

RESEARCH ARTICLE

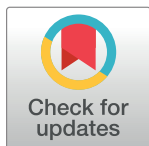
Prevalence and associated factors of acute respiratory infection among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia: A comparative cross-sectional study

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Abstract

Background

Acute respiratory infections are rising in developing countries including Ethiopia. Lack of evidence for the prevalence and associated factors of acute respiratory infection among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia is a challenge for the implementation of appropriate measures to control acute respiratory infection. Thus, this study was designed to address the gaps.

Methods

A comparative cross-sectional study was conducted among 84 door-to-door waste collectors and 84 street sweepers from March to May 2018. A simple random sampling technique was used to select study participants. Data were collected by trained data collectors using a pretested structured questionnaire and on-the-spot direct observation checklist. Data were analyzed using three different binary logistic regression models at 95% confidence interval (CI): the first model (Model I) was used to identify factors associated with acute respiratory infection among street sweepers, whereas the second model (Model II) was used to identify factors associated with acute respiratory infection among door-to-door waste collectors, and the third model (Model III) was used for pooled analysis to identify factors associated with

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Abbreviations: AOR, Adjusted Odds Ratio; ARI, Acute Respiratory Infection; CI, Confidence Interval; COR, Crude Odds Ratio; PPE, Personal Protective Equipment.

acute respiratory infection among both street sweepers and door-to-door waste collectors. From each model multivariable logistic regression, variables with a p -value <0.05 were taken as factors significantly associated with acute respiratory infection.

Results

The overall prevalence of acute respiratory infection among studied population was 42.85% with 95% CI (35.1, 50.0%). The prevalence of acute respiratory infection among street sweepers was 48.80% (95% CI: 37.3, 64.8%) and among door-to-door waste collectors was 36.90% (95% CI: 27.4, 46.4%). There was no statistically significant difference between the prevalence of acute respiratory infection among the two groups due to the overlapping of the 95% CI. Among the street sweepers, we found that factors significantly associated with acute respiratory infection were not cleaning personal protective equipment after use (adjusted odds ratio [AOR]: 2.40; 95% CI: 1.15, 5.51) and use of coal/wood for cooking (AOR: 3.95; 95% CI: 1.52, 7.89), whereas among door-to-door waste collectors, were not using a nose/mouth mask while on duty (AOR: 5.57; 95% CI: 1.39, 9.32) and not receiving health and safety training (AOR: 3.82; 95% CI: 1.14–7.03) were factors significantly associated with acute respiratory infection among door-to-door-waste collectors. From the pooled analysis, we found that not using a nose/mouth mask while on duty (AOR: 2.19; 95% CI: 1.16, 4.53) and using coal/wood for cooking (AOR: 2.74; 95% CI: 1.18, 6.95) were factors significantly associated with acute respiratory infection for both street sweepers and door-to-door waste collectors.

Conclusion

The prevalence of acute respiratory infection among street sweepers and door-to-door waste collectors has no statistically significant difference. For both groups, not using a nose/mouth mask while on duty and using coal/wood for cooking fuel factors associated with acute respiratory infection. The municipality should motivate and monitor workers use of personal protective equipment including masks and gloves. Workers should use a nose/mouth mask while on duty and should choose a clean energy source for cooking at home.

Background

Acute respiratory infections (ARIs), which are caused by viruses and bacteria that affect the upper and lower respiratory tract, are a leading cause of morbidity and mortality globally, accounting for approximately 5.8 million deaths worldwide in 2010 [1]. Acute respiratory tract illnesses are the most frequent illnesses in humans and are an important cause of disability and days lost from school or work [2, 3].

Industrialized countries have significantly reduced occupational health impacts on street sweepers and waste collectors by applying standardized waste management processes including regular use of closed containers for waste collection [4]. In developing countries, waste that is put out for collection is rarely stored in closed containers. Rather, it is dumped in the open or left in an open carton or basket, requiring it to be picked up by hand. Therefore, workers in developing countries will have more direct contact with solid waste than their counterparts in developed countries [5].

