UNFAIR QUALITY

THE IMPACT OF AIR POLLUTION ON THREE OCCUPATIONS

JUNE 2023

CLEAN AIR FUND

chintan
environmental research and action group

About Chintan Environmental Research and Action Group

We are a registered non-profit organization dedicated to achieving inclusive, sustainable, and equitable growth for all. Our objective is to make consumption more responsible and less taxing on the environment and the underprivileged. We conduct research, advocate for, and assist various stakeholders in transitioning from a linear to a circular economy and away from unsustainable consumerism. We combat air pollution by conducting research, strengthening capacity, and making science and policy more accessible to the public. In all our efforts, vulnerable populations—the poor, the marginalized, children, and women—will remain in the forefront of our attention.

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JUNE 2023

A Research by
Chintan Environmental Research and Action Group

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List of Abbreviations

AIDS:	Acquired Immune Deficiency Syndrome
AQI:	Air Quality Index
BMI:	Body Mass Index CAG: Comptroller and Auditor General
CAG:	Comptroller and Auditor General
COPD:	Chronic Obstructive Pulmonary Disease
CoV:	Coefficient of Variation
DWCC:	Dry Waste Collection Centre
EDMC:	East Delhi Municipal Corporation
FEV1:	Forced Expiratory Volume in one second
FVC:	Forced Vital Capacity
GRAP:	Graded Rapid Action Plan
GLI:	Global Lung Function Initiative
HIV:	Human Immunodeficiency Virus
LLN:	Lower Limit of Normal
LPG:	Liquefied Petroleum Gas
MRF:	Material Recovery Facility
NCAP:	National Clean Air Programme
NCR:	National Capital Region
NCT:	National Capital Territory
N-DMC:	North Delhi Municipal Corporation
New Delhi MC:	New Delhi Municipal Council
NGO:	Non-Governmental Organization
OSH:	Occupational Health and Safety
PF:	Pulmonary Function
PFT:	Pulmonary Function Test
PPE:	Personal Protective Equipment
SD:	Standard Deviation
SDMC:	South Delhi Municipal Corporation
TPD:	Tonnes Per Day
ULB:	Urban Local Body
WHO:	World Health Organization

Executive Summary

Outdoor air pollution is estimated to cause 4.2 million premature deaths worldwide in 2019. Indoor air pollution is additionally estimated to cause 3.2 million deaths in 2020, according to the World Health Organization fact sheets on ambient and household air pollution 2022[1]. Air pollution has been included as the fifth risk factor for noncommunicable diseases[2]. The most vulnerable to the risks of air pollution are the outdoor occupational groups.

This study is an assessment of the relationship between air pollution and incidence of respiratory illness for three essential occupational groups – wastepickers, safai karamcharis (municipal sweepers) and security guards. These groups were identified based on their everyday work, which regularly exposes them to dust, waste, particulate matter as well as toxic gases during their worktime.

In order to conduct this investigation, 400 participants were selected across 15 sites across Delhi, the identified research site. Hundred participants were selected from each category and hundred from a control group. The participants were surveyed on-site using a questionnaire, followed by a pulmonary function (PF) test. The results were analyzed. The key results are as follows:

- Approximately 97% safai karamcharis, 95% wastepickers, and 82% security guards reported exposure to air pollution during work. However, more than 60% safai karamcharis, 50% wastepickers, and 30% security guards did not know about PPE kits that could reduce their exposure.
- Wintertime burning was identified as prevalent across the groups, but most widely amongst wastepickers. Nearly half of the wastepickers, 5% safai karamcharis and 9% security guards reported burning wood or coal to keep warm during winter. Waste burning was practiced by more than 30% wastepickers.
- Abnormal pulmonary function results were recorded in 86% safai karamcharis and security guards 75% wastepickers. In contrast, 45% of participants of the control group had abnormal lung function.
- No severe cases of lung illness were observed among the control group. However, 17% wastepickers, 27% safai karamcharis, and 10% security guards were found to be suffering from severe lung illnesses.
- Women participants of all studied groups had lower lung function than the males.

The study discussed recommendations based on the findings of this study in consultation with the 3 groups and health and air pollution experts. These are as below:

OCCUPATIONAL HEALTH AND SAFETY :

- Provision of Personal Protective Equipment (PPE) and trainings on efficient use of PPE must be ensured. Trainings on gargling after duty hours to effectively remove dust particles from nasal and throat cavities should be conducted.
- Provision of hand and face washing facilities near place of work should be mandated.
- Warm kits and heated bottles should be provided for the winter months to reduce open burning to security guards.

POLLUTION MANAGEMENT:

- Sanitary inspectors should be delegated power to report and fine waste burning.
- Mechanized sweepers on larger arterial roads should be used.

LIMITING EXPOSURE:

- Work shifts should be changed during hazardous AQI to reduce pollutant exposure.
- All resting places should be engineered at levels above the tail-pipe level of SUVs.
- Annual health check-ups focused on monitoring occupational health should be carried out.

SYSTEMIC SHIFTS:

- Composting must be mandated to prevent landfill fires.
- In-situ horticulture waste management systems should be set up.
- Photographic compliance reports must be filed by ULBs every quarter.
- Improved access to healthcare for outdoor workers must be ensured.
- Drones and other imagery must be used to identify garbage burning.
- Bioremediation strategies should be executed to prevent landfill fires.


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जांच शिविर
दिनांक
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1 Introduction

According to the World Health Organization (WHO), outdoor air pollution was estimated to cause 4.2 million premature deaths worldwide in 2019[3], and indoor air pollution an additional 3.2 million deaths in 2020[4]. The inclusion of air pollution as the fifth risk factor for noncommunicable diseases alongside tobacco, alcohol, unhealthy diets, and physical inactivity highlights the extent of risk from polluted air to human health[5]. Globally, loss of life expectancy from air pollution surpasses that of HIV/AIDS, parasitic, vector-borne, and other infectious diseases by a large margin[6]. In 2023, India was ranked as the world's eighth most polluted country according to the Annual World Air Quality Report, IQAir[7]. Delhi continues to be the most polluted capital city and fourth most-polluted city in the world[8].

While air pollution is a global threat, its impacts are felt differently by the marginalized low-income communities, who bear a greater burden of excessive health risks compared to other communities[9]. They are particularly vulnerable to its impacts because of their occupation, inter-generational poverty and poor access to healthy lifestyles and healthcare. Low-income groups in the urban landscape (urban poor) lack access to basic healthcare and sanitation and there is low prevalence or awareness of health–promoting behaviors given the inadequate social support received by them. Irregular incomes and the time taken up due to livelihood pressures, prevent them from focusing on health-related concerns[10]. Further, due to their dependence on biomass burning for heating and cooking, they suffer from the additional health risks of indoor air pollution.

In the past few decades, scholars have highlighted the urgent need to investigate how ambient air pollution affects various demographic groups around the world[11]. A study conducted in Iran to understand the effects of dust inhalation on street sweepers emphasized how outdoor workers such as sweepers are particularly exposed to air pollution[12]. Overall, however, limited studies have been conducted in India on the impact of air pollution exposure on these vulnerable groups[13] .

Upon conducting a literature review, no published reports were found on the comparative effects of ambient air pollution on occupationally exposed groups. The National Clean Air Programme (NCAP) was launched in 2019 as a policy with the goal of developing action plans to combat particulate matter pollution through periodic reviews based on scientific input. However, much is yet to be achieved in terms of limiting exposure to air pollution, particularly for the populations most exposed. There are some constraints to consider, such as inter-sectoral coordination, a lack of public awareness, and the capacity of State Boards. Due to various factors, as a result, occupationally exposed outdoor worker groups are more vulnerable because there are no defined laws to protect them. Further, the lack of insulation during winters, which includes blankets and heaters, warm homes, or clothing, often leads to open burning for warmth. This in turn adds to air pollution and particularly exposes these groups to particulate pollution. This study covers the three following occupationally exposed groups, all of whom work outdoors:

SAFAI KARAMCHARIS

'Safai Karamchari' refers to a person, including his or her dependents, engaged in or employed for any sanitation work and includes waste pickers, but excludes domestic worker and manual scavengers[14] . For the purpose of this report, only the street and road-side sweepers who are contracted by the municipal body (municipal sweepers) are referred to as safai karamcharis. Wastepickers are considered as a separate category. The disproportionate impact of air pollution on safai karamcharis is due to their close exposure to dust itself while sweeping and handling waste.

SECURITY GUARDS

According to the Private Security Agencies (Regulation) Act, 2005, a 'private security guard' means a person providing private security with or without arms to another person or property or both and includes a supervisor[15].

Due to the long hours spent at night and early mornings at work, security guards are exposed to air pollution in two primary ways. One, they are directly exposed to the outdoor air for extended periods of time and two, they often burn waste to keep themselves warm during extreme winter due to the lack of provisions for insulation or warm clothing at work.

WASTEPICKERS

The Solid Waste Management Rules, 2016 refer to wastepickers as "a person informally engaged in the collection and recovery of reusable and recyclable solid waste from the source of waste generation to sale of waste to recyclers directly or through intermediaries."

In India, wastepickers are the backbone of recycling. Even though the law mandates their inclusion in the formal waste management system via urban local bodies, the reality is far from it. Wastepickers continue to work hazardous conditions with waste, on sites ranging from landfills to industrial areas, exposing them to particulate matter, including that from waste.

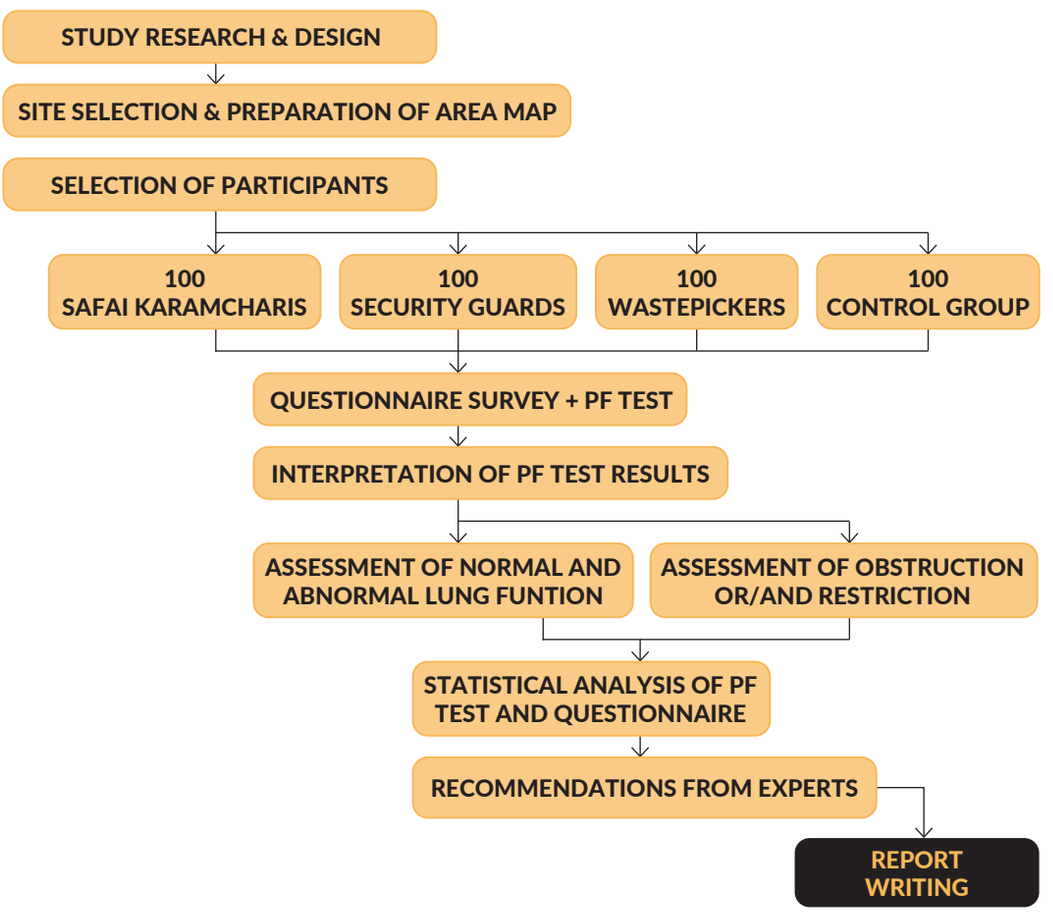
This research investigates the relationship between air pollution and respiratory health for three key outdoor occupational categories - safai karamcharis (municipal sweepers), security guards and wastepickers. Key research focus is:

- To investigate the state of knowledge on air pollution of the identified groups.
- To examine the respiratory health of these studied groups.
- To assess the relationship between respiratory health and occupational factors.
- To identify practical means of reducing exposure and protecting environmental health.

2 Methodology

This study was designed through extensive literature review along with consultations with medical professionals and air quality experts. A survey followed by pulmonary function tests (PFT) were used for data collection. Four hundred participants across Delhi were surveyed. The survey aimed to understand perception, lifestyle, and pollution exposure, while the PF Tests provided information about lung health. The gender differences in lung function were kept under consideration during participant selection. Approximately

Figure 1: *Overview of methodology.*



equal male and female participants were surveyed from the selected groups, except for security guards due to the male-dominated nature of this occupation. The data collection was completed between May 2021 and December 2021.

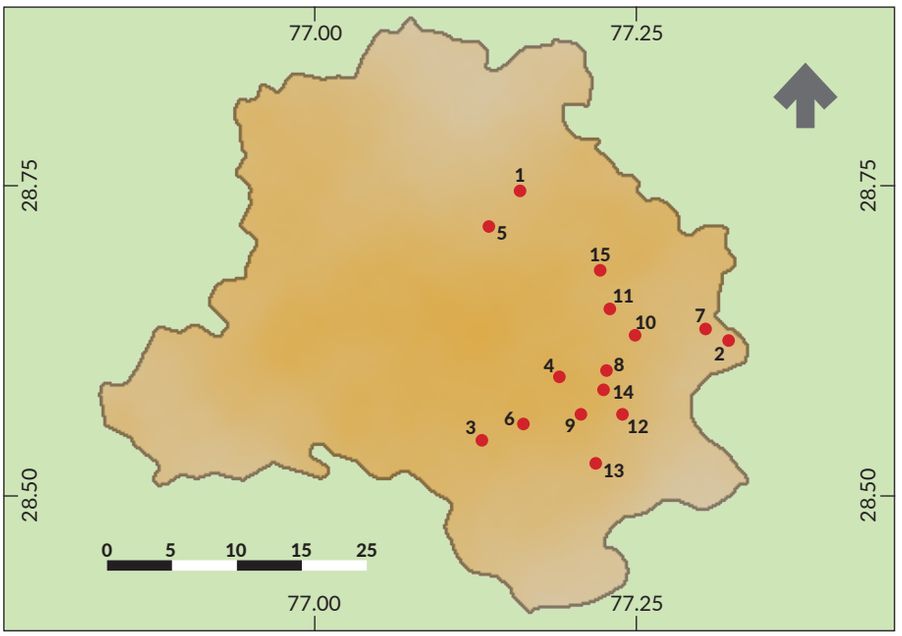
STUDY AREA

The study was carried out in the Delhi National Capital Territory, a megacity located in the subtropical climate (28°36' N and 77°12' E). The overall area of the NCT, which includes 11 districts, is approximately 1483 km2. According to the 2011 Census, the population of Delhi was 16.8 million, which has now grown to 32.94 million in 2023, according to the World Population Prospects 2022 of the United Nations[16] . Delhi has four different seasons: Winter (December-February), Summer (March-May), Monsoon (June-September), and Post-Monsoon (October-November). In the previous 2-3 decades, Delhi has experienced significant urbanization, expansion of transportation network, construction activity, and land use change, all of which have contributed to a decline in air quality in the Delhi region. Delhi is 97.5% urbanized[17] which also translates to increased demand for increased waste management, traffic control, sanitation, construction, etc. - all of which have increased the demand for the essential services provided by outdoor workers like safai karamcharis, security guards and wastepickers.

SAMPLING

To meet the objectives of the research, 15 sites were selected and presented in Map 1. The open-source software QGIS (version 3.22) was used to create the study area map.

Map 1: *The study locations in Delhi.*



Map 1 shows the 15 study sites marked by serial number. Details of the study sites and relevant municipal bodies are mentioned below.

Table 1: *Study sites and municipality*

S. No.	Study site	Municipality
1	Bhalaswa Landfill	North Delhi Municipal Corporation
2	Ghazipur Landfill	East Delhi Municipal Corporation
3	Mahipalpur	South Delhi Municipal Corporation
4	Vivekanand Camp	New Delhi Municipal Corporation
5	Prashant Vihar	North Delhi Municipal Corporation
6	Vasant Vihar	South Delhi Municipal Corporation
7	Madhu Vihar	East Delhi Municipal Corporation
8	Khan Market	New Delhi Municipal Council
9	Safdarjung Hospital	South Delhi Municipal Corporation
10	CAG Building	North Delhi Municipal Corporation
11	Reliance Building, Chandni Chowk	North Delhi Municipal Corporation
12	Lajpat Nagar	South Delhi Municipal Corporation
13	Saket	South Delhi Municipal Corporation
14	Lodhi Colony	New Delhi Municipal Council
15	Civil Lines	North Delhi Municipal Corporation

The study comprised 400 participants, 100 from each occupational category - safai karamcharis, security guards, and wastepickers, and 100 from a control group. The control group comprised of people who predominantly worked indoors, however, had no or less occupational exposure to air pollution. They were non-smokers and with no history of reported respiratory illness. The office staff of two schools, one shopping mall and a non-profit office were chosen as the control group. Participants in the study were randomly selected by zone (East, West, North, and South) to gather a representative sample having geographical diversity across Delhi as air pollution might be differently experienced across the city. Recommendations by the relevant municipalities based on suitability were also taken into account during selection. Table 2 contains information about the study participants, including their location, gender distribution, and the nature of their daily work.

SURVEY

The first stage of the study was to conduct an on-site survey. This was based on a tested survey instrument whetted by the study collaborators. The concept of consent was explained following which participants' informed consent was obtained through signed consent forms in Hindi.

Table 2: *Details of study participants, their locations, and gender wise distribution*

Study participants	Location (Delhi)	Gender wise distribution		Nature of job and working conditions
		Male	Female	
Wastepickers (n=100)	• Bhalaswa landfill • Ghazipur landfill • Mahipalpur • Vivekanand Camp	45	55	Collection, segregation, and primary dumping of wastes
Safai Karamcharis (n=100)	• Prashant Vihar, North Delhi Municipal Corporation • Vasant Vihar, South Delhi Municipal Corporation • Madhu Vihar, East Delhi Municipal Corporation • Khan Market, New Delhi Municipal Council	57	43	Street cleaning with traditional brooms, collection of waste and disposal
Security Guards (n=100)	• Safdarjung Hospital • Government office, ITO • Private Sector Office, Chandni Chowk	94	6	Indoor and outdoor duties at buildings, both day & night (rotation wise)
Control Groups (n=100)	• Office staff, offices located near busy traffic junctions and main roads in South Delhi • Select City Walk Mall, Saket • Sardar Patel School, Lodhi Colony • Cleaning and security staff, St. Xaviers School, Central Delhi	63	37	Official work

The questionnaire included questions about personal information, socioeconomic status (education, occupation, number of dependents), lifestyle and surroundings (smoking habits, cooking habits, etc.), working environment conditions, and health issues related to their job. Open-ended questions were also included to gather perceptions and viewpoints, such as solutions to air pollution exposure and workplace logistics.

TESTING PULMONARY FUNCTION

The Pulmonary Function Test (PFT) used to assess lung function was Spirometry. This test measures the volume of air exhaled at specific time points during complete exhalation by force, which is preceded by a maximal inhalation[18]. The Respiratory Function Spirometer tests were performed on all study groups (Model: RMS Helios 401, Version 1.3) by an

accredited laboratory, Goodlife Diagnostics, Delhi, in accordance with the standard operating procedure. During the test, the subject exhales with force, followed by a deep inhalation into a tube linked to a spirometer. It measured the amount of air that enters and exits during the process. Each participant was evaluated at least three times but no more than five times, and the top values were chosen for analysis.

The responses from stakeholders were gathered on the same day as the PF testing. The complete process, including the face-to-face interviews and PF testing, took about 30-40 minutes per participant.

LUNG FUNCTION PARAMETERS

Two lung function parameters - forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC ratios were used to trace respiratory disorders among participants. FEV1 and FVC are measurements used to identify signs of blockage and restriction in ventilatory dysfunction[19].

