70.6) | 11 (47.8) | 148 (69.2) | 29 (65.9) |
Pet | 0.564 | 0.390 | 0.503 |
No | 83 (45.9) | 33 (50.0) | 114 (48.5) | 9 (39.1) | 100 (46.7) | 23 (52.3) |
Yes | 98 (54.1) | 33 (50.0) | 121 (51.5) | 14 (60.9) | 114 (53.3) | 21 (47.7) |
Domestic cooking fuel | 0.303 | 0.213 | 0.791 |
Cleaner fuel | 107 (59.1) | 44 (66.7) | 142 (60.4) | 17 (73.9) | 131 (61.2) | 28 (63.6) |
Biomass fuel | 73 (40.3) | 22 (33.3) | 92 (39.2) | 6 (26.1) | 82 (38.3) | 16 (36.4) |
Other | 1 (0.6) | 0 | 1 (0.4) | 0 | 1 (0.5) | 0 |
Kitchen | 0.786 | 0.998 | 0.579 |
Yes | 134 (74.0) | 48 (72.7) | 173 (73.6) | 17 (73.9) | 156 (72.9) | 34 (77.3) |
No | 46 (25.4) | 18 (27.3) | 61 (26.0) | 6 (26.1) | 57 (26.6) | 10 (22.7) |
Unknown | 1 (0.6) | 0 | 1 (0.4) | 0 | 1 (0.5) | 0 |
Chimney/exhaust fan | 0.482 | 0.430 | 0.190 |
Yes | 14 (7.7) | 7 (10.6) | 19 (8.1) | 3 (13.0) | 16 (7.5) | 6 (13.6) |
No | 166 (91.7) | 59 (89.4) | 214 (91.0) | 20 (87.0) | 196 (91.6) | 38 (86.4) |
Unknown | 1 (0.6) | 0 | 2 (0.9) | 0 | 2 (0.9) | 0 |
Family history | 0.017 | 0.001 | 0.654 |
No | 137 (75.7) | 40 (60.6) | 173 (73.6) | 9 (39.1) | 151 (70.6) | 31 (70.5) |
Yes | 33 (18.2) | 21 (31.8) | 45 (19.2) | 11 (47.8) | 45 (21.0) | 11 (25.0) |
Unknown | 11 (6.1) | 5 (7.6) | 17 (7.2) | 3 (13.1) | 18 (8.4) | 2 (4.5) |
Health insurance | 0.451 | 0.584 | 0.880 |
No | 35 (19.3) | 10 (15.1) | 46 (19.6) | 3 (13.0) | 41 (19.2) | 8 (18.2) |
Yes | 146 (80.7) | 56 (84.9) | 189 (80.4) | 20 (87.0) | 173 (80.8) | 36 (81.8) |

n (%), \( \chi^2 \) test. \( P \) value excludes unknown.
INR, Indian rupees; OBC, other backward class; SC, scheduled caste; ST, scheduled tribe.
* Mean (SD).
† Simple logistic regression.
models. The aim of the study was to explore the prevalence of respiratory diseases among coal-based sponge iron plant workers, and there was no control group in the study. The study findings are compared with other studies conducted in different occupational settings where smoke and dust are common [13–18], because similar studies conducted among coal-based sponge iron plant workers are lacking. Thus, similar research needs to be conducted among coal-based sponge iron factory workers working in other parts of India and other countries to enhance the generalizability of these results. Because this was a cross-sectional study, it was not possible to determine the causal association between different variables and the prevalence of respiratory diseases. A long-term, longitudinal study should be conducted among these coal-based sponge iron factory workers to assess the impact of various factors (these as well as other potential factors) on the prevalence of respiratory diseases. A good example would be to have a cohort study comparing coal-based sponge iron factory workers with other types of factory workers (healthy worker effect), rather than with the general population.

Conclusions
Many coal-based sponge iron plant workers in Barjora report the presence of respiratory diseases, and the predictors, such as overcrowding and poor quality housing, were identified. The study findings could be taken into consideration in future interventional studies aimed at managing respiratory diseases of these workers.

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Competing Interests
The author has no competing interests to declare.

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Table 2: Multiple Backward Stepwise Regression Analyses to Determine Factors Independently Associated with the Presence of any Chronic Respiratory Disease, Asthma, or Rhinoconjunctivitis.

|                                   | OR  | 95% CI  | P     |
|-----------------------------------|-----|---------|-------|
| **Any chronic respiratory disease** |     |         |       |
| Family history                    |     |         |       |
| No                                | 1   |         | 0.024 |
| Yes                               | 0.47| 0.24–0.91|       |
| **Asthma**                        |     |         |       |
| People in a room                  |     |         |       |
| <3                                | 1   |         | 0.023 |
| ≥3                                | 2.86| 1.16–7.07|       |
| Family history                    |     |         |       |
| No                                | 1   |         | 0.001 |
| Yes                               | 0.20| 0.08–0.53|       |
| **Rhinoconjunctivitis**           |     |         |       |
| Age                               | 1.04| 1.00–1.09| 0.078 |
| Education                         |     |         |       |
| Literate                          | 1   |         | 0.038 |
| Illiterate                        | 0.34| 0.12–0.94|       |
| Drinking                          |     |         |       |
| No                                | 1   |         | 0.096 |
| Yes                               | 0.56| 0.28–1.11|       |
| Social caste                      |     |         |       |
| General                           | 1   |         | 0.517 |
| SC/ST/OBC                         | 0.77| 0.36–1.68|       |
| House type                        |     |         |       |
| Pucca/semipucca                   | 1   |         | 0.027 |
| Kachha                            | 2.44| 1.11–5.39|       |

OBC, other backward class; SC, scheduled caste; ST, scheduled tribe.
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