Bioaerosols liberated from waste and compost may contain bacteria, spore forms of bacteria and fungi [6, 7]. Exposure to bioaerosols is associated with health effects such as respiratory

symptoms and influenza-like symptoms [8]. Different studies have identified age, educational status, type of home cooking fuel used, prolonged duration of working hours and employment, past medical history, use of face mask as factors having an association with ARI and respiratory symptoms [9–16]. Many studies have been conducted on the prevalence of and associated factors for ARI, but the majority of the studies have been restricted to children [13, 17–22] and so ARI data related to other age groups are limited.

In this study, the primary target population was door-to-door solid waste collectors, whose health is affected by manual sorting of waste before it is disposed of at solid waste disposal sites, and street sweepers, who inhale dust swept up by their manual brooms, which aggravates respiratory problems. The prevalence of and associated factors for ARI in street sweepers and door-to-door waste collectors remain poorly understood. It is therefore vital in this study to identify the prevalence of ARI and associated factors among door-to-door waste collectors and street sweepers in Dessie City, Ethiopia.

Materials and methods

Study area, study design and participants

An institution-based comparative cross-sectional study was conducted during March to May 2018 in Dessie City. Dessie City is located 401 km northeast of the capital city of Addis Ababa on the high plateau in Amhara regional state, South Wollo zone.

The city sanitation, beautification and parks development department runs the solid waste management activities of the town. The solid waste management includes door-to-door waste collection and transport to the disposal site. There are 485 door-to-door waste collectors working under ten micro-enterprises and 100 street sweepers working under ten micro-enterprises recruited by the municipality to undertake this activity. Door-to-door solid waste collectors and street sweepers employed by Dessie City municipality were the source population from which the study population was systematically selected.

Sample size and sampling procedure

The sample size was determined using double proportion population formula

$$(Z_{\alpha/2} + Z_{\beta})^2 * [P_1(1-P_1) + P_2(1-P_2)] / (P_1 - P_2)^2$$

where:

- $Z_{\alpha/2}$ is the critical value of the normal distribution at $\alpha/2$ (for a confidence level of 95%, α is 0.05 and the critical value is 1.96)
- Z_{β} is the critical value of the normal distribution at β (for a power of 80%, β is 0.2 and the critical value is 0.84).
- P_1 is the prevalence of respiratory symptoms among street sweepers 0.689 [10].
- P_2 is the prevalence of respiratory symptoms among door-to-door waste collectors 0.5 considering 50% prevalence.

$$n = \frac{(1.96 + 0.84)^2 * (0.69(1 - 0.69) + 0.5(1 - 0.5))}{(0.69 - 0.5)^2} = 75.62 \sim 76$$

By considering 10% non-response rate, which is 8, then the sample size for each group was 84; finally; the overall total sample size of the study for the two groups was 168.

There were ten door-to-door waste collecting micro-and small-scale enterprises and ten street sweeping micro-and small-scale enterprises. For both street sweepers and door-to-door waste collectors, proportional allocation of sample size was employed among ten micro enterprises working on waste collection and then simple random sampling technique was used to select study participants. Finally, 168 participants were selected using simple random sampling technique (84 street sweepers and 84 door-to-door waste collectors) (Figs 1 and 2).

Study variables

The dependent variable of this study was the presence or absence of acute respiratory infection (ARI), whereas the independent variables included socio-demographic factors, behavioral factors, housing condition, occupational and environmental factors, institutional factors, and history of past medical illness. Presence of ARI was defined by the study participant having suffered from any ARI symptoms: a cough, fever, sore throat, chest tightness, shortness of breath (wheezing or difficulty in breathing) in the preceding two weeks before the interview [14].