- Forced Vital Capacity (FVC): FVC is defined as the entire volume of air that can be expelled at a maximal forced expiration effort after full inspiration. In general, FVC can be used as an indicator for lung capacity.
- Forced Expiratory Volume in one second (FEV1): FEV1 is the volume of air that can forcibly be blown out in the first 1 second, after full inspiration. In general, FEV1 can be used as an indicator for airway resistance.
- FEV1/FVC ratio: FEV1/FVC ratios imply the percentage of Forced Vital Capacity expired in one second.
- Obstruction and Restriction Lung Disorders: Obstruction and restriction are two significant lung disorders (air going in or out) that were identified using spirometry test readings[20]. The two types of respiratory disorders have been compared below.

Table 3: *Obstruction vs restriction lung diseases*[21]

	Obstruction	Restriction
Definition	A person experiences shortness of breath due to difficulty exhaling all the air from the lungs because the lungs are obstructed.	A person cannot fully fill their lungs because the lungs are restricted due to limitations in chest wall motion.
Cause	• Narrowing inside the lungs. (inflammation/ swellings in airways) • Thick mucus in the airways • Damage to the walls of the air sacs	• Stiffness of the chest wall • Weak muscles • Damaged nerves
Examples	Asthma, COPD, Bronchiectasis, Cystic Fibrosis, etc.	Sarcoidosis, Asbestosis, Silicosis, Muscular Dystrophy, Interstitial Lung Disease, etc.

Figure 2: *How the spirometry test is done*

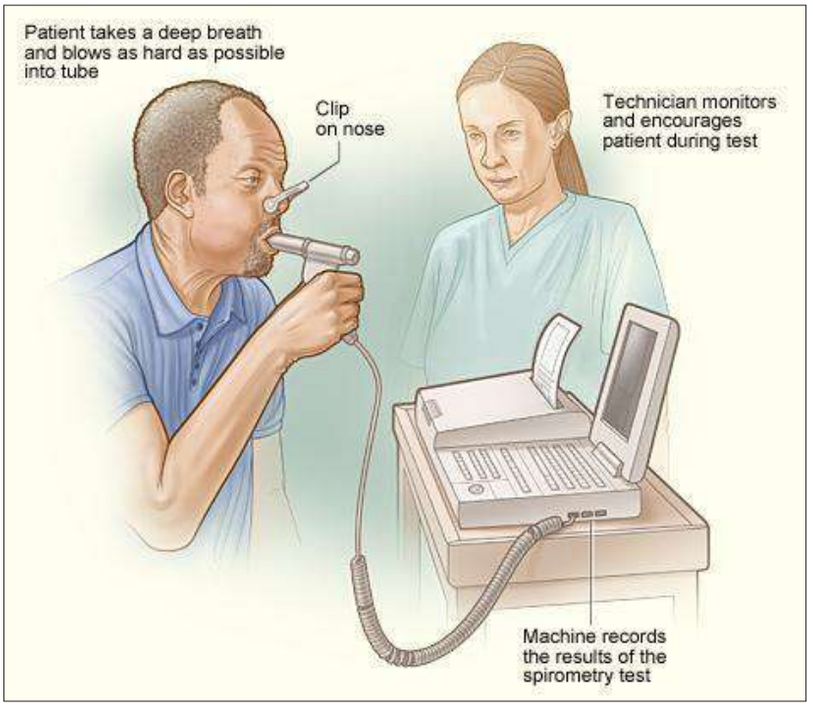


Figure 2 depicts a diagrammatic representation of how the spirometry test works

$$\text{BMI} = \frac{(\text{Body Weight})}{(\text{Height})^2}$$

DATA ANALYSIS AND CONCLUSIONS

The survey responses were analysed using binary logistic regression analysis and PF test results were analysed using descriptive statistics (details of the analyses in Annexures). The results were discussed with respect to health and occupational safety. Recommendations based on peer reviews, air quality experts and healthcare professionals were incorporated.


ON DUTY

3 Safai Karamcharis: The Results

This chapter discusses the results of survey data and conducted pulmonary function (PF) tests for safai karamcharis (municipal sweepers). A total of 100 safai karamcharis, 57 men and 43 women were the respondents.

OVERVIEW

Table 4 summarises the demographic characteristics of safai karamcharis derived from the survey.

Table 4: *Demographic data collected from safai karamcharis.*

Sr. No.	Characteristics	Total (100)	Male (57)	Female (43)
1	Age (Years)			
	18-45	51	32	19
	46-60 or above	49	25	24
2	Educational status			
	No education	42	20	22
	1 – 8	42	25	17
	8 – 12 or above	16	12	4
3	BMI			
	Normal (< 25 kg/m^2)	47	32	15
	Overweight (25-29.9 kg/m^2)	35	16	19
	Obese (>30 kg/m^2)	18	9	9
4	Smoking status			
	Smoker	12	11	1
	Non-smoker	88	46	42
5	Passive smoking at home or workplace			
	Yes	8	5	3
	No	92	52	40
6	Cooking fuel			
	Wood/Dung cake	16	10	6
	LPG	84	47	37
7	No of dependents			
	No	0	-	-
	1-4	55	30	25
	>4	45	27	18

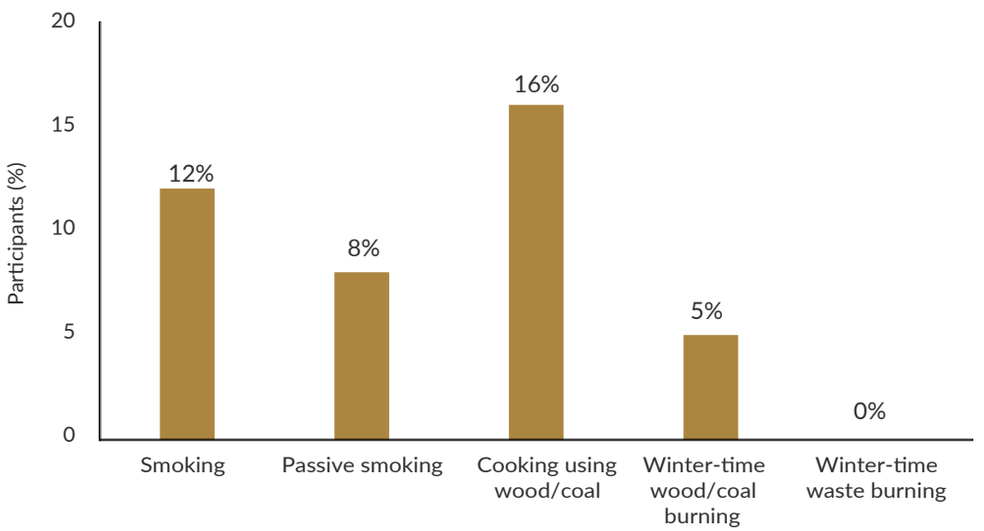
The key learnings are as below:

- The studied subjects' age ranges were 18-45 (51%) and 46-60 years (49%).
- Forty two percent of the safai karamcharis surveyed had no education.
- Almost 95% of them had engaged in sweeping on streets and 12% were also involved in waste segregation at waste disposal sites.
- Of the total respondents, 55% had at least 1 dependent and 45% had more than 4 dependents.
- Upon being asked, 21% stated that they were given health insurance and 27% had life insurance.

EXPOSURE AND PROTECTIVE GEAR

While ambient air pollution causes serious health impacts, other sources also add to the risks. The additional sources of air pollution exposure are summarized below.

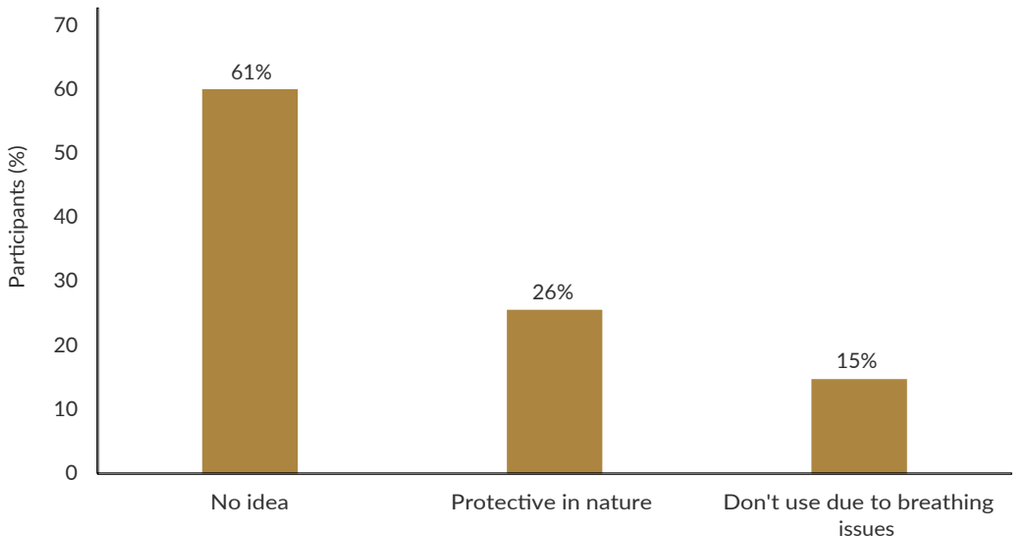
Figure 3: *Sources of exposure to air pollution for safai karamcharis.*



Based on the survey, the following observations about exposure to air pollution sources for safai karamcharis were made.

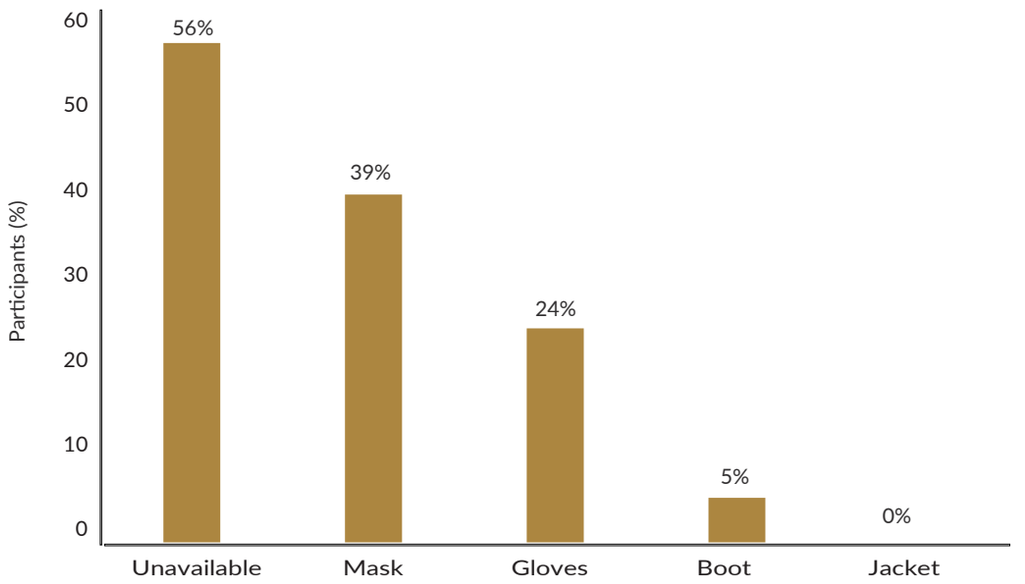
- Most of the study participants (97%) reported exposure to air pollution during their work. This perception was gathered by asking the participants if they were exposed to air pollution while working.
- Sixteen percent of participants reported using coal, cow dung, or wood for cooking, which exposes them to indoor air pollution.
- Exposure to air pollution through smoking was low; twelve percent of the participants were smokers and eight percent lived with smokers in their family.
- In total 5% safai karamcharis burn biomass to keep warm, while no one reported burning any waste during winter.

Figure 4: *Perception of safai karamcharis around PPE kits.*



- Based on the survey, it was found that the majority (61%) were unaware about the concept of PPE. This could also be because they do not use this specific terminology indicating the need for symmetry in terminology from top to bottom.
- Among the participants who were aware, approximately 20% participants reported not using PPE kits due to difficulty in breathing while using them during work.

Figure 5: *Availability of PPE kits.*

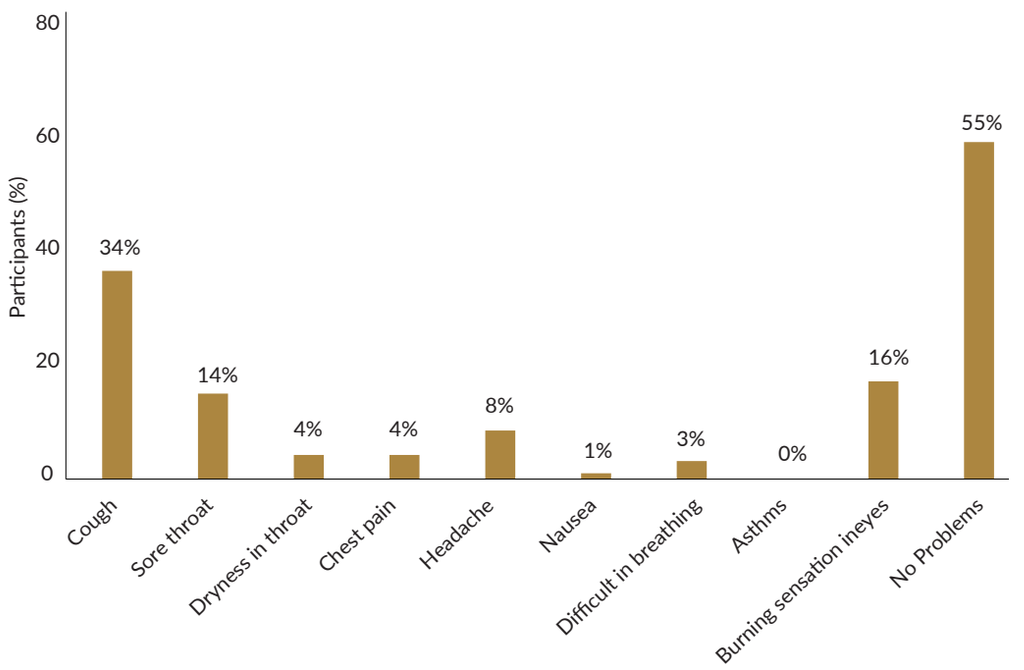


Even though their work exposes safai karamcharis to dust, solid waste, and toxic materials that they are at risk of touching, inhaling, or ingesting, PPE kits were neither available, nor used by more than half (52%) of the participants. Masks and gloves were the most used personal protective equipment. This can be explained by the easy availability of masks and gloves in a post COVID era.

HEALTH IMPACTS

- The majority, or 85% of the surveyed safai karamcharis know of air pollution and its health impacts and 61% feel that the nature of their job increases their risks from air pollution.
- Approximately 42% of safai karamcharis feel that they do not have access to appropriate health care facilities.
- Only 19% safai karamcharis reported visiting doctors annually regardless of illness.

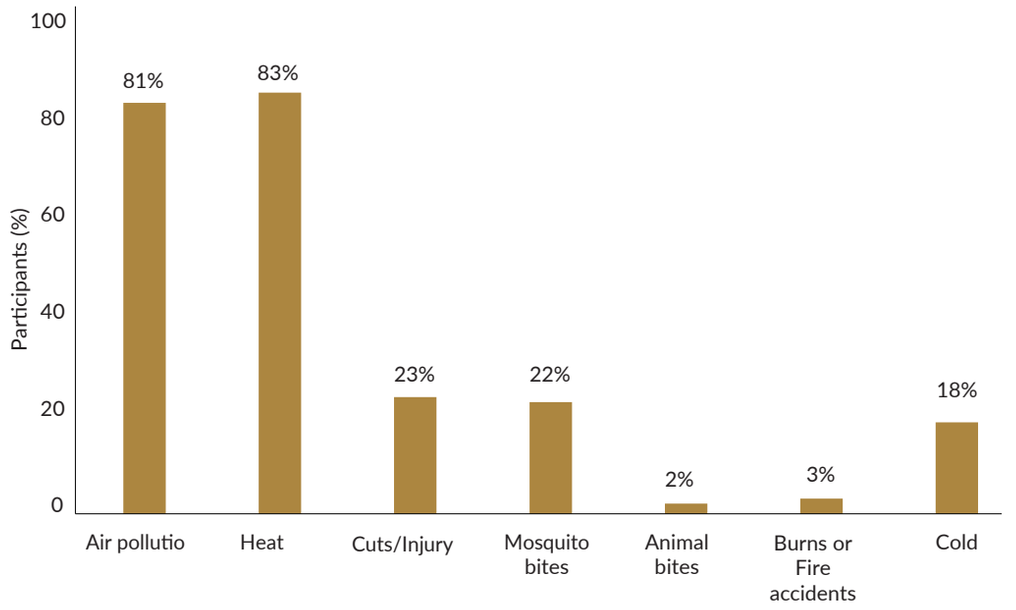
Figure 6: *Reported health impacts since starting work in their current role.*



When asked about the status of their health since starting work in their current role, approximately 50% of participants reported health problems. Forty seven percent of the respondents reported facing health issues such as cough, headache, burning of eyes, sore throat, nausea, etc. Among them, only 11% visited hospitals for these health concerns.

Air pollution (81%) and heat (83%) were the top two health challenges faced by safai karamcharis while working. Cuts, injury, mosquito bites and cold were the other health problems faced due to the nature of their work.

Figure 7: *Top occupational health concerns while working.*



PULMONARY FUNCTION TEST RESULTS

Overall and gender-wise descriptive statistics of lung function parameters for safai karamcharis have been recorded in Table 5 and 6, respectively.

Table 5: *Lung function parameters for safai karamcharis.*

	Average ± SD	Range	CoV
FVC absolute (L)	2.1 ± 0.7	0.8 - 4.1	34.4
FVC % predicted	62.0 ± 14.7	30 -94.6	23.7
FEV1 absolute (L)	1.8 ± 0.6	0.7 - 3.6	35.2
FEV1 % predicted	64.2 ± 16.1	30.5 - 107.9	25.1
FEV1/FVC	0.85 ± 0.1	0.59 - 1.0	8.5

The average FVC% predicted for safai karamcharis was found to be 62.0 ± 14.7 and average FEV1 % predicted was found to be 64.2 ± 16.1. Both results are significantly lower compared to the normal value of 80% for a healthy adult of their age and weight. Standard deviations of ± 14.7 and ± 16.1 indicate that the values in some participants could be higher, however in some cases significantly lower than the average, which is already lower than the normal healthy range.

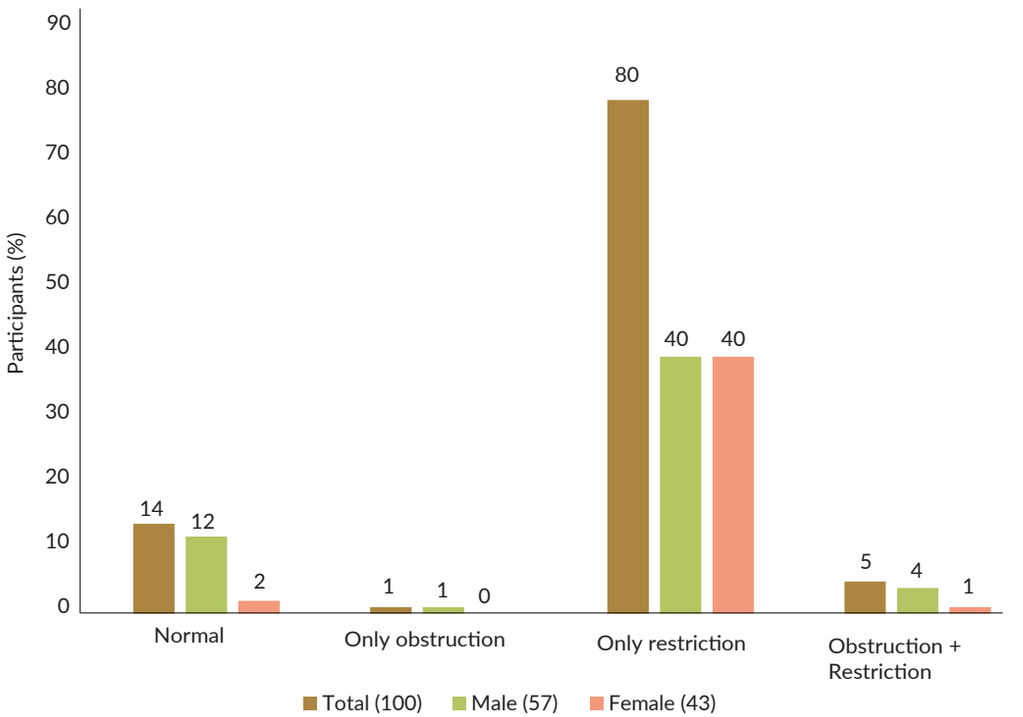
Table 6: *Lung function parameters for male and female safai karamcharis.*

	Male (n=57)		Female (n=43)	
	Average ± SD	Range	Average ± SD	Range
FVC absolute (L)	2.5 ± 0.7	1.3 - 4.1	1.7 ± 0.5	0.8 - 3.9
FVC % predicted	64.9 ± 14.5	34.6 - 94.6	58.2 ± 14.2	30 - 85.5
FEV1 absolute (L)	2.1 ± 0.6	1.1 - 3.6	1.5 ± 0.5	0.7 - 3.4
FEV1 % predicted	66.3 ± 15.7	36.8 -107.9	61.4 ± 16.4	30.5 - 90.3
FEV1/FVC	0.84 ± 0.1	0.62 - 0.97	0.87 ± 0.1	0.59 -1

FVC % predicted was 64.9 ± 14.5 for males and 58.2 ± 14.2 for females. FEV1 % predicted was 66.3 ± 15.7 for men and 61.4 ± 16.4 for women. The observed lung function parameters for females were noted to be significantly lower as compared to males, which inferred that female safai karamcharis had more deteriorated lung capacities.

The prevalence of pulmonary function impairment in safai karamcharis is presented in Figure 8.

Fig, 8: *Spirometry results for safai karamcharis.*



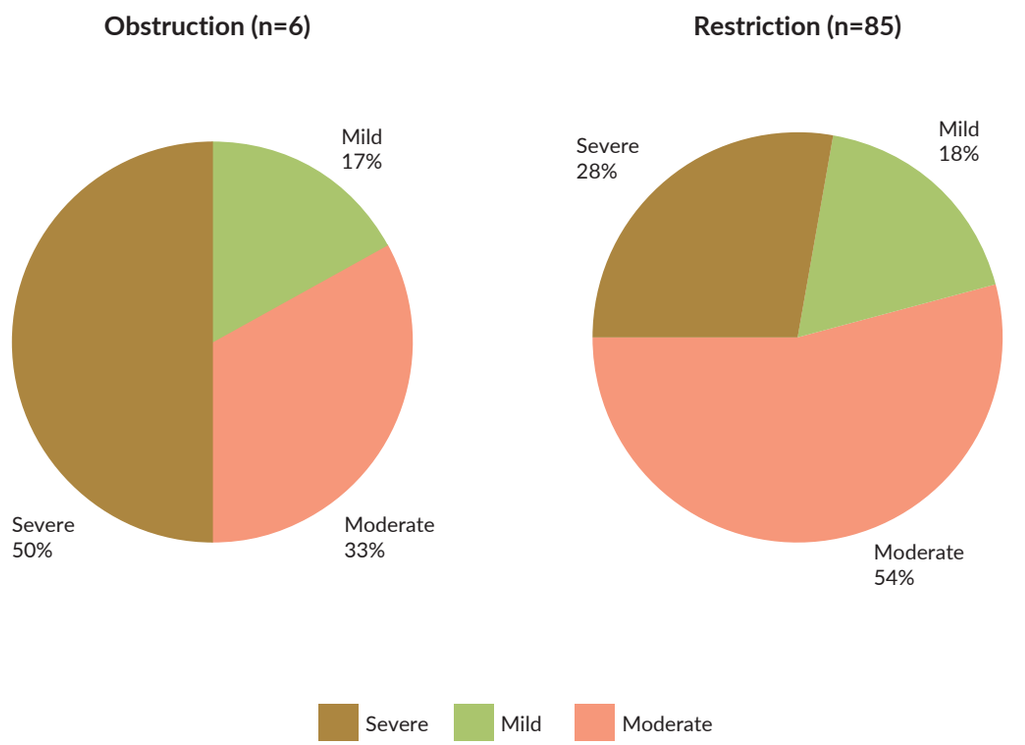
The Pulmonary Function Test results showed the following:

- Only 14% showed normal spirometry (lung function capacity), while abnormal spirometry corresponded to 86% of the participants.
- Eighty percent of the participants showed only restriction, 1% showed only obstruction and 5% of participants showed both obstructive and restrictive lung disorders. Therefore,
- Total participants suffering from restriction = Only restriction + both = 80+5 = 85.
- Total participants suffering from obstruction = Only obstruction + both = 1+5 = 6.

Co-existing obstruction and restriction disorders may have higher health impacts in some patients, while in some patients the severity of only obstruction or only restriction may be higher. This may require further medical intervention based on severity of the lung disorder. Figure 9 illustrates the observed severity of obstruction and restriction of respiratory illnesses for safai karamcharis.

- Six participants fell in the obstruction category. Severe obstruction was found in 50% of participants, followed by moderate (33%) and mild (17%) cases.
- Eighty five participants fell in the restriction category. Moderate illness (54%) was dominant followed by severe and mild cases.

Figure 9: *Disease severity (%) of observed pulmonary impairments in safai karamcharis.*



GENDERED IMPACT

A comparison of disease severity of pulmonary impairments in male and female safai karamcharis is illustrated in Figure 10.

Further, the data reveled the following:

- Out of the total cases of restriction, 44 cases were recorded in males and 41 cases in females.
- Moderate restriction was dominant in both males (61%) and females (46%).
- Six cases of obstruction were recorded. Forthy percent of the cases were severe and moderate in males. The only case of obstruction in d=females was severe.

Figure 10: *Disease severity (%) for male and female safai karamcharis.*

STATISTICAL ANALYSIS OF SURVEY RESPONSES

In addition, the survey results indicate the following (details of analysis in Annexure 3):

- Female safai karamcharis were approximately 6 times more likely to have respiratory illness.
- Lack of education is associated with a 34% increase in the probability of respiratory illness.
- People with larger families had approximately 1.8 times more probability of respiratory illness.

4 Security Guards: The Results

This chapter discusses the results of survey data and the conducted pulmonary function (PF) test for the security guards. A total of 100 security guards, 94 men and 6 women were the respondents.

OVERVIEW

Table 7 summarises the demographic characteristics of security guards derived from the survey.

Table 7: *Demographic data collected from security guards.*

Sr. No.	Characteristics	Total (100)	Male (94)	Female (6)
1	Age (Years)			
	18-45	66	62	4
	46-60 or above	34	32	2
2	Educational status			
	Illiterate	-	-	-
	1 – 8	3	3	-
	8 – 12 or above	97	91	6
3	BMI			
	Normal (< 25 kg/m^2)	44	43	1
	Overweight (25-29.9 kg/m^2)	47	43	4
	Obese (>30 kg/m^2)	9	8	1
4	Smoking status			
	Smoker	16	16	-
	Non-smoker	84	78	6
5	Passive smoking at home or workplace			
	Yes	6	5	1
	No	94	86	8
6	Cooking fuel			
	Wood/Dung cake	11	10	1
	LPG	89	84	5
7	No of dependents			
	No	-	-	-
	1-4	55	55	-
	>4	45	39	6

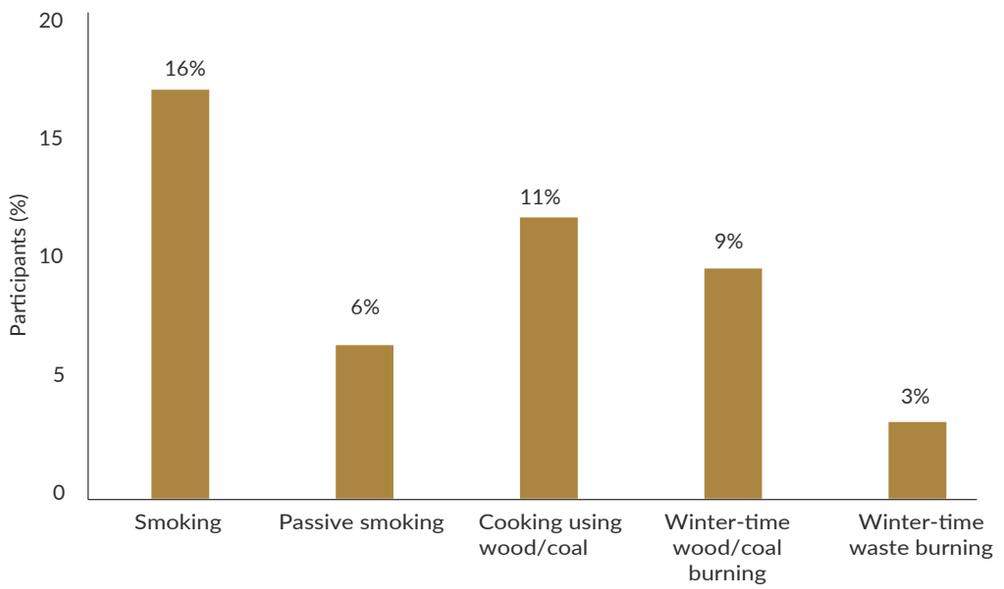
The key learnings are as below:

- About 66% of the participants are in the age range of 18-45 years and 34% in the age range of 46-60 years.
- Fifty four percent security guards had both day and night-time duty at their workplace.
- Fifty five percent of the participants supported at least 1 dependent and 45% had greater than 4 dependents.
- Only 26% owned a life insurance policy.

EXPOSURE AND PROTECTIVE GEAR

While ambient air pollution causes serious health impacts, other sources also add to the risks. The additional sources of air pollution exposure are summarized below.

Figure 11: *Sources of exposure to air pollution for security guards.*



Air pollution sources affecting security guards were the following:

- A large percentage (80%) of security guards reported encountering problems of air pollution at workplace.
- Sixteen percent of the security guards were smokers, while 6% of them had family members who smoked.
- Eleven percent of security guards were dependent on wood or dung cakes for cooking. Approximately 15% burned biomass or waste to keep warm during winter.

Sixty two percent of the security guards believed that PPE kits were helpful to protect them from air pollution. Therefore, security guards demonstrated the knowledge of PPE kits but the incentives to use them are lacking. Approximately 30% were unaware of PPE terminology and concept.

Figure 12: *Perception of security guards around PPE kits.*

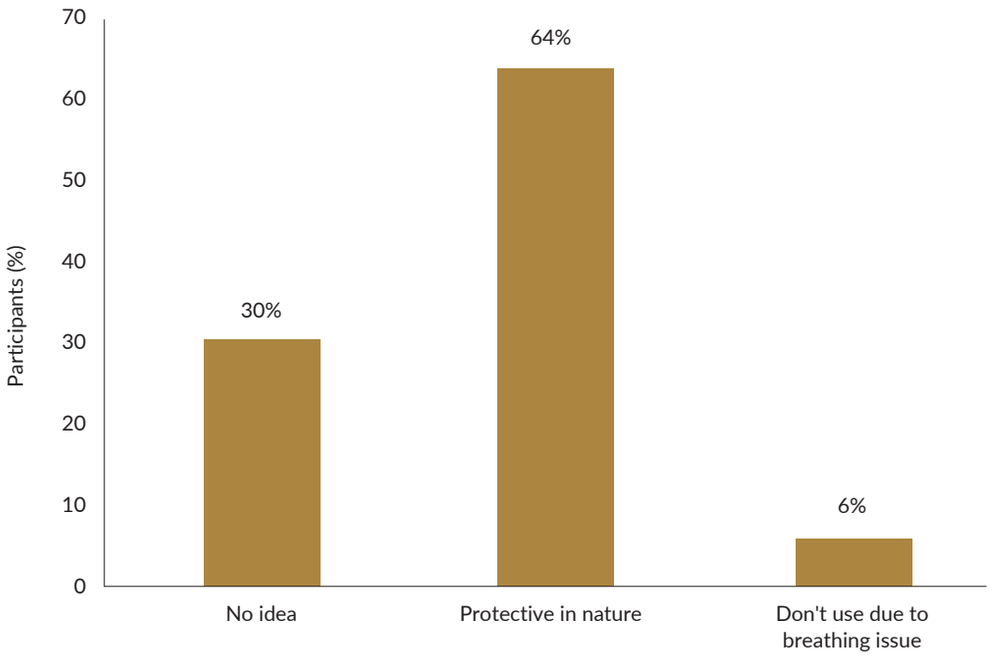
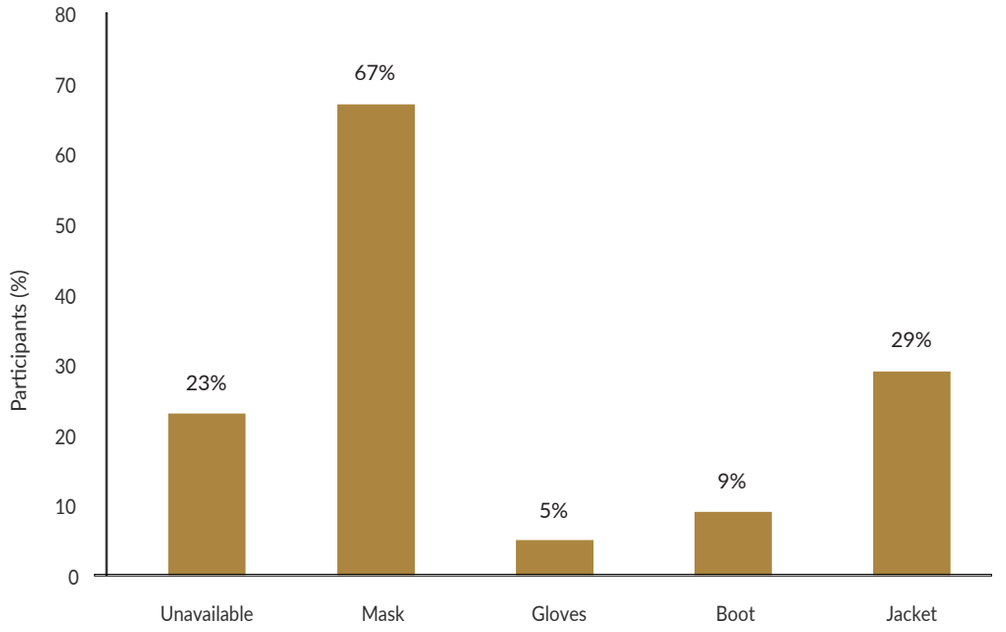


Figure 13: *Availability of PPE kits to security guards.*

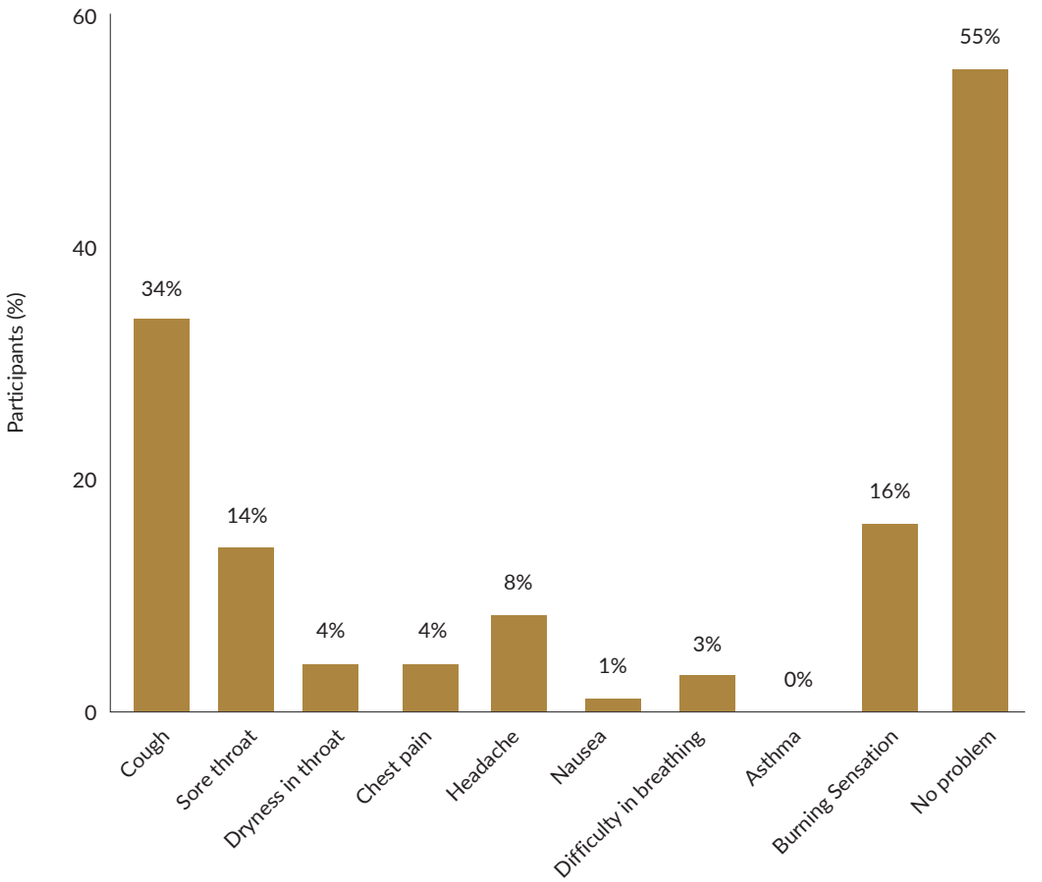


Masks were the most used Personal Protective Equipment. Sixty seven percent of the security guards reported having access to masks. Seventy one percent of the participants reported not wearing jackets, which increases their propensity of burning biomass to keep warm during winter months.

HEALTH IMPACTS

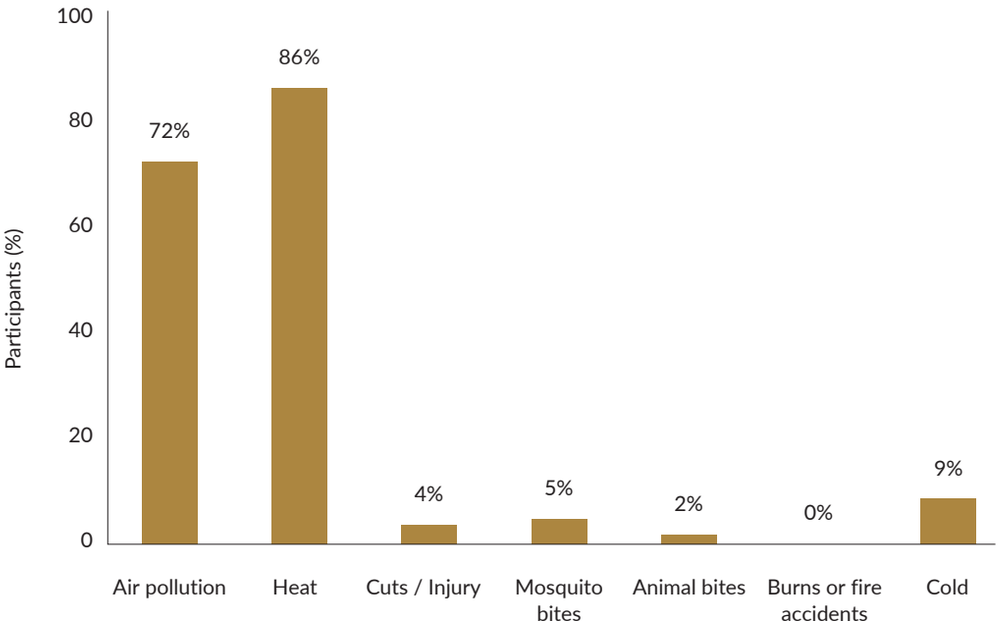
Approximately 33% reported going to hospitals for an annual routine health check-up regardless of symptoms. Majority, or 86% of security guards, reported that they understood air pollution issues and 62% felt that the outdoor nature of the job increased the air pollution risk to them.

Figure 14: *Reported health concerns since starting work in the current role.*



Approximately 45% of the participants have been facing health issues such as cough, sore throat, burning sensation in eyes, headache etc., since they started work in their current role. Among them, only 13% visited hospitals for these health issues.

Figure 15: *Top health concerns faced while working.*



Air pollution (72%) and heat (86%) were the top two health challenges faced by security guards while working.

PULMONARY FUNCTION TEST RESULTS

Overall and gender-wise descriptive statistics of lung function parameters for security guards have been recorded in Table 8 and 9, respectively.

Table 8: *Lung Function parameters of security guards.*

	Average ± SD	Range	CoV
FVC absolute (L)	3.0 ± 0.6	1.0 – 4.3	0.21
FVC % predicted	71 ± 12.2	32.9 – 97.3	0.17
FEV1 absolute (L)	2.5 ± 0.6	0.74 – 3.78	0.22
FEV1 % predicted	72.1 ± 13.4	30.5 – 102.3	0.19
FEV1/FVC	0.84 ± 0.07	0.59 – 0.98	0.08

Overall, the mean predicted value of FVC % was observed to be 71 ± 12.2 and mean predicted FEV1% was 72.1 ± 13.4, which are lower compared to the normal value of 80% for a healthy adult of their age and weight. Standard deviations of ± 12.2 and ± 13.4 suggest that some security guards can meet the healthy limits, however some were worse off than the average which is already lower than the normal healthy range.