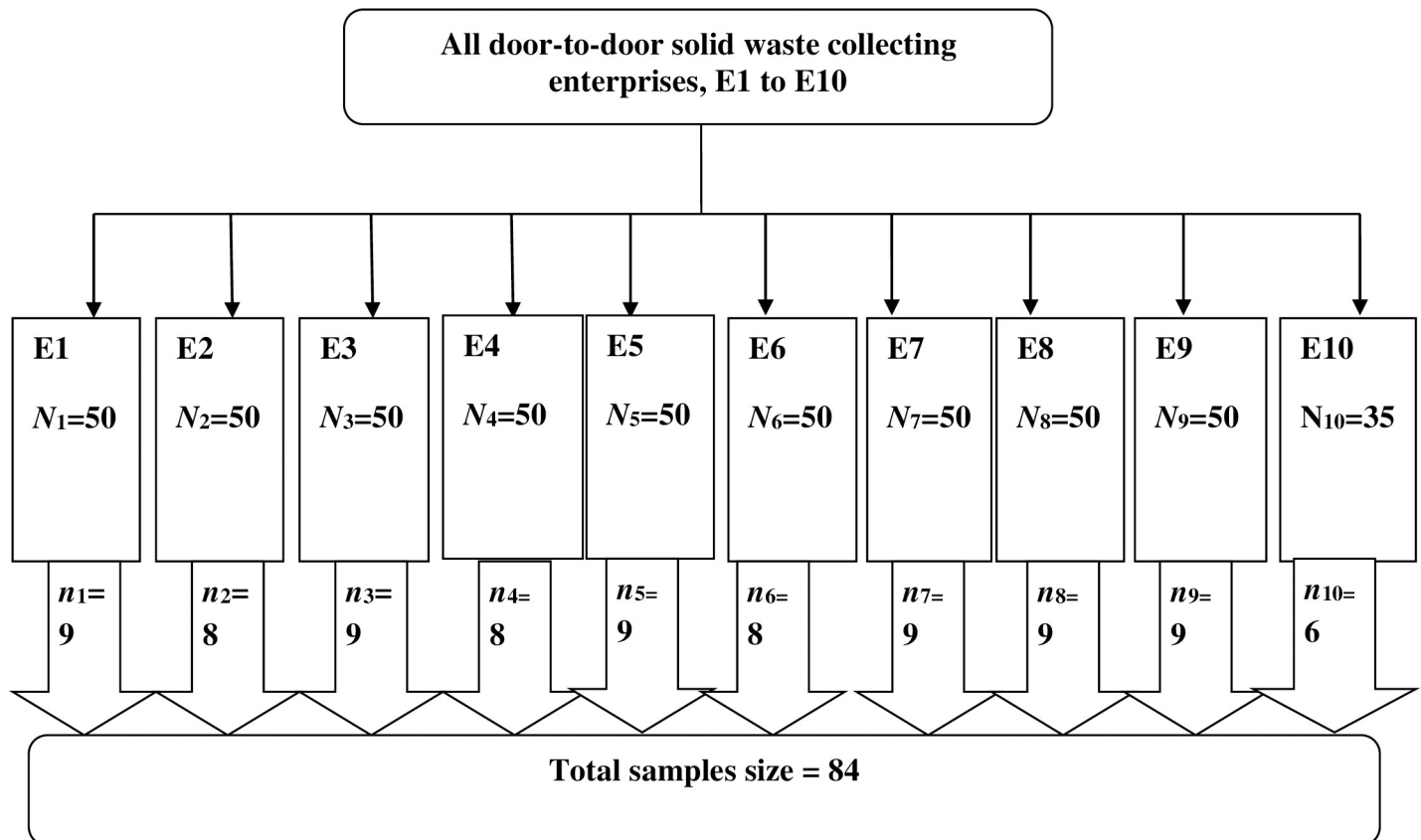
Data collection

Data were collected using face-to-face interviewer-administered questionnaire and an on-the-spot observation checklist for utilization of PPE and at home housing conditions. The questionnaire was first prepared in English, translated to Amharic and then re-translated back to English to keep consistency. The questionnaire consisted of 6 parts. Part I included questions about socio-demographic data, Part II about behavioral factors, Part III about occupational and environmental factors, Part IV about institutional factors, part V about past medical illness and Part VI about the presence of any ARI symptoms in the preceding two weeks.