Table 9: *Lung function parameters for male and female security guards.*

	Male (n=94)		Female (n=6)	
	Average ± SD	Range	Average ± SD	Range
FVC absolute (L)	3.1 ± 0.6	1.4 – 4.3	2.0 ± 0.5	1.0 – 2.5
FVC % predicted	71.4 ± 11.8	32.8 – 97.3	64.6 ± 16.4	34.8 – 79.1
FEV1 absolute (L)	2.6 ± 0.6	1.3 – 3.8	1.6 ± 0.5	0.74 – 2.14
FEV1 % predicted	72.6 ± 12.8	35 – 102.3	64 ± 19.8	30.5 – 81.9
FEV1/FVC	0.84 ± 0.07	0.59 – 0.98	0.82 ± 0.07	0.72 – 0.89

The average FVC% and FEV1% for men was observed to be above 70%, however in females the values were approximately 64%. Therefore, female security guards exhibited poorer lung function than males which signifies that they had higher deterioration in lung function.

Figure 16: *Spirometry results for security guards.*

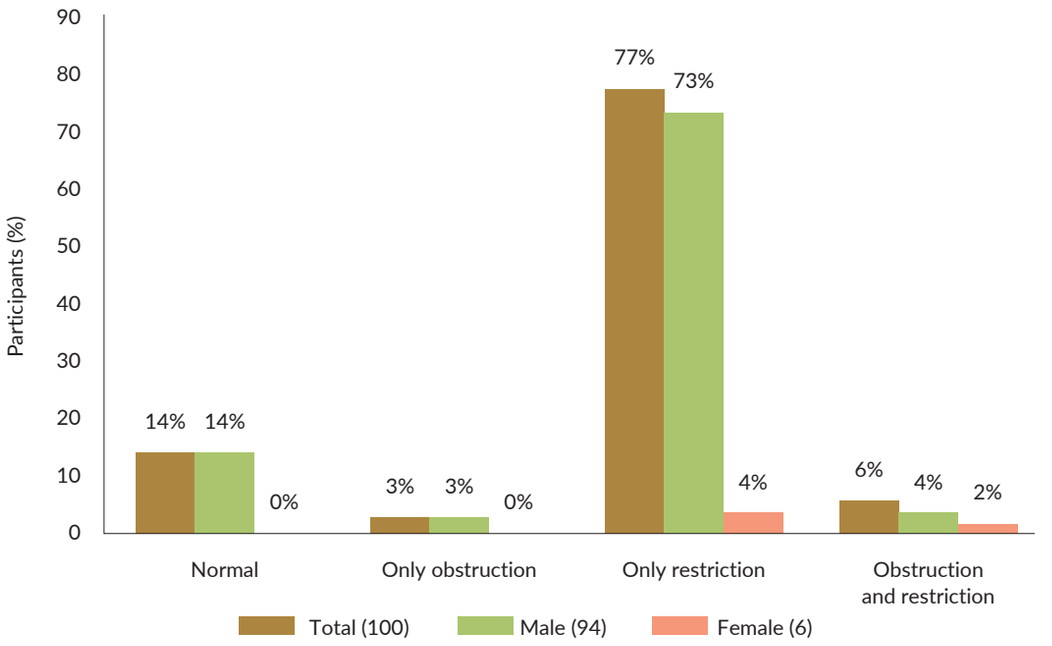


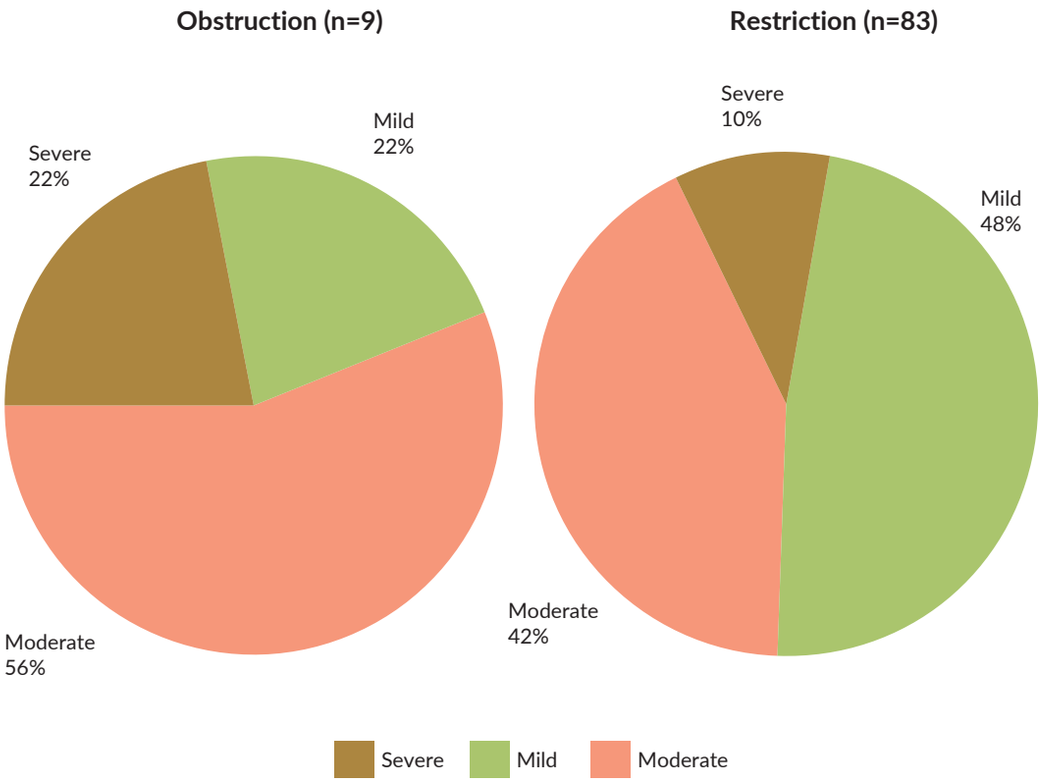
Figure 16 depicts the occurrence of pulmonary function impairment in security guards.

- Of the total, 14% showed normal lung function, whereas 86% showed abnormal lung function.
- The data shows 3% had only obstruction, 77% had only restriction and 6% had both. None of the female participants had normal lung function.
  Therefore,

- Total participants suffering from obstruction = Only obstruction + both = 3+6 = 9.
- Total participants suffering from restriction = Only restriction + both = 77+6 = 83.

Co-existing obstruction and restriction disorders may have higher health impacts in some patients, while in some patients the severity of only obstruction or only restriction may be higher. This may require further medical intervention based on severity of the lung disorder.

Figure17: *Disease severity (%) of observed pulmonary impairments for security guards.*



The following observations were made from disease severity assessment:

- Of the 9 participants suffering from obstructive lung disease, 56% cases were moderate, and 22% cases were severe and mild each.
- Of the 83 participants suffering from restrictive lung disease, the majority of the cases were mild (48%) and moderate (42%).
- Ten percent of the restriction cases were severe.

GENDERED IMPACT

A comparison of disease severity of pulmonary impairments for male and female security

guards is illustrated in Figure 18.

Figure 18: *Disease severity (%) for male and female security guards.*

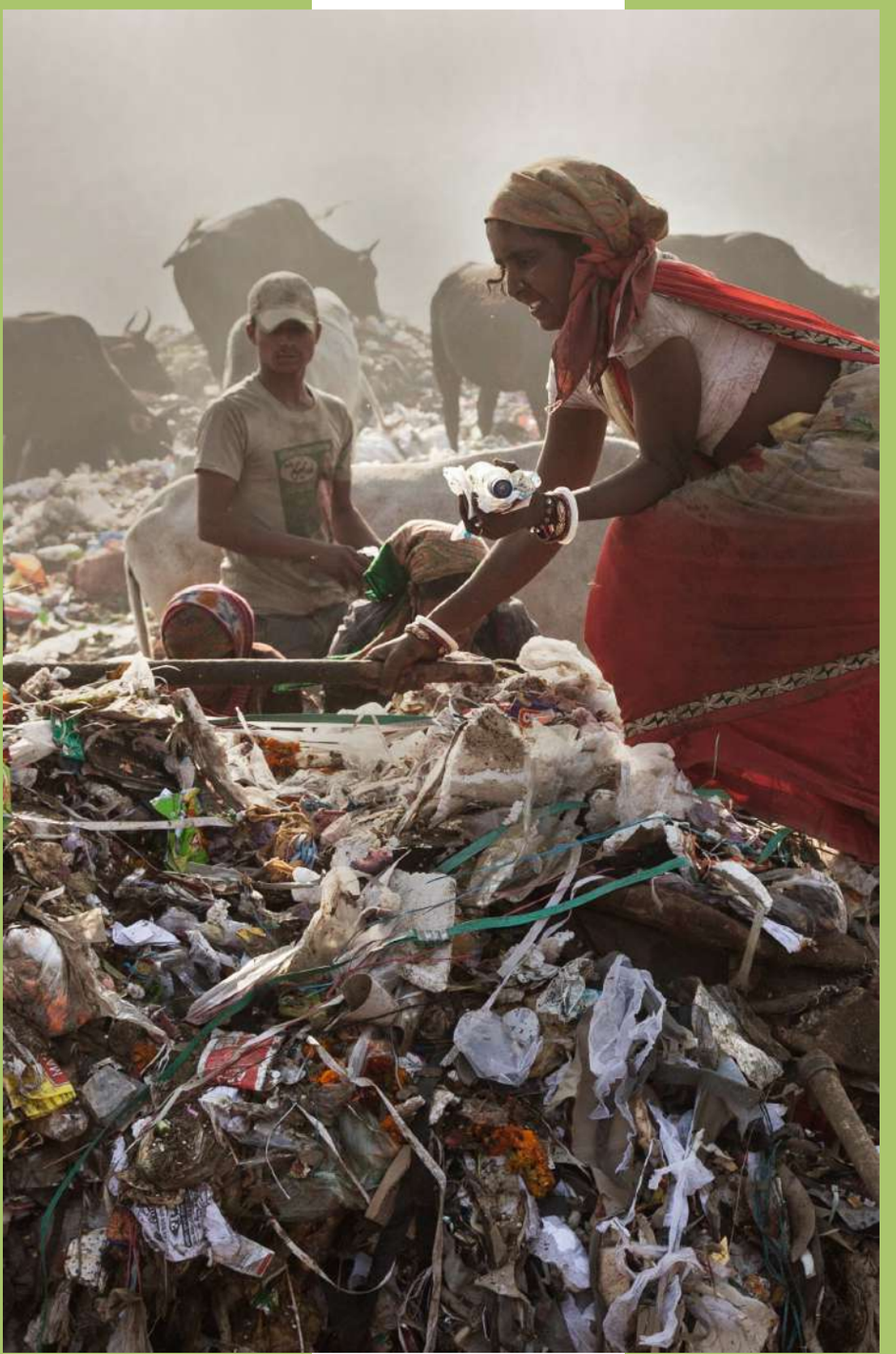
Further the data revealed the following:

- Out of the total cases of restriction, 77 cases are recorded in males and 6 cases in females. Forty eight percent of the cases in males and fifty percent cases in females are mild.
- Out of the total cases of obstruction, 7 cases are recorded in males. Fifty seven percent cases in males are moderate.
- Out of the two obstruction cases one case is severe and one is moderate.

STATISTICAL ANALYSIS OF SURVEY RESPONSES

In addition, the survey results indicate the following (details of analysis in Annexure 4):

- Larger families had approximately 1.8 times more probability of respiratory illness than the smaller families.
- Lack of education increased the probability of respiratory illness by approximately 2.6 times.



5 Wastepickers: The Results

This chapter discusses the results of survey data and conducted pulmonary function (PF) tests for wastepickers. A total of 100 wastepickers, 45 men and 55 women were the respondents.

OVERVIEW

Table 10 summarises the demographic characteristics of wastepickers derived from the survey.

Table 10: *Demographic data collected from wastepickers.*

Sr. No.	Characteristics	Total (100)	Male (45)	Female (55)
1	Age (Years)			
	18-45	83	38	45
	46-60 or above	17	7	10
2	Educational status			
	No education	41	16	25
	1 – 8	45	21	24
	8 – 12 or above	14	8	6
3	BMI			
	Normal (< 25 kg/m^2)	74	37	37
	Overweight (25-29.9 kg/m^2)	20	8	12
	Obese (>30 kg/m^2)	6	-	6
4	Smoking status			
	Smoker	17	15	2
	Non-smoker	83	30	53
5	Passive smoking at home or workplace			
	Yes	24	2	22
	No	76	43	33
6	Cooking fuel			
	Wood/Dung cake	84	34	50
	LPG	16	11	5
7	No. of dependents			
	No	2	-	2
	1-4	54	29	25
	>4	44	16	28

The key learnings are as below:

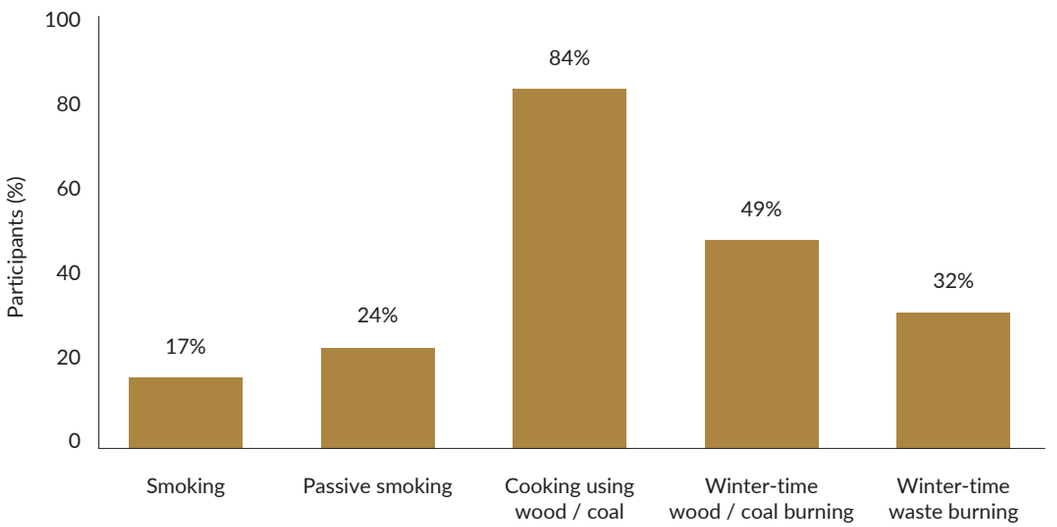
- Approximately 83% of wastepickers were between the ages of 18 and 45, showing younger persons are being impacted, with impact on future productivity.
- Forty one percent of the respondents were uneducated.
- The working conditions for wastepickers were as follows: 46% worked near landfill sites, while 47% worked in other parts of the city.
- Most wastepickers (58%) were self-employed, while 36% worked with contractors.
- Approximately 54% of wastepickers supported at least 1 dependent and 44% supported more than 4 dependents.
- Only 4% have health insurance and 9% have life insurance. The lack of awareness and access to insurance increases wastepickers' vulnerability to health risks.

EXPOSURE AND PROTECTIVE GEAR

While ambient air pollution causes serious health impacts, other additional sources also add to the risks.

Ninety five percent of the wastepickers reported that they encounter air pollution at their workplace.

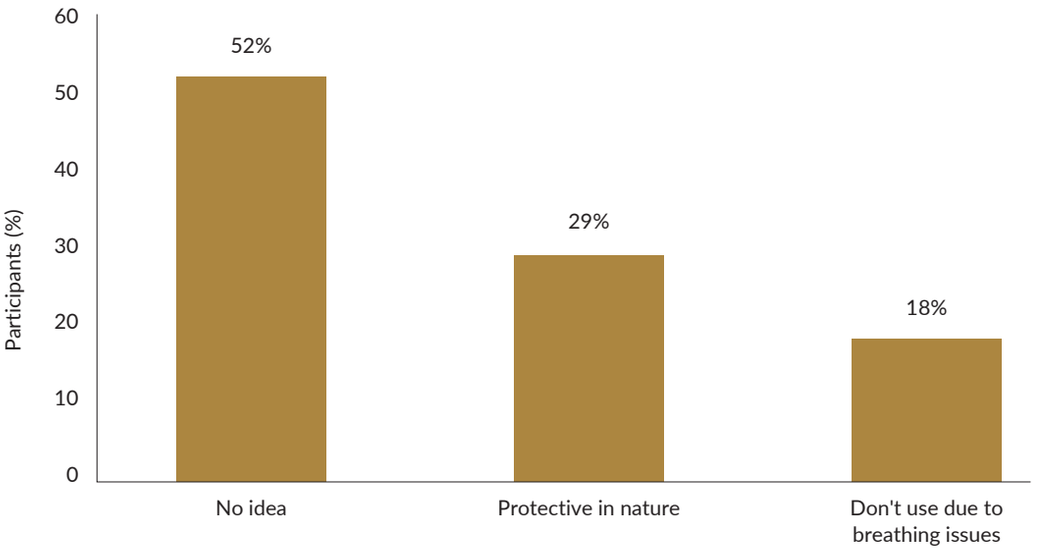
Figure 19: *Sources of exposure to air pollution for wastepickers.*



Based on the survey, the following observations about exposure to air pollution sources for wastepickers were made.

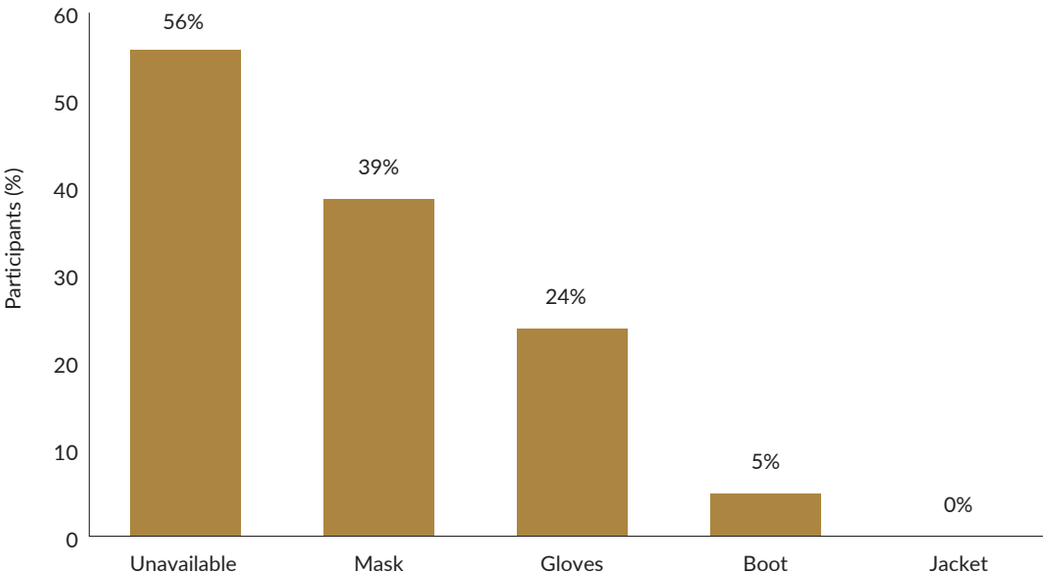
- Approximately 17% of wastepickers were smokers and 24% reported passive smoking either at home or workplace.
- Majority, or 84% of wastepickers cooked using wood, dung cakes or kerosene, exposing them, particularly women, to additional air pollution burden.
- During the winters, 49% of wastepickers burn wood or coal while 32% burn waste to keep warm.

Figure 20: *Perception of wastepickers around PPE kits.*



More than 50% wastepickers had no knowledge of PPE kits. Since nearly 60% of them are self-employed, the lack of PPE use could be due to inaccessibility, and due to differing terminology used. This suggests the need for symmetry in terminology from top to bottom. Approximately 20% wastepickers reported not using PPE kits due to breathing issues.

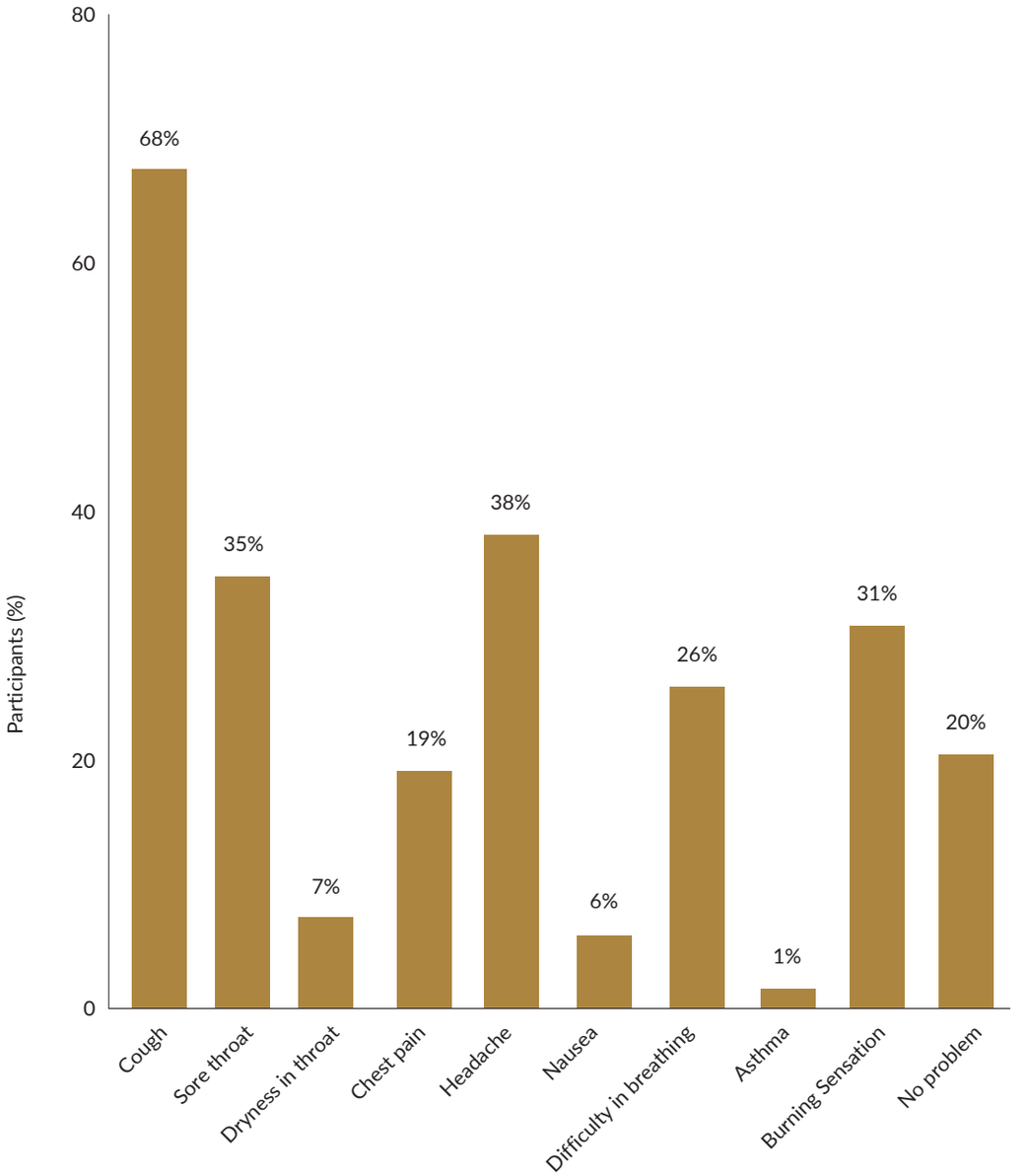
Figure 21: *Availability of PPE kits to wastepickers.*



More than half (56% of wastepickers had no personal protective equipment (PPE) kits.

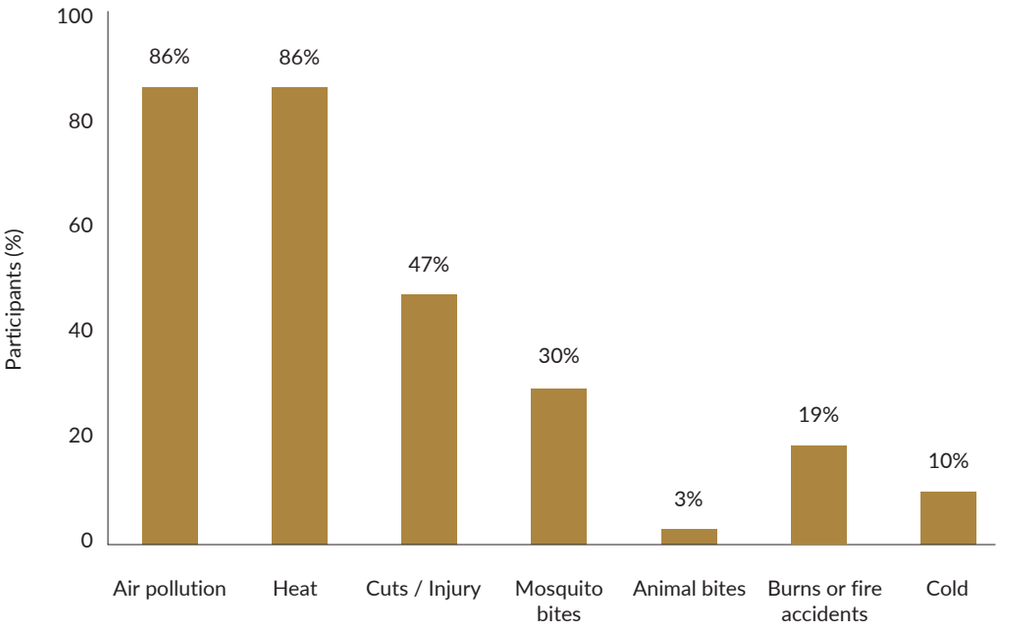
HEALTH IMPACTS

Figure 22: *Reported health concerns since starting work in their current role.*



Since beginning work in their current role, 80% of wastepickers have been facing health issues such as cough, headache, burning of eyes, breathing problems, etc. Among them, only 25% visited hospitals for these health issues. Less than 20% of participants reported no health problems.

Figure 23: *Top health concerns faced while working.*



The following conclusions were drawn:

- Almost 90% of wastepickers were aware of the adverse impacts of air pollution on human health while 78% feel that their nature of job (outdoor, working on landfill/toxic wastes) increases the air pollution risk to them.
- Approximately 54% of wastepickers believe that they do not have access to appropriate health care facilities.
- Air pollution and heat were the top two challenges faced by 86% of the respondents. Cuts and injury were challenges for 47% of the respondents.

PULMONARY FUNCTION TEST RESULTS

Overall and gender-wise descriptive statistics of lung function parameters for wastepickers have been recorded in Table 11 and 12, respectively.

Table 11: *Lung function parameters for wastepickers.*

	Average ± SD	Range	CoV
FVC absolute (L)	2.4 ± 0.7	1.2 - 4.1	28.6
FVC % predicted	72.9 ± 12.5	40.5-100	17.2
FEV1 absolute (L)	2.1 ± 0.7	0.61 - 3.6	32.1
FEV1 % predicted	73.2 ± 15.3	24.2-105.1	21
FEV1/FVC	0.85 ± 0.1	0.43 – 0.99	10.5

The mean predicted value of FVC% was 72.9 ± 12.5 and mean predicted value of FEV1% was 73.2 ± 15.3, which is lower compared to the normal value of 80% for a healthy adult of their age and weight. Standard deviations of ± 12.5 and ± 15.3 suggest that some wastepickers would fall under the normal lung function category (80%), however others would have poorer lung function than the average.

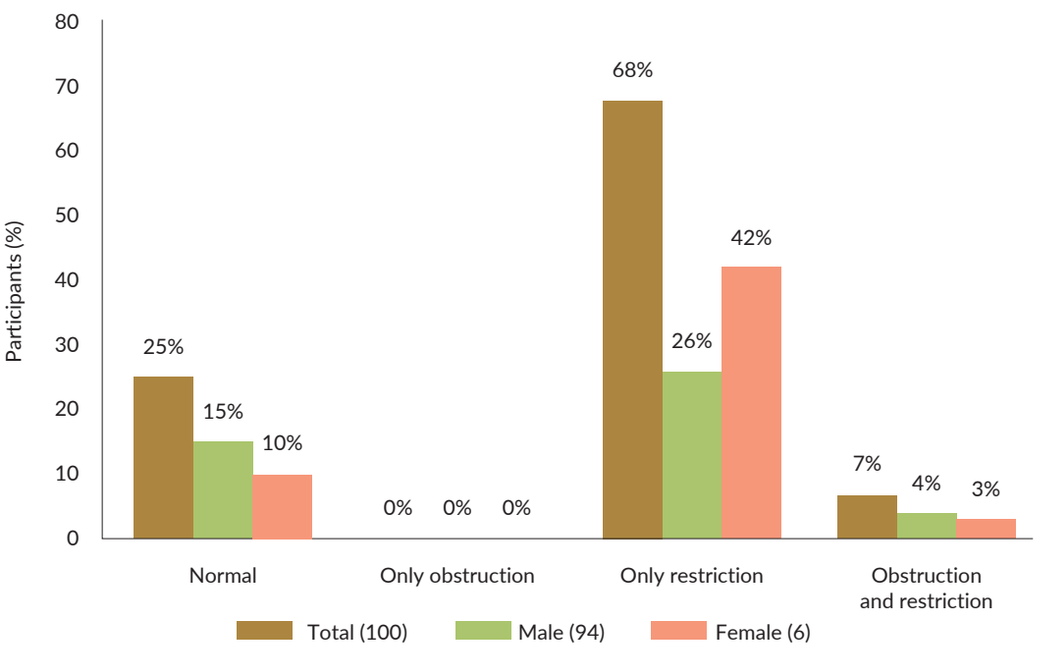
Table 12: *Lung function parameters for male and female wastepickers*

	Male (n=45)		Female (n=55)	
	Average ± SD	Range	Average ± SD	Range
FVC absolute (L)	2.9 ± 0.6	1.4 - 4.1	2.0 ± 0.4	1.2 - 3.2
FVC % predicted	75.4 ± 14.0	40.5 -100	70.8 ± 10.9	41.4 - 92.9
FEV1 absolute (L)	2.5 ± 0.6	0.9 - 3.6	1.7 ± 0.4	0.6 - 2.8
FEV1 % predicted	77.3 ± 16.5	31.4 - 105.1	69.9 ± 13.6	24.2 - 92.8
FEV1/FVC	0.86 ± 0.1	0.58 - 0.99	0.85 ± 0.1	0.43 - 0.99

Male wastepickers showed FVC% and FEV1% values above 75, while females showed approximately 70%, which suggests poorer lung function among women wastepickers compared to men.

Figure 24 shows the prevalence of pulmonary function impairment in wastepickers based on pulmonary function tests.

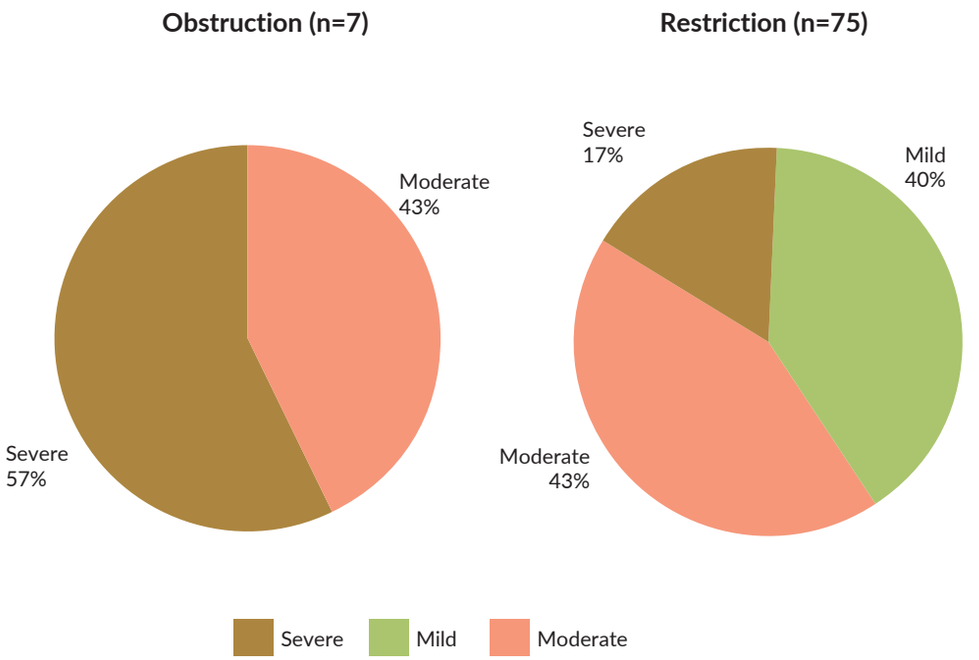
Figure 24: *Spirometry results for wastepickers.*



The results of the spirometry test of wastepickers were as follows:

- Approximately, 75% of participants had abnormal spirometry patterns, and only 25% had normal lung function.
- A majority, or 68%, accounted for only restriction. Seven percent had both obstructive and restrictive disorders.
  Therefore,
- Total participants suffering from restriction = Only restriction + both = 68+7 = 75.
- Total participants suffering from obstruction = Only obstruction + both = 0+7 = 7.

Figure 25: *Disease severity (%) of observed pulmonary impairments for wastepickers.*



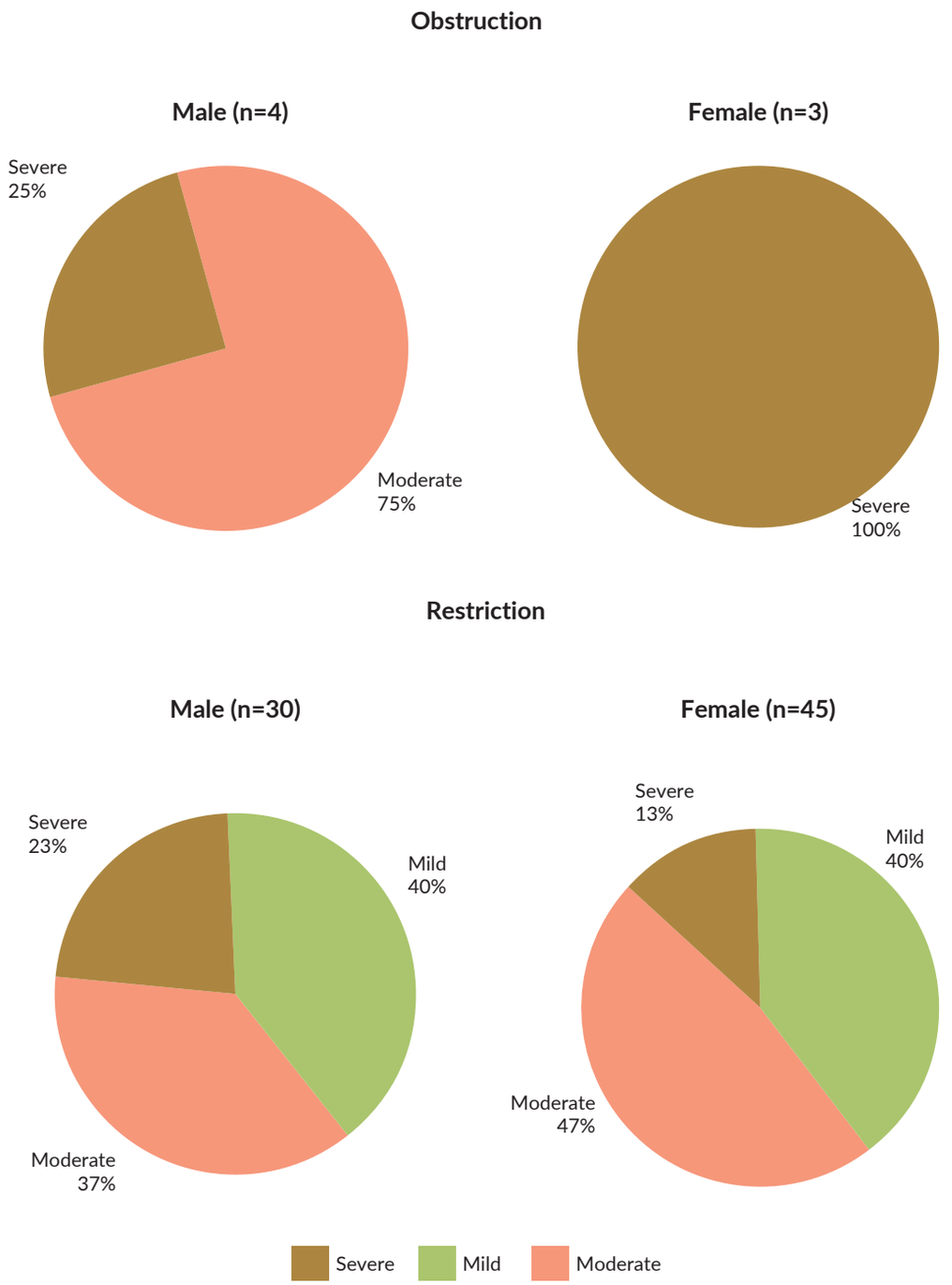
The severity of obstruction and restriction impairments for wastepickers is presented in Figure 25.

- Of the 7 participants suffering from obstructive lung disease 57% of the cases were severe. None had mild obstruction impairment.
- Of the 75 participants suffering from restrictive lung disease,43% of the cases were moderate, 40% of the cases were mild, and 17% cases were severe.

GENDERED IMPACT

A comparison of disease severity of pulmonary impairments in male and female wastepickers is illustrated in Figure 26.

Figure 26: *Disease severity (%) for male and female wastepickers.*



Further, the data revealed the following:

- Out of the total cases of restriction, 30 cases were recorded in males and 45 cases in females.
- Moderate cases were recorded in 47% females and 37% males.
- Out of the total cases of obstruction, all cases recorded in females were severe and 75% cases in males were moderate.

STATISTICAL ANALYSIS OF SURVEY RESPONSES

In addition, the survey results indicate the following (details of analysis in Annexure 5):

- Female wastepickers are 3.9 times more likely to have respiratory illness.
- Lack of education is associated with a 17% increase in the probability of respiratory illness.

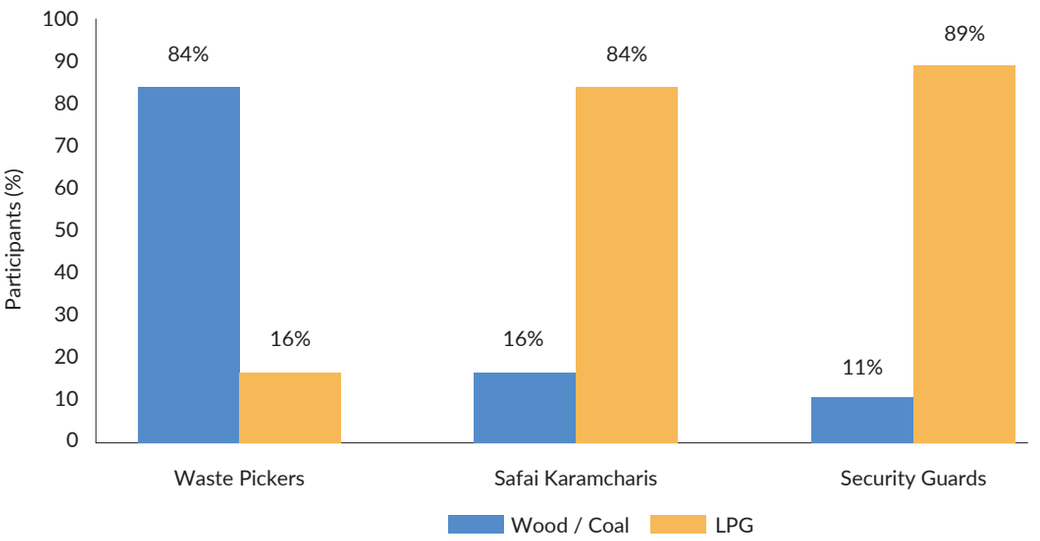
6 Comparative Analysis of Studied Groups and Control Group

This chapter discusses the comparative analysis of the surveys and pulmonary function (PF) tests for the 100 participants from the 3 studied groups (safai karamcharis, security guards, and wastepickers) with the 100 participants from the control group. In the following sections, the response to the questionnaire will first be discussed, followed by the severity of the respiratory illness (obstruction and restriction) based on PF tests.