Four data collectors and two supervisors, who had a BSc degree in environmental health were involved in the survey. They were given two days' training about data collection tools, the procedures to take written informed consent and other ethical issues. A pretest was done outside of the selected area using a number of people equal to 10% of study participants. Then the questionnaire amendment was done for its consistency based on the findings of the pretest before the actual data collection commenced. The supervisors regularly monitored data collectors. The completeness and consistency of the questionnaires was checked daily during data collection.

Data analysis

Data were entered into EpiData version 3.1 and exported to SPSS version 24.0 for data cleaning and analysis. During data analysis, mean and standard deviation (SD) (mean \pm SD) were calculated for continuous variables, whereas descriptive statistics of frequencies (n) and percentage (%) were conducted for categorical variables. Using the outcome variable of presence of ARI among street sweepers and door-to-door waste collectors, we estimated the prevalence of ARI separately for each groups. To examine whether there was a significant difference or no difference in the prevalence ARI among street sweepers and door-to-door-waste collectors, we estimated the 95% CI of the prevalence of ARI for the two groups by bootstrap using SPSS version 24.0. When there was overlapping of the 95% CI, we concluded that there was no significant difference of prevalence of ARI between street sweepers and door-to-door-waste collectors, whereas if there was no overlapping of the 95% CI of the prevalence of ARI among the two groups, we concluded there was a significant difference of the prevalence of ARI between them.