EXPOSURE AND PROTECTIVE GEAR

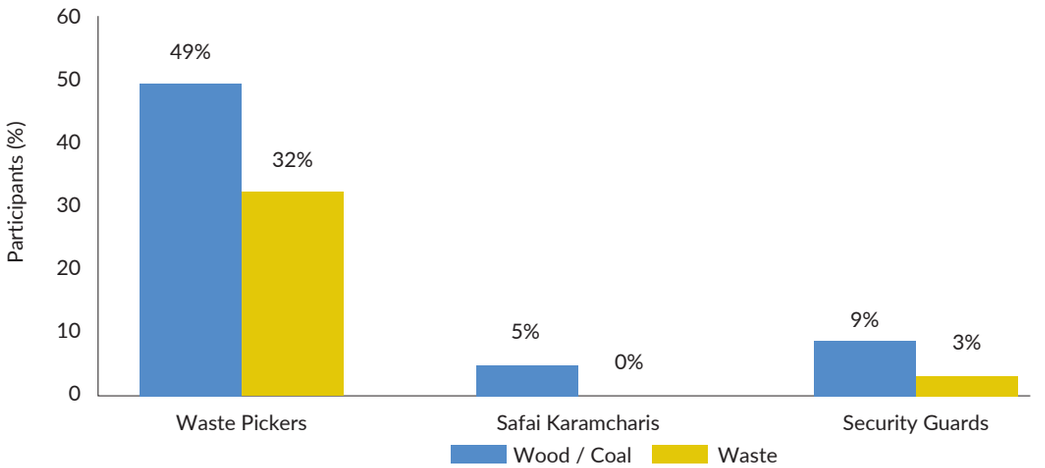
A significant percentage of the studied groups, 97% safai karamcharis, 95% wastepickers, and 82% security guards reported exposure to air pollution during work. This indicates that all three categories are aware of their exposure to air pollution during work.

Figure 27: *Cooking fuel usage.*



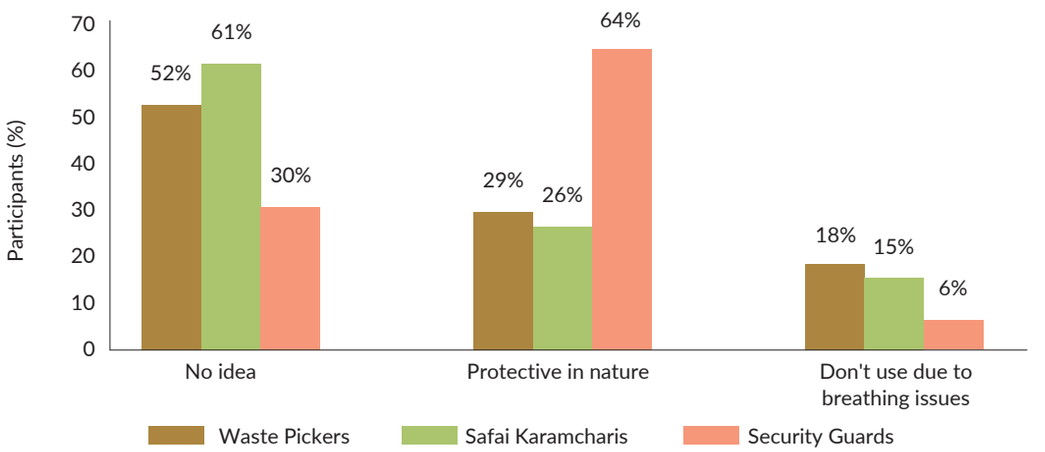
Wastepickers had the highest incidence (84%) of cooking with wood, dung and other fuels which are known to emit high amounts of pollutants. LPG cylinders are used by more than 80% safai karamcharis and security guards. The incidence of using polluting fuels is very high among wastepickers and the primary reason identified for the same is that clean cooking fuels such as liquified petroleum gas (LPG) is beyond their budget.

Figure 28: *Extent of open burning during winter.*



Nearly half, or 49% wastepickers, and a small percentage of safai karamcharis (5%) and security guards (9%) reported burning wood or coal to keep warm during winter. Waste burning is reported to be practiced by more than 30% wastepickers and less than 5% security guards. Safai karamcharis did not report burning waste.

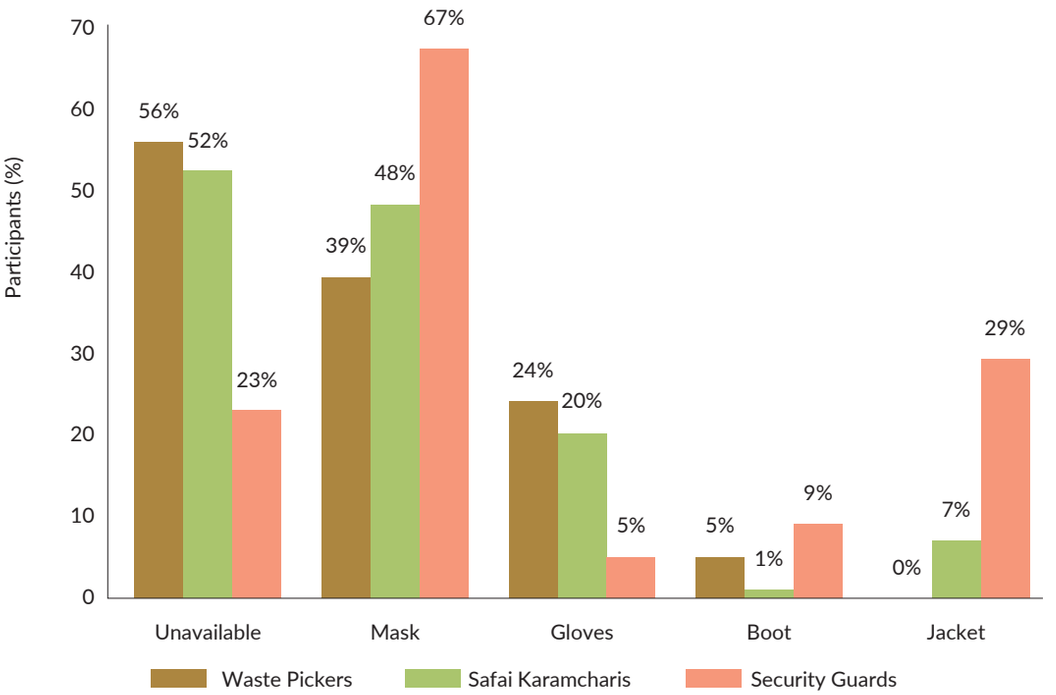
Figure 29: *Perception around Personal Protective Equipment (PPE).*



The survey results indicate the following:

- Approximately 61% safai karamcharis, 52% wastepickers, and 30% security guards are unaware of the PPE terminology and concept.
- Awareness of PPE kits is higher among security guards. Approximately 65% security guards believe that PPEs were protective in nature. Six percent of security guards said they didn't use PPEs due to breathing issues.
- Almost 30% wastepickers and safai karamcharis stated that PPEs are protective in nature, however, nearly 20% and 15% said they don't use them due to breathing issues.

Figure 30: *Availability of PPE kits.*



In addition to low awareness, access to PPE kits was also low across all the groups.

- Wastepickers and safai karamcharis had minimum access to PPE kits. More than half, or 56% of the wastepickers and 52% safai karamcharis had no PPE kits. Approximately 20% of security guards did not have access to PPE kits.
- Masks were the most used protective gear among all 3 groups. This might be due to the pandemic which shifted mask usage across populations.
- Gloves were used by approximately 24% wastepickers and 20% safai karamcharis. Poor use of gloves may pose increased health risks due to direct interaction of wastepickers and safai karamcharis with waste.

HEALTH IMPACT OBSERVATIONS

Of all the study participants, 90% of wastepickers, 85% safai karamcharis, and 86% security guards said they were aware of air pollution and its impacts. Thus, even though there is high awareness of the risks, they remain compelled to work in these professions for financial security.

Most respondents from all groups perceived air pollution and extreme heat as the top two challenges during work.

Since starting to work in their current role, 80% wastepickers, 47% of safai karamcharis, and 45% security guards have been experiencing health issues such as cough, headache, burning of eyes, breathing issues, chest pain, etc.

Figure 31: *Top health concerns faced by all groups while working.*

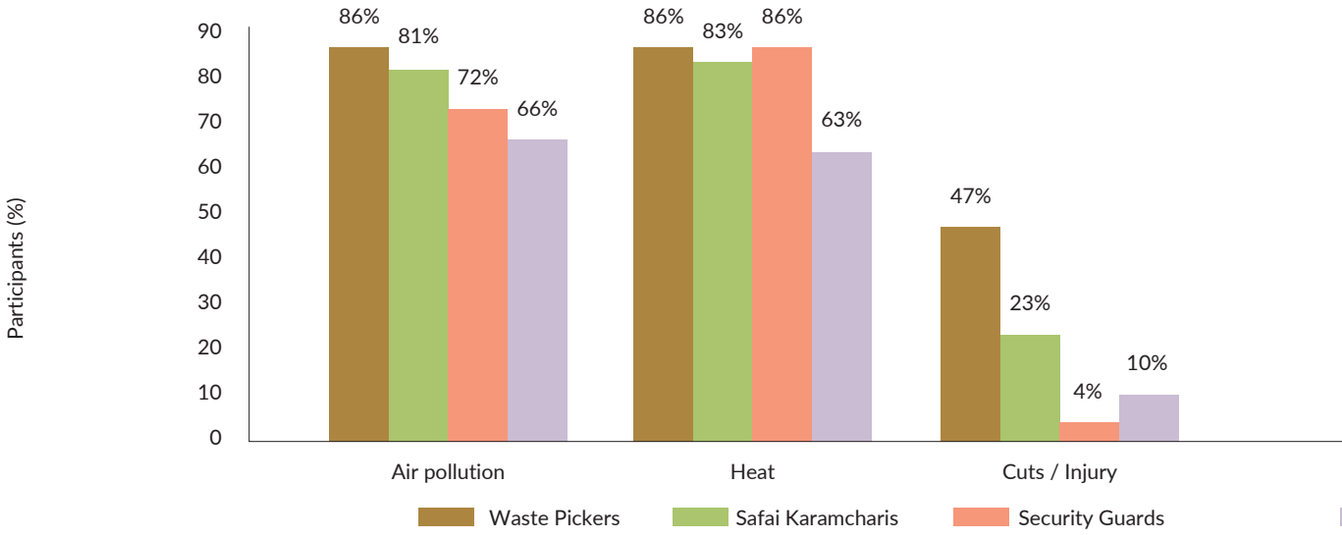
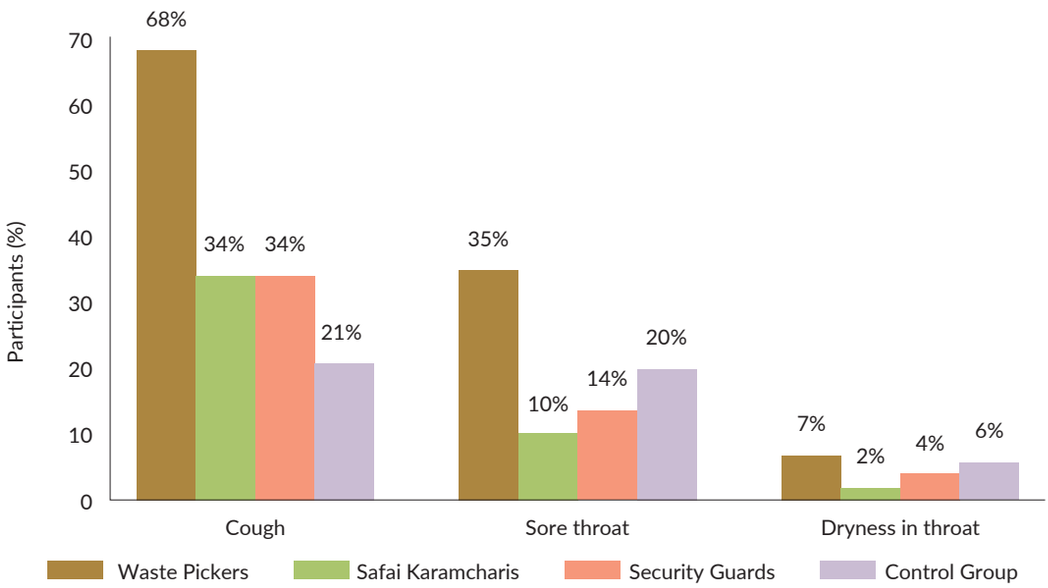


Figure 32: *Reported throat-related health concerns by all groups since starting current role.*



Nearly 70% wastepickers and 34% safai karamcharis and security guards reported cough as the top throat-related health concern experienced since they started working in their current role.

Burning sensation in eyes was experienced by 31% wastepickers and approximately 15% safai karamcharis and security guards. Thirty eight percent wastepickers and sixteen percent safai karamcharis also experienced headaches since starting their current role.

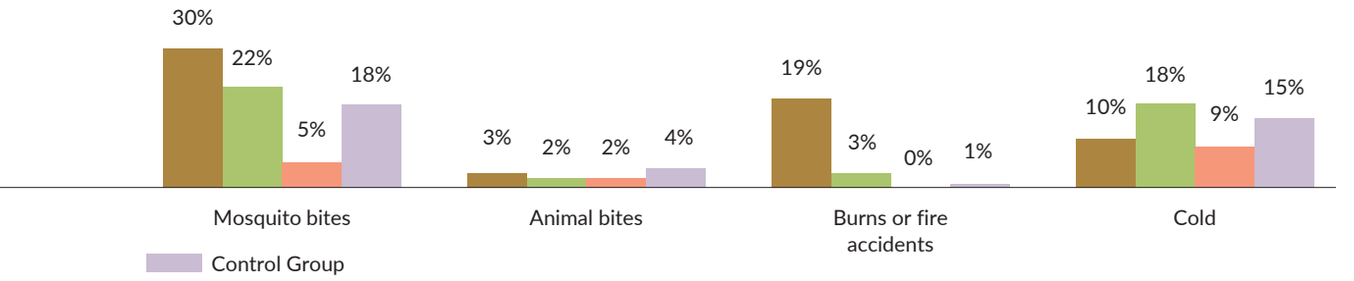


Figure 33: *Reported eye-related health concerns by all groups since starting current role.*

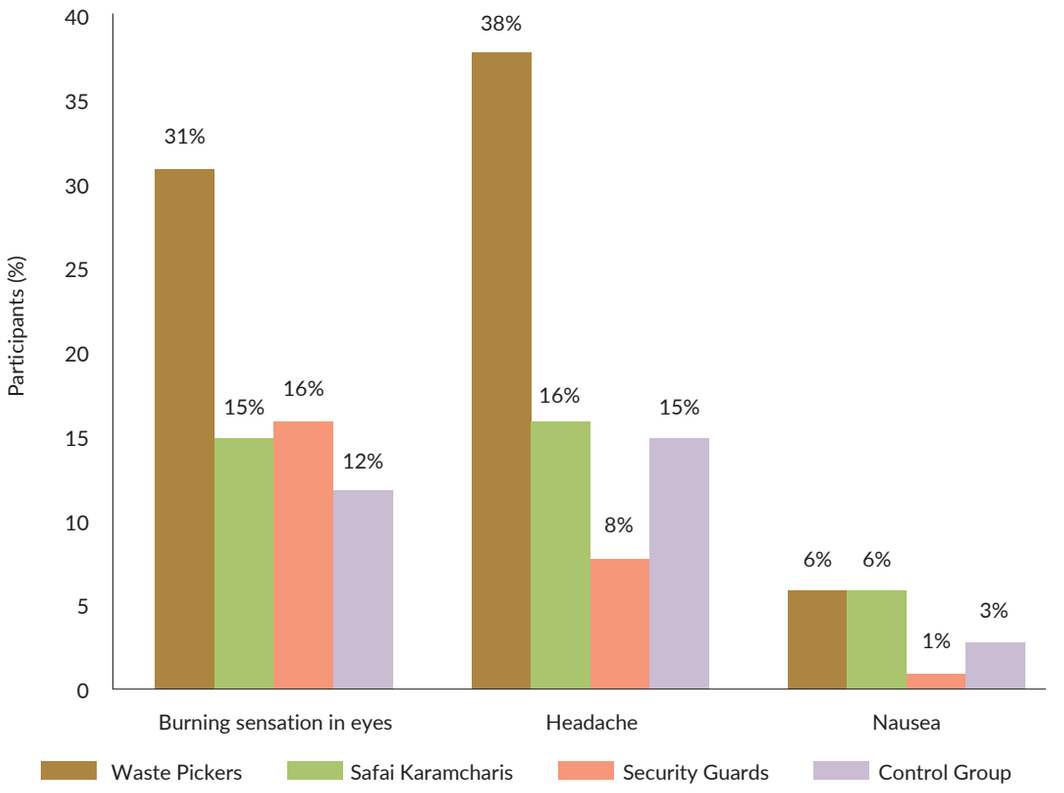
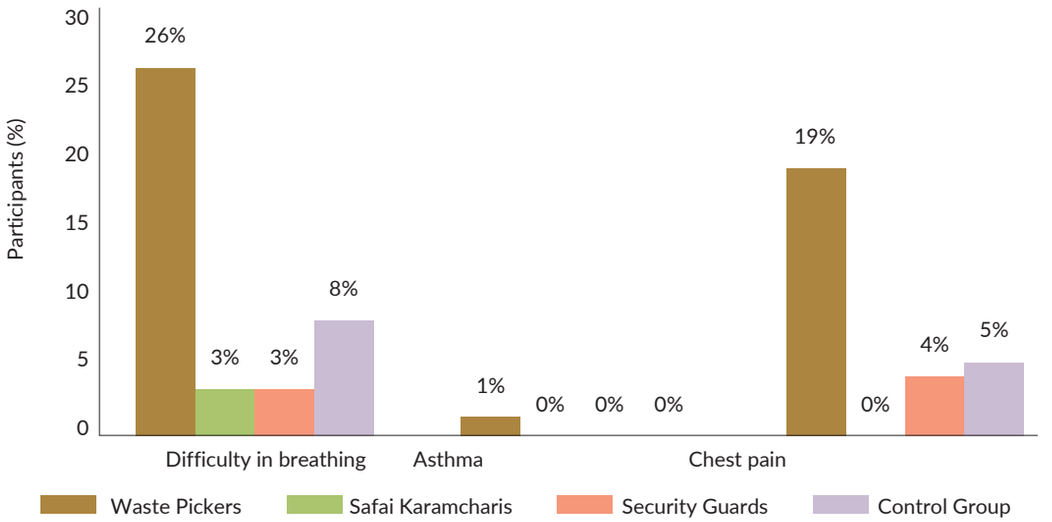
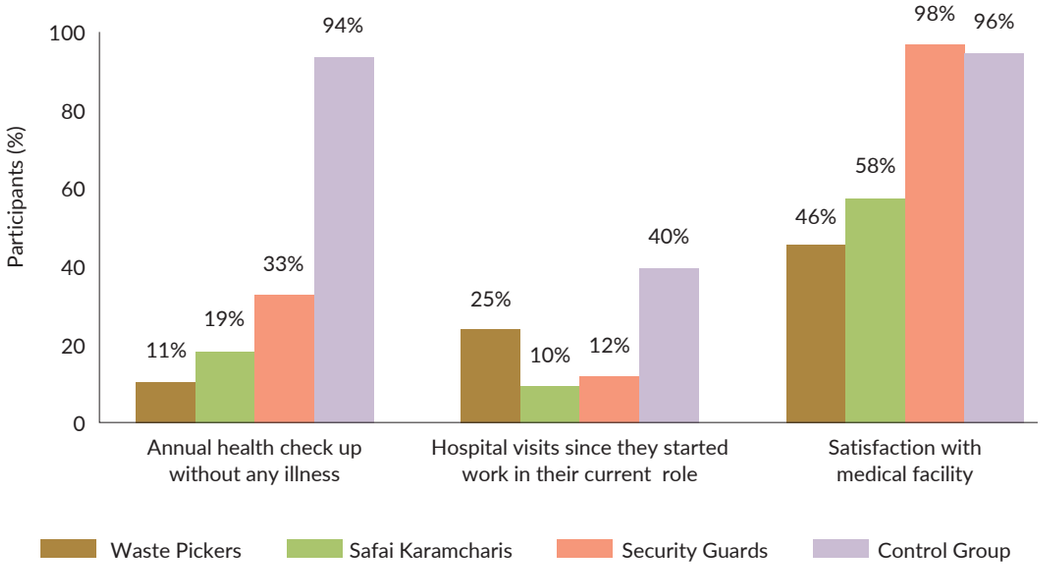


Figure 34: *Reported chest-related health concerns by all groups since starting current role.*



Wastepickers also reported difficulty in breathing (26%) and chest pain (19%). Asthma was not reported by the studied groups, however, the PF tests showed deteriorated lung function for all studied groups. This further strengthens the observation that the studied communities did not get health checkups unless they experienced serious health impacts.

Figure 35: *Healthcare access.*



The following conclusions about access to healthcare were drawn from the survey.

- Approximately 54% and 42% of wastepickers and safai karamcharis believe that they do not have appropriate health care facilities.
- Approximately 80% safai karamcharis, 89% wastepickers, and 67% security guards do

not have access to routine annual health checkups unless they experience symptoms of an illness. This shows that the studied groups perceive the health impacts of their occupation but don't get regular health checkups. By improving healthcare access, this gap can be bridged.

PULMONARY FUNCTION TEST RESULTS OF ALL GROUPS

The present section deals with the measured lung function parameters for all the groups.

Predicted values for FVC and FEV1 represent the normal result calculated based on age, height, and sex. Absolute values for FVC and FEV1 represent the values obtained upon conducting the spirometry test. Percent predicted values for FVC and FEV1 represent the percentage of the predicted FVC. As discussed previously, 80% lung function is considered normal for a healthy adult. The mean values were calculated to get the average values for the 4 categories. Standard deviation was calculated to understand the deviation of the data collected from the average.

Table 13 lists the descriptive statistics of lung function parameters for studied groups.

The table above indicates that participants from all three studied groups had lower lung function than the healthy limits.

Safai karamcharis had the lowest lung function followed by security guards and wastepickers. In comparison, participants of the control group had better lung function than the studied groups.

Table 13: *Lung function parameters for studied groups and control group.*

	Wastepickers (n=100)	Safai Karamcharis (n=100)	Security Guards (n=100)	Control Groups (n=100)
FVC absolute (L)	2.4 ± 0.7	2.1 ± 0.7	3.0 ± 0.6	3.2 ± 0.6
FVC % predicted	72.9 ± 12.5	62.0 ± 14.7	71 ± 12.2	81.5 ± 7.8
FEV1 absolute (L)	2.1 ± 0.7	1.8 ± 0.6	2.5 ± 0.6	2.7 ± 0.5
FEV1 % predicted	73.2 ± 15.3	64.2 ± 16.1	72.1 ± 13.4	82.5 ± 7.7
FEV1/FVC	0.85 ± 0.1	0.85 ± 0.1	0.84 ± 0.07	0.86 ± 0.05

Further the data revealed the following:

- The gender-wise comparison concluded that women participants of all studied groups had lower lung volumes than the males. This signifies that females had more deteriorated lung function capacity.
- Female safai karamcharis showed maximum lung function deterioration, followed by security guards and wastepickers. All three groups showed average values lower than normal. This can be attributed to the fact that women are more exposed to indoor air pollution during cooking using wood or coal.
- In contrast, female participants from control group showed average values above 80%, indicating normal lung function.

Figure 36: *Spirometry results for all groups.*

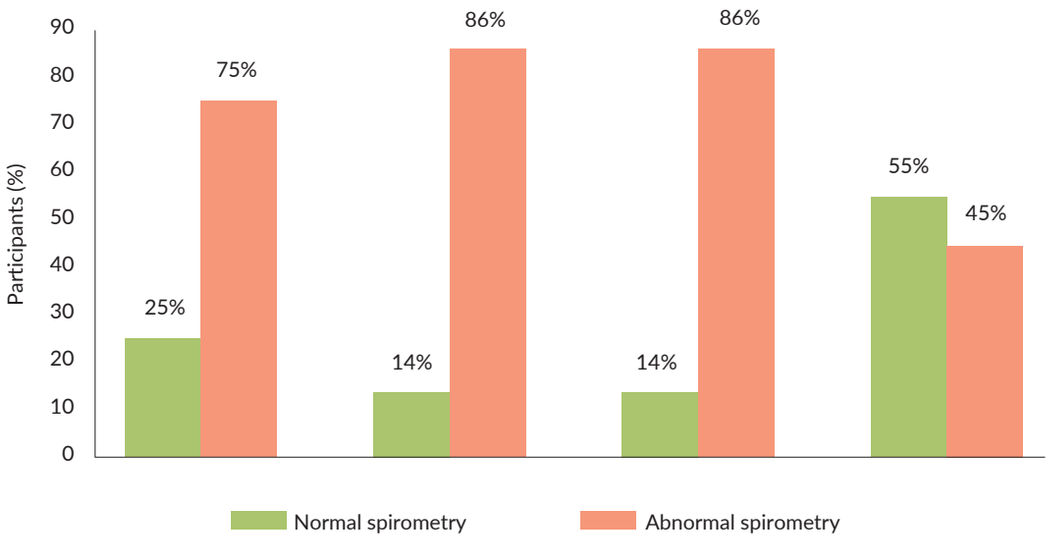
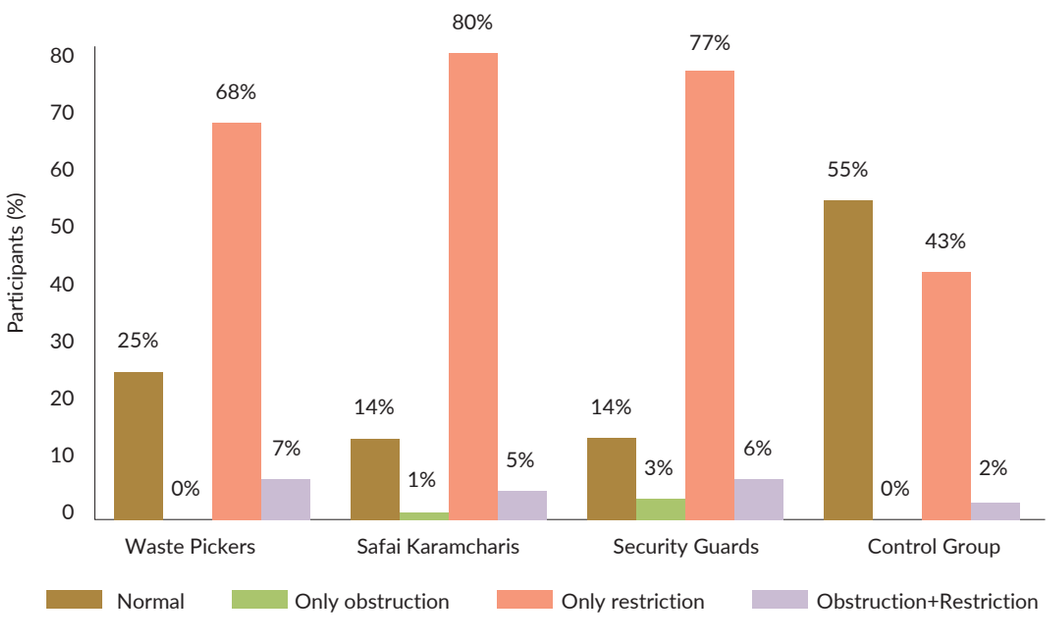


Figure 36 illustrates the observed spirometry pattern based on the conducted PF test for all groups.

The following results were obtained from the spirometry tests:

- Approximately 80% of the 3 groups had abnormal spirometry results.
- A small percentage of wastepickers (25%), safai karamcharis (14%) and security guards (14%) had normal spirometry patterns.
- In comparison, the control group accounted for 55% of normal spirometry test results.

Figure 37: *Disease severity for studied groups.*



Distribution of respiratory disorders (obstruction, restriction and mixed) for all studied groups has been presented in Figure 37. The following observations were drawn.

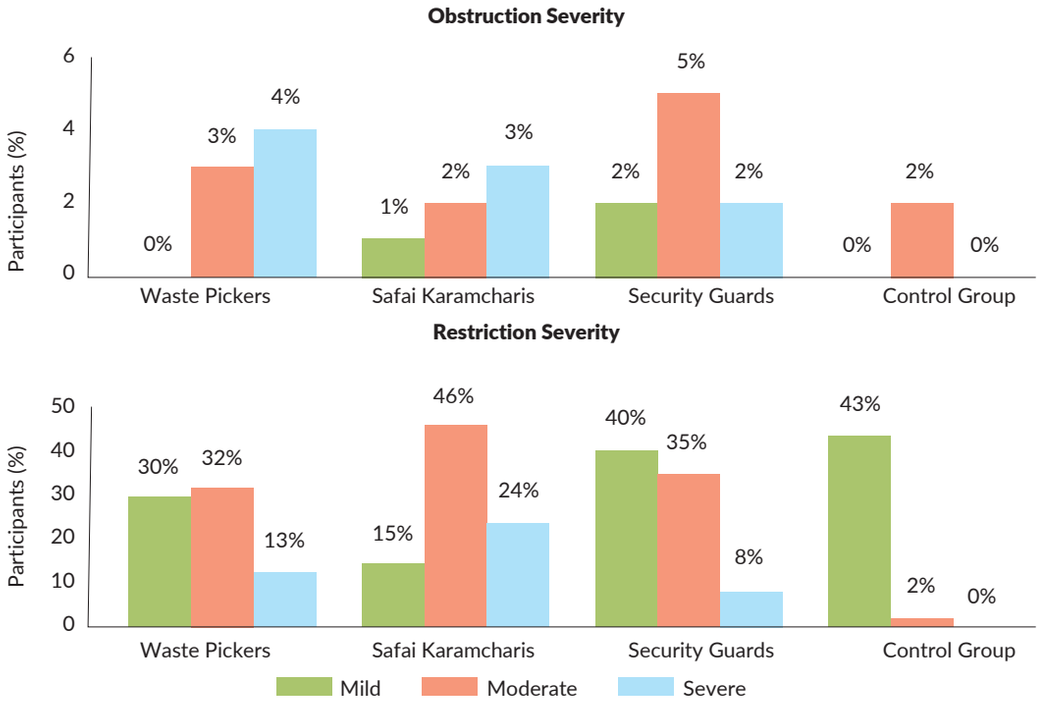
- Cases of only obstruction were recorded in only 1% safai karamcharis and 3% security guards.
- Restriction disorders were dominant in all studied groups - 75% wastepickers, 85% safai karamcharis, and 83% security guards.
- In contrast, 45% participants from the control group exhibited restriction disorders.
- A combination of both obstruction and restriction disorders were recorded in 7% wastepickers, 5% safai karamcharis, 6% security guards, and only 2% participants from the control group.

The following can be drawn from the disease severity assessment:

- Moderate and severe cases of restriction are dominant among safai karamcharis. Out of the total cases of restriction in safai karamcharis, 54% are moderate and 28% are severe.
- Mild cases of restriction are most common among security guards. Out of the total cases of restriction in security guards, approximately 48% are mild.
- Moderate cases were recorded in approximately 43% wastepickers.
- The control group has the lowest severity of respiratory disorders. Approximately 95% of the cases of restriction among the control group are mild.

Gender-wise comparison between obstruction and restriction severity among all groups showed the following:

Figure 38: *Obstruction and restriction severity for all studied groups.*



SAFAI KARAMCHARIS

- Severe cases were recorded in 34% female and 23% male safai karamcharis suffering from restriction.
- Forty percent of obstruction cases in men were severe and moderate.
- The only case of obstruction in female safai karamcharis was severe.

SECURITY GUARDS

- Moderate cases were recorded in 33% female and 42% male security guards suffering from restriction.
- Fifty seven percent of the obstruction cases among men were moderate.
- Two cases of obstruction in female security guards were moderate and severe.

WASTEPICKERS

- Moderate cases were recorded in 46% of the total cases of restriction among women and 36% of restriction cases in men.
- Hundred percent of the cases of obstruction in women were severe.

The following conclusions on the gendered impact of air pollution are drawn:

- Female wastepickers and safai karamcharis show higher instances of severe obstructive and restrictive disorders. This could be due to higher use of biomass fuels and exposure to ambient pollutants in the workplace.
- Control groups working indoors also had a prevalence of respiratory impairment, although mild and moderate. Approximately 75% of restriction cases in men from the control group were moderate. The two cases of obstruction recorded in females were both moderate. No severe cases were observed.
- This suggests that air pollution poses health risks to both indoor and outdoor occupational groups. However, outdoor workers, particularly women, display higher instances of severe lung disorders.

7 Conclusions

The results suggest that the three outdoor worker groups studied are exposed to air pollution due to the nature of their work. All three groups perceived air pollution a risks to their health. This perception was also validated by the pulmonary function test results.

Participants from all groups supported at least one dependent, which suggests that they are likely to continue working to support their families, despite the risks of their occupation. Lack of education was also recorded across the groups, which further makes finding better livelihood opportunities difficult. Additionally, participants below the age of 45 across all groups may experience worsening health impacts over time, which can further impact their work and livelihood security in the future. The following section discusses the conclusions drawn from the study.

1. **WORKERS IN THE STUDY PERCEIVE AIR POLLUTION TO BE THE BIGGEST CHALLENGE AT WORK DESPITE LOW LEVELS OF EDUCATION.**
   According to the survey results, 81% of safai karamcharis, 72% of security guards, and 86% of wastepickers agreed that one of the main challenges they experience at work is exposure to air pollution. This shows that people are aware of pollution levels in Delhi. Additionally, each group (78% of wastepickers, 61% of safai karamcharis, and 62% of security guards) acknowledges that the nature of their jobs exposes them to air pollution.

2. **THE RISK PERCEPTION OF HARM TO HEALTH DURING WORK IS HIGH AMONGST ALL THE STUDIED WORKERS.**
   While exposure to air pollution is cited as one of the main concerns for all studied groups, exposure to extreme weather conditions like heat and cold as well as cuts and bruises are also identified as dangers. Approximately 86% of security personnel and wastepickers, and 83% safai karamcharis acknowledged that exposure to heat is a top challenge that comes with their work. Workers are therefore clearly able to identify the environmental hazards they experience during work.

3. **HIGH PREVALENCE OF BIOMASS BURNING FOR COOKING AND OPEN BURNING, PARTICULARLY AMONG WASTEPICKERS**

   The study identifies that the wastepicker group has the highest incidence of using biomass as cooking fuels (84%) as well as burning waste and wood or coal (49%) during winter for insulation. For safai karamcharis and security guards the reported numbers for use of biomass for cooking (16% safai karamcharis, 11% security guards) and burning waste (5% safai karamcharis, 9% security guards) are significantly lower. It is possible that there is an under-reporting on open burning as it is disallowed by law. Unlike wastepickers, in case of safai karamcharis and security guards employed by government, there is a hesitation to acknowledge this as it could negatively impact job security.

4. **THE OCCUPATIONAL GROUPS, SAFAI KARAMCHARIS, SECURITY GUARDS AND WASTEPICKERS, SUFFER FROM WORSENED LUNG FUNCTION CAPACITY COMPARED TO THE CONTROL GROUP.**

   The study finds that the wastepickers, safai karamcharis, and security guards, suffered from decreased lung function capacity when compared to the control group. While 55% of the control group exhibited normal lung function, only 25% wastepickers, 14% safai karamcharis, and 14% security guards exhibited normal lung function.

5. **WOMEN ACROSS ALL GROUPS HAVE HIGHER INCIDENCE OF RESPIRATORY ILLNESS AS COMPARED TO MEN**

   According to the study, women's lung capacities are deteriorated in comparison to men in all categories. It can thus be concluded that air pollution disproportionately affects and puts at risk women more. Women wastepickers, for instance, are 3.9 times more likely than males to have a respiratory disease, while women safai karamcharis are 6 times more likely to deteriorated lungs, according to the results. Indoor air pollution through cooking particularly when using biomass exposes women to household pollution because they are often the carers. Thus, women are more vulnerable since they are exposed to both outdoor and indoor air pollution.

6. **WORKERS STUDIED REPORT POOR ACCESS TO HEALTHCARE FACILITIES**

   The study finds that the groups surveyed reported poor access to health care services. While 54% of wastepickers and 42% safai karamcharis reported that they were unsatisfied with the health services available to them, 96% of the control group felt satisfied with the health services available to them.

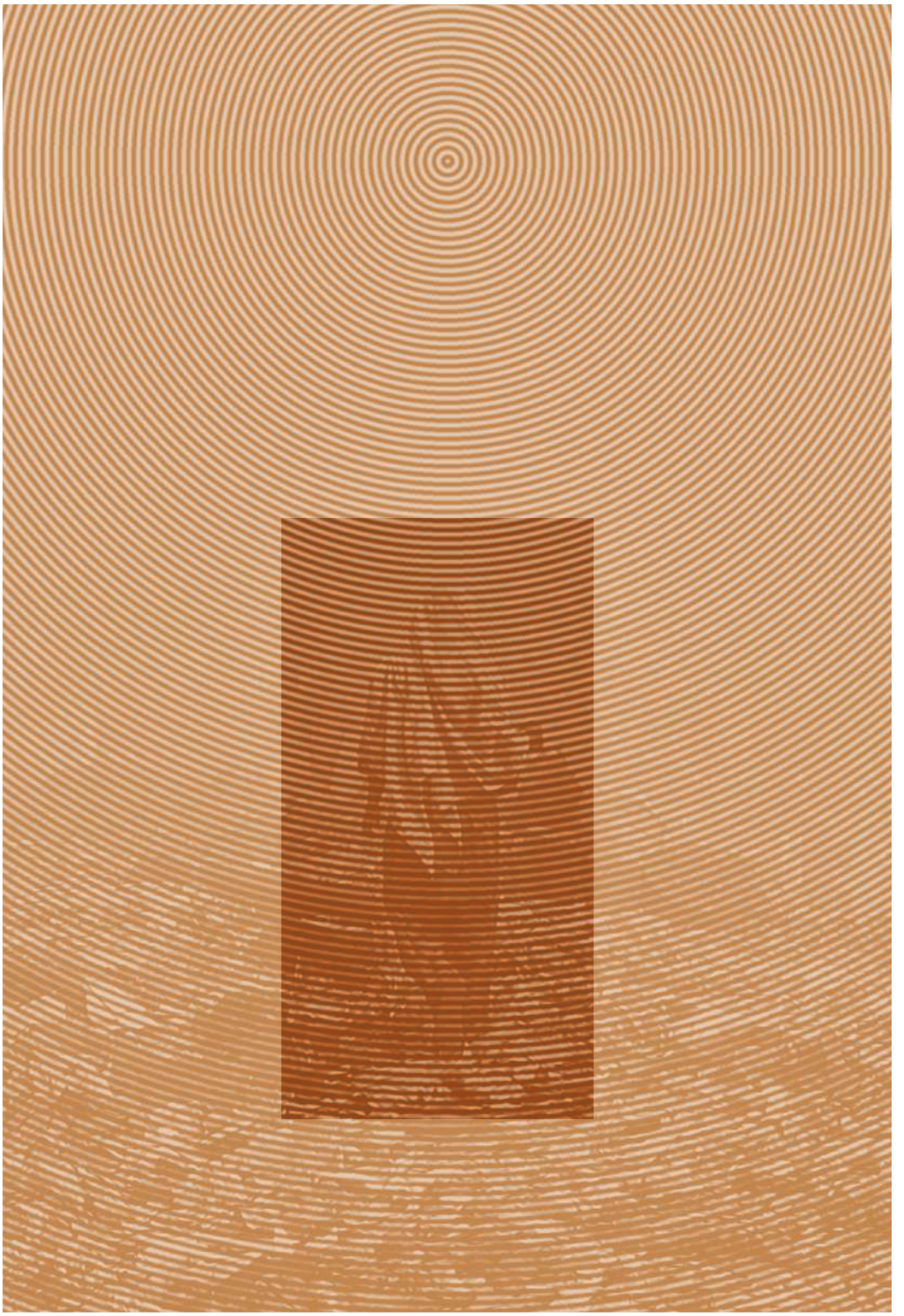
7. **LOW AWARENESS OF HEALTH-PROMOTING BEHAVIOR**

   Even though 80% wastepickers, 47% safai karamcharis, and 45% security guards report health conditions like cough, headaches, and asthma since they joined their current role, only 25% wastepickers, 11% safai karamcharis and 13% security guards sought healthcare services for the same. The study also finds that only 11% wastepickers, 19%

safai karamcharis, 33% security guards seek for annual health checkups regardless of illness. This indicates low awareness of and poor access to healthcare, even possibly low confidence in it.

8. LOW USAGE AND ACCESS TO PERSONAL PROTECTIVE EQUIPMENT (PPE)

Awareness about personal protective equipment was found to be low. The study found that 52% wastepickers, 61% safai karamcharis and 30% security guards did not know of PPEs. Moreover, due to lack of access, 52% of wastepickers, 23% of safai karamcharis and security guards never used PPE kits. Further, it was found that wherever available, no incentives are in place to encourage PPE use among these groups, indicating a need for further nudges in this direction.