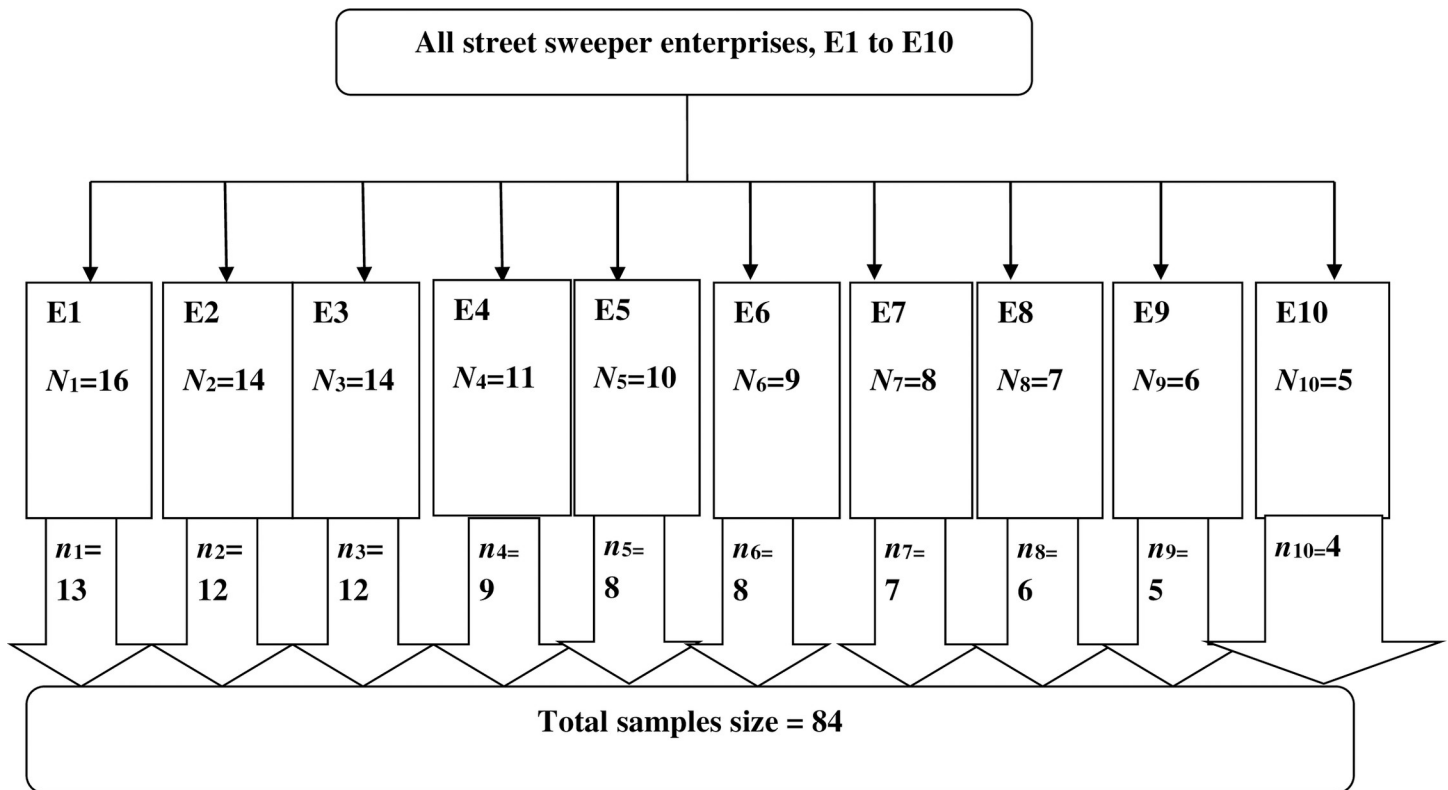
**Key:**

- E1, E2, E3, etc. = Enterprise One (E1), Enterprise Two (E2), Enterprise Three (E3) and so on to Enterprise Ten.
- N_1, N_2, N_3 , etc. = Number of study population in each enterprise from Enterprise One to Enterprise Ten.
- n_1, n_2, n_3, \dots = Proportional allocated sample size from study population in Enterprise One to Enterprise Ten.

Fig 1. Proportional allocation of sample size among enterprises of door-to-door waste collectors in Dessie City, Ethiopia, March to May 2018.

<https://doi.org/10.1371/journal.pone.0251621.g001>

Data were analyzed using three different binary logistic regression models at 95% CI: the first model (Model I) was used to identify factors associated with ARI among street sweepers, the second model (Model II) was used to identify factors associated with ARI among door-to-door waste collectors, and the third model (Model III) was used for pooled (combined) analysis

**Key:**

- E1, E2, E3, etc. = Enterprise One (E1), Enterprise Two (E2), Enterprise Three (E3) and so on to Enterprise Ten.
- N_1, N_2, N_3 , etc. = Number of study population in each enterprise from Enterprise One to Enterprise Ten.
- n_1, n_2, n_3, \dots = Proportional allocated sample size from study population in Enterprise One to Enterprise Ten.

Fig 2. Proportional allocation of sample size among enterprises of street sweepers in Dessie City, Ethiopia, March to May 2018.

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to identify factors associated with ARI among both street sweepers and door-to-door waste collectors. For each model, bi-variable and multivariable analysis were estimated and variables with $p < 0.25$ in bi-variable logistic regression were transferred to each adjusted model for street sweepers and door-to-door waste collectors, as well as to the pooled analysis. Finally, variables with p -value < 0.05 from Model I (street sweepers), Model II (door-to-door waste collectors) and Model III (pooled analysis) of the multivariable logistic regression were taken as factors significantly associated with ARI, respectively. Potential confounders for the three models were controlled by the adjusted analysis during multivariable logistic regression analysis.

Multi-collinearity test was carried out using standard error (SE) to see the correlation between independent variables. There was no multi-collinearity and values were 1.85, which is in the ranges of $-2 < SE < 2$. The Hosmer Lemeshow goodness-of-fit test [23] with p -value greater than 0.05 was used to check the fitness of the model; the p -value of each Model I, Model II and Model III was 0.931, 0.857 and 0.890, respectively.

Ethics approval and consent to participate

Ethical clearance was obtained from Ethical Review Committee of College of Medicine and Health Sciences, Wollo University. Before conducting the survey, a supportive letter from Wollo University's Department of Environmental Health was written to the Dessie City Health Bureau and Dessie City municipality, which in turn secured permission to conduct the study. Informed written consent was obtained from the study participants after they were given information about the aim of the study. Study participants were assured that their information would not be used for purposes other than scientific research, that participation was voluntary and that they could withdraw from the interview at any time for whatever reason. Study participants who had ARI symptoms at the time of data collection were linked to the nearest health facility for treatment. Data were gathered anonymously without recording the names and any other identifiers of the study participant to keep confidentiality of the study.