8 Recommendations

This study demonstrates the pulmonary health of outdoor occupational groups is heavily impacted due to air pollution. Further, when compared to the control group, the workers surveyed suffered from significantly worse pulmonary health. The recommendations below are based on inputs from doctors, suggestions from those surveyed, and interventions based on Chintan's work on occupational health previously. Prevention of pollutants reaching the eyes, nasal cavity and throat must be the first priority. Key amongst the combined inputs for all 3 groups were:

- Standardize PPE for worker groups that are common for all
- Hand and face washing facilities at the work place for municipal workers and all MRFs, composting facilities and waste dumps and landfills, along with nudges for the workers to use them
- Many workers take to cotton *gamchas* or cotton cloths more than to masks, which are often discarded rapidly, even after COVID. Hence, masks must be tried out first, and if the uptake is not satisfactory, *gamchas* may be tried out. These can be modified based on local cultural norms.
- Training to gargle every morning after night duty or at night after day duty to remove dust particles from the nasal cavity and throat to be conducted.
- Prevention of exposure also requires removal of the individual from work during peak pollution, and rotation of duties.
- Training to use protective gear and individual action to reduce occupational exposure
- Annual health check-ups focused on monitoring pulmonary, eye, sinus, and ENT illnesses should be conducted and the data shared with the worker as well as stored. This could be by ULBs as well as identified local government hospitals, who must be mandated and incentivized to undertake this data collection and identify the worse impacted persons.
- Any worker in a non-attainment city to access PFT in a government clinic or hospital or any affiliated health care

The following should be made available to pregnant and lactating women security guards:

- Check-ups every trimester with focus on monitoring occupational illness and pathways for those impacted.
- Nutrient supplements via government schemes (like the Take Home Ration Scheme) which focus on pregnant and lactating mothers.

- Access to social security, including paid leave during pregnancy to prevent exposure to the fetus.
- Occupational safety must be incentivized and measured, including in the Swachh Sarvekshan and other national protocols.
- Guidelines on exposure prevention and its widespread dissemination

Key to these recommendations is they be practical, sustainable in the long term and scalable. They are organized according to occupational groups below. In all groups, the workers pointed out the need to reduce vehicles on the road, as these create not only particulate matter pollution from vehicle exhaust pipes but also resuspend road dust, thereby increasing pollution levels significantly.

SAFAI KARAMCHARIS

Occupational Health and Safety

The following should be issued and made available to all Safai Karamcharis across ULBs:

- Industry standard Personal Protective eyeglasses to protect the eyes against pollution.
- Masks (N-95) issued every fortnight.
- Training to gargle every night to remove dust particles from the nasal cavity and throat.
- *Gamcha* or cotton cloth to cover the head, face, and nose in addition.
- Awareness on the need for removal of *gamcha* or cotton cloth, footwear and eyeglasses before entering the home.
- Provision of hand and face washing facilities should be mandated near the place of work, such as reporting point, etc.
- Training on effective way to use protective gear and individual action to reduce occupational exposure
- Annual health check-ups focused on monitoring occupational illness with work-rest pathways for those impacted

Protection for pregnant and lactating women

The following should be made available to pregnant and lactating women safai karamcharis:

- Check-ups every trimester with focus on monitoring occupational illness and pathways for those impacted
- Nutrient supplements via government schemes (like the Take Home Ration Scheme) which focus on pregnant and lactating mothers
- Flexible working hours – to prevent exposure when AQI is severe
- Access to washroom and resting places closeby which are open throughout working hours and can be used per need.

Pollution Management

- Delegation of power to sanitary inspectors is essential to report waste burning with concurrent power to issue reprimands and escalate them for fining. This can reduce burning and hence, workers' exposure.

- Use of mechanized sweepers on arterial and larger roads with traffic should be adopted to reduce workers' exposure in highly polluted areas.

Limiting exposure

- Change of work shifts from early morning to later in the day during peak pollution months, including when the AQI is likely to touch hazardous levels must be mandated.
- Where possible, reduction of the frequency of sweeping when AQI touches hazardous levels, along with public communication on the need for this must be ensured.
- Resting places for Safai Karamcharis must be re-designed as above the tail-pipe level of SUVs even if near any road, small or large.
- Shifting safai karamcharis working on arterial roads or landfills and other highly polluted sites frequently to prevent long-term exposure.

Systemic

- Guidelines on occupational health protection to be issued by Pollution Control Boards. ULBs should be mandated to file photographic compliance reports with these guidelines every quarter in non-attainment cities and industrial townships and annually in other cities.
- Localized action is key. Use of drones and other imagery must be adopted to identify garbage burning. Organizations or individuals to be fined per law based on such inputs.
- Provision of mist-spray must be ensured when AQI is 250 or higher to prevent rising dust during work.
- Bioremediation of landfills must be undertaken per the Swachh Bharat Urban.2
- Composting of wet waste should be adopted to prevent landfill fires. Investment in capital costs should be made for decentralized composting with limited buyback at costs sustainable to the waste generators/those undertaking the composting. Chintan recommends a cost price plus 10% as the purchase price. The cost price must include minimum wages of workers, enzymes, water costs, and repair, usually 5% of overall capital costs per annum.
- Improvement in in-situ horticulture waste management to prevent burning should be ensured.
- Increase in e-waste and used tyre collection should be initiated to prevent open burning and increase recycling rates.

SECURITY GUARDS

Occupational Health and Safety

- Masks (N-95) to be issued during peak pollution by companies or individuals hiring them.
- Electric or other heated bottles must be provided, along with access to electricity to reduce wood burning during winter.
- Warm kits with woolen caps, thick socks, warm jackets, plug-in hot water bottles, and more to be provided to combat peak winter temperatures.

- Kiosks should be designed or placed to minimize road dust exposure. These should be closed on the side of the road, but with windows for increased comfort. Use of digital monitoring for security must be increased.
- Kiosks and porta cabins or any covered space for security guards must be provided, apart from thermal heating from hot water bottles or electric heat bottles and blankets. Digital surveillance devices should be optimized.

Protection for pregnant and lactating women

The following should be made available to pregnant and lactating women security guards:

- Check-ups every trimester with focus on monitoring occupational illness and pathways for those impacted
- Nutrient supplements via government schemes (like the Take Home Ration Scheme) which focus on pregnant and lactating mothers. Security agencies may also provide nutritional kits in consultation with a relevant medical practitioner
- Flexible working hours – to prevent exposure when AQI is severe
- Access to washroom and resting places closeby which are open throughout working hours and can be used per need.

Limiting exposure

- Enclosed spaces to sit should be provided. Seating should be engineered at higher than tail-pipe level to reduce exposure.
- Trainings must be conducted for security guards to use electronic devices to monitor better from inside the enclosed seating.
- Rotation in duties from high pollution spots to lower pollution spots to reduce exposure must be mandated.
- Shifting security guards working on arterial roads or landfills and other highly polluted sites frequently to prevent long-term exposure.

Systemic

- Specific focus on security that works on construction sites, schools and lower income areas for procurement of kiosks and electric hot water bottles must be ensured.
- Trainings on dust control for security staff at construction sites must be conducted so they can self-monitor for a safer workplace.
- Pollution Control Boards to pass guidelines on occupational health protection. Volunteers to monitor adherence in light of capacity constraints, along with photographic and written self-reporting on compliance to be filed every quarter.
- Occupational health protection to become part of all air pollution monitoring.
- Any emergency measures to control air pollution must include occupational safety. This includes all stages of GRAP (Graded Rapid Action Plan) for NCR and others as they are formulated.
- Discounts to be provided for kiosks/porta-cabins if purchased by registered Residents or Market Associations for security personnel in non-attainment cities, cities with over

300 AQI recorded for over 30 days in a year and industrial townships. The ULBs may apply to the Urban Development Department of the State for eligibility.

- Swachh Air Survey should include occupational safety for security guards.

WASTEPICKERS

Occupational Health and Safety

The study found that the stereotypical gloves and masks is not the only PPE that this group needs. Wastepickers may also receive PPE kits from funds collected from various environmental fees, cess etc. by the Pollution Control Boards or an equivalent.

The following should be issued and made available to all wastepickers across ULBs.

- Industry standard personal protective eyeglasses to protect the eyes against pollution.
- Masks (N-95) issued every fortnight. RWAs to also issue these, where possible.
- Use of *gamcha* or cotton cloth to cover the head, face and nose in addition to be made mandatory.

Protection for pregnant and lactating women

- Free gas cylinders for all identified wastepickers. Identification can mean with I cards from any ULB, agency or a work contract with a bulk generator.
- Access to washroom and resting places closeby which are open throughout working hours and can be used per need.

Pollution Management

- Workers must be encouraged to report any waste burning to the local Sanitary Inspectors.
- Campaigns and fines to ensure waste is segregated per the law. Doorstep waste collectors to be empowered to pressurize residents for segregated waste. Handling of mixed waste to be minimized.
- Wastepickers to be enabled to shift from segregating dry waste on roadsides or dhalaos to well-organized dry waste collection centres or MRFs.

Limiting exposure

- All segregation spaces and MRFs to be ideally away from main roads, and seating designed to be above tail-pipe level of SUVs.
- All MRFs, or Dry Waste Collection Centres must be well-ventilated.
- MRFs or DWCCs to be designed such that those working there do no hunch over for hyper-segregation.
- Free gas cylinders for wastepickers registered as part of an organization, with work contracts with waste generators or with the ULB. One a month is identified as adequate.

Systemic

- Wastepickers should be empowered to shift to other forms of recycling and circular economy livelihoods, instead of working on landfills. This includes doorstep collection,

composting, running MRFs and upgrading to formally dismantling e-waste under safe working conditions.

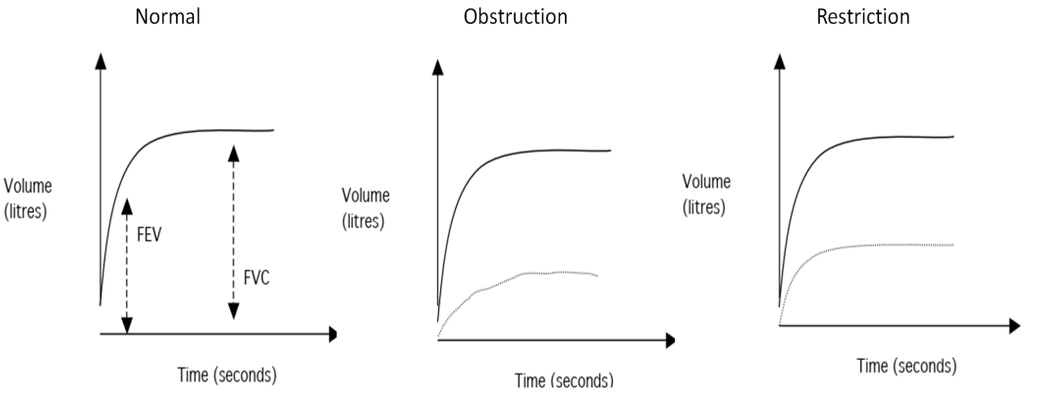
- Wet waste must be composted to prevent landfill fires. Investments need to be made in capital costs for decentralised composting. This needs to be done with limited buy back at costs sustainable to the waste generators/those undertaking the composting. Chintan recommends cost price plus 10% as the purchase price. The cost price must include minimum wages of wastepickers, enzymes, water costs, and repair (usually 5% of overall capital costs per annum).
- In-situ horticulture waste management must be improved to prevent burning. Wastepickers must be involved in executing this.
- The Swachh Bharat Mission must issue guidelines on occupational health protection, syncing it with the Swachh Sarvekshan to create incentives. ULBs must be mandated file photographic compliance reports every quarter in non-attainment cities and industrial townships and annually in other cities.
- Access to healthcare for wastepickers carrying any ID card stating they are wastepickers must be improved. This may be done by identifying hospitals where they can meet specialists and be tested for free. No individual should have to travel more than 10 kilometers.
- Drones and other imagery must be used to identify garbage burning. Organizations or individuals to be fined per law.
- Bioremediation of landfills must be undertaken to prevent fires.

Such recommendations are by no means comprehensive. Rather, they provide a first step in the efforts to prevent exposure of vulnerable workers to air pollution.

ANNEXURE 1:
Details of Pulmonary Function Test

The pulmonary function test (PFT) results were calculated using two parameters: FVC (forced vital capacity), FEV1 (forced expiratory volume in one second), and FEV1/FVC ratios. FVC is defined as the entire volume of air that can be expelled at a maximal forced expiration effort. FEV1 is defined as the volume of air exhaled in the first second after a maximal intake. Furthermore, FEV1/FVC ratios imply the percentage of FVC expired in one second. These three factors were estimated based on the participants' age, gender, body weight, and height. Obstruction and restriction are two significant lung disorders (air going in or out) that can be identified with spirometry tests (Aggarwal et al., 2019). FEV1 and FVC are measurements used to identify signs of blockage and restriction in ventilatory dysfunction (Linares et al., 2010). In general, FEV1 can be used as an indicator for airway resistance and FVC as an indicator for lung capacity. Figure 39 shows the curves for normal, obstructive, and restrictive lung disorders.

Figure 39: *Spirometry curves for normal, obstruction and restriction lung disease*[22].



INTERPRETATION OF PF TEST RESULTS

Global Lung Function Initiative (GLI) calculators[23] were used to interpret the individuals' spirometry results. The GLI network has become the largest resource for reference values for routine lung function testing ever assembled. It is established as a result of international collaboration, and altruism between researchers, clinicians and industry partners[24].

ASSESSMENT OF NORMAL AND ABNORMAL LUNG FUNCTION

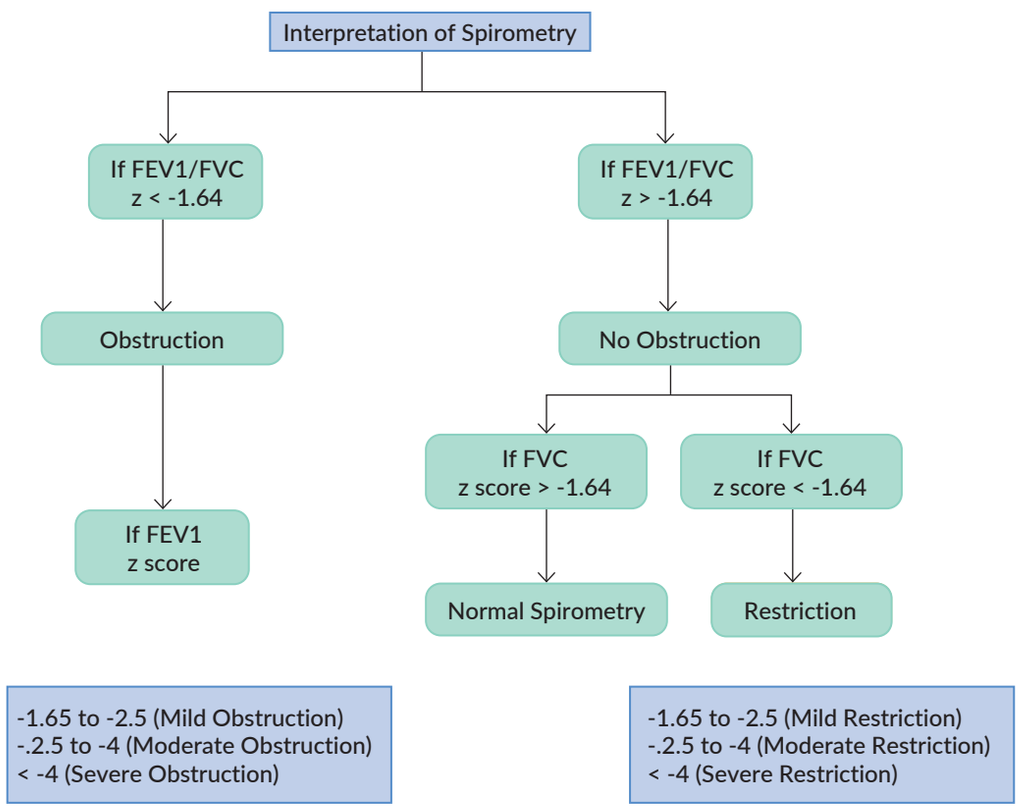
The predicted values for normal lung functioning (FVC and FEV1 predicted) for every individual are calculated based on anthropometric measurements such as gender, age, height, and race. This value represents the lung function of a healthy individual with the same anthropometric measurements. The predicted values were then compared with the recorded (or absolute) values for each participant to obtain their respective lung function results.

Normal findings of spirometry are an FEV1/FVC ratio of greater than 0.70 and both FEV1 and FVC above 80% of the predicted value. Values below the normal range indicate abnormal lung functioning.

ASSESSMENT OF OBSTRUCTION AND RESTRICTION

Using the 2012 GLI equations, Z-scores were calculated for FEV1, FVC, and FEV1/FVC. The respiratory sickness types (obstruction and restriction) and disease severity (mild, moderate, and severe) were then characterized based on the z-scores and the Lower Limit of Normal (LLN). A z-score -1.645 represents the lowest limit of normal LLN. Z-score of FVC and FEV1/FVC less than -1.645 indicates reduced lung capacity[25]. Figure 40 below depicts the interpretation of spirometry results.

Figure 40: *Interpretation of spirometry results based on z-scores of FVC, FEV1 and FEV1/FVC.*



STATISTICAL ANALYSIS

All statistical analyses were performed using Microsoft Excel (Microsoft 365, version 2010). Descriptive statistics were calculated for the on-site questionnaire and PFT results. Binary logistic regression was applied to assess the association of independent determinants with the incidence of respiratory illness for the different groups of study participants.

The association of lung capacities with age and body mass index (BMI) for the studied stakeholders was evaluated. For this, BMI of each participant was calculated by division of body weight (kg) with square of height (m). The anthropometric parameters like body weight and height of each participant were taken during the conduct of the PF test.

Statistical analysis was carried out using three different variables - coefficient (b), standard error (SE) and odd ratios (OR) for the interpretation of the respiratory function results.

Coefficient (b): It is coefficient of logistic regression and describes the relationship (positive or negative) between the taken variable and occurrence of respiratory illness.

Standard Error: It is a measure of uncertainty of the logistic regression coefficient. It is useful for calculating the p-value and the confidence interval for the corresponding coefficient.

Odd Ratio: It is calculated by the exponential function of logistic regression coefficient.

ANNEXURE 2:
Socio-demographic characteristics

Table 14 lists the comparative summary of socio-demographic characteristics and lifestyle & surroundings for vulnerable communities and control groups.

Table 14: *Comparison of demographic parameters for all groups.*

Sr. No.	Characteristics	Waste Pickers (n=100)	Safai Karamcharis (n=100)	Security Guards (n=100)	Control Groups (n=100)
1	**Sex**				
	Male	45	57	94	63
	Female	55	43	6	37
2	Age (Years)				
	18-45	83	51	66	87
	46-60 or above	17	49	34	13
3	**Educational status**				
	No education	41	42	-	-
	1 – 8	45	42	3	3
	8 – 12 or above	14	16	97	97
4	**BMI**				
	Normal (< 25 kg/m2)	74	47	44	56
	Overweight (25-29.9 kg/m2)	20	35	47	31
	Obese (>30 kg/m2)	6	18	9	13
5	**Smoking status**				
	Smoker	17	12	16	-
	Non-smoker	83	88	84	100
6	**Passive smoking at home or workplace**				
	Yes	24	8	6	-
	No	76	92	94	100
7	**Cooking fuel**				
	Wood/Dung cake	84	8	11	-
	LPG	16	92	89	100
8	**No of dependents**				
	No	2	-	-	15
	1-4	54	55	55	55
	>4	44	45	45	30

ANNEXURE 3:
Results of binary logistic regression

The detailed results of binary logistic regression for safai karamcharis is shown below.

Table 15: *Odd ratios and standard errors of questionnaire based respiratory outcomes safai karamcharis.*

	coeff b	Standard Error	Odd ratio
Gender	**1.80**	**0.84**	**6.07**
Smoking	-0.40	0.86	0.67
Smoker in Family	**0.29**	**1.37**	**1.34**
Education	**-0.42**	**0.66**	**0.66**
Family size	**0.57**	**0.93**	**1.77**
Exposed to air pollution	-19.95	19990.06	0.00
Working hours (during/after)	-0.19	0.64	0.83

The detailed results of binary logistic regression for security guards is shown below.

Table 16: *Odd ratios and standard error of questionnaire based respiratory outcomes security guards.*

	coeff b	Standard Error	Odd ratio
Smoking	**0.28**	**0.83**	**1.33**
Smoker in Family	-0.31	1.22	0.73
Education	0.95	0.66	2.58
Family size	**0.61**	**0.88**	**1.8**
Exposed to air pollution	**0.25**	**0.50**	**1.28**

The detailed results of binary logistic regression for wastepickers is shown below.

Table 17: *Odd ratios and standard error of questionnaire based respiratory outcomes wastepickers.*

	Coeff b	Standard Error	Odd ratio
Gender	1.38	0.60	3.97
Smoking habit	0.43	0.61	1.54
Smoker in family	-0.30	0.74	0.74
Education	-0.18	0.69	0.83
Family size	0.69	0.83	2.00
Exposed to air pollution	0.95	0.89	2.59
Working hours (during/after)	0.11	0.52	1.12

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