Result

Characteristics of street sweepers and door-to-door waste collectors

Data were collected and analyzed from 84 street sweepers and 84 door-to-door waste collectors, with 100 percent response rate. The sex frequency distribution in street sweepers was male 11 (13.1%), female 73 (86.9%) and in door-to-door waste collectors was male 28 (33.3%), female 56 (66.7%). Study subjects' age range was 20–61 years. Most (91.7%) of the street sweepers and three-fourths (76.2%) of door-to-door waste collectors had a monthly income less than 27 \$ USD. Among street sweepers, 22 (26.2%) had completed primary school or above, whereas 47 (56.0%) of them could not read and write (Table 1).

Occupational and environmental factors

All study participants of both group worked 8 hours per day. Two street sweepers and 22 (26.2%) door-to-door waste collectors worked more than 48 hours per week. Among street sweepers who had worked for more than 5 years 25 (48.1%) had ARI. Of the 4 street sweepers who had past exposure to gas or chemical fumes, 2 had ARI. Only one door-to-door waste collector had past exposure to gas/chemical fumes and that participant had ARI. Of all study participants, 6 street sweepers and 8 door-to-door waste collectors had exposure to another dusty job. The number of participants with less than 5 years' work experience among street sweepers was 32 (38.0%) and among door-to-door waste collectors 77 (91.7%).

Institutional factors

For neither category of study subjects was there a shower facility provided by the municipality. Of the study participants, masks that covered their mouths were worn by 67 (79.8%) street sweepers and 58 (69.0%) door-to-door waste collectors. The number of participants who had gloves was 67 (79.8%) among street sweepers and 74 (88.1%) among door-to-door waste collectors (Fig 3). Data on the utilization of PPE while on duty at the time of data collection showed 50 (59.5%) street sweepers and 49 (58.3%) door-to-door waste collectors used a mask; and 55 (65.5%) street sweepers and 68 (81.0%) door-to-door waste collectors used gloves (Fig 4).

Table 1. Socio-demographic characteristics among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia, March to May 2018.

Variable	Category	ARI among street sweepers (N = 84)		ARI door-to-door waste collectors (N = 84)	
		Yes	No	Yes	No
		n (%)	n (%)	n (%)	n (%)
Sex	Male	3 (27.3)	8 (72.7)	11 (39.3)	17 (60.7)
	Female	38 (52.1)	35 (47.9)	20 (35.7)	36 (64.3)
Age (years)	18–35	18 (52.9)	16 (47.1)	22 (36.7)	38 (63.3)
	36–45	20 (57.1)	15 (42.9)	6 (31.6)	13 (68.4)
	46–61	3(20.0)	12(80.0)	3 (60.0)	2 (40.0)
Marital status	Single	7 (50.0)	7 (50.0)	10 (38.5)	16 (61.5)
	Married	20 (60.6)	13 (39.4)	11 (32.4)	23 (67.6)
	Separated	12 (42.9)	16 (57.1)	9 (45.0)	11 (55.0)
	Widowed	2 (22.2)	7 (77.8)	1 (25.0)	3 (75.0)
Educational status	Cannot read and write	18 (38.3)	29 (61.7)	18 (41.9)	25 (58.1)
	Can read and write	6 (40.0)	9 (60.0)	5 (41.7)	7 (58.3)
	Primary school or above	17 (77.3)	5(22.2)	8 (27.6)	21 (72.4)
Family size (persons)	≤2	4 (57.1)	3 (42.9)	9 (25.7)	26 (74.3)
	3–4	23 (55.1)	28 (54.9)	17 (43.6)	22 (56.4)
	≥ 5	14 (53.8)	12 (46.2)	5 (50.0)	5 (50.0)
Monthly income (\$ USD)*	≤ \$27	37 (48.1)	40 (51.9)	23 (35.9)	41 (64.1)
	> \$27	4 (57.1)	3 (42.9)	8 (40.0)	12 (60.0)

*\$1 United States Dollars equal to 29 Ethiopian Birr (ETB) during March to May 2018.

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Of all study participants who were given health and safety training, 55 (65.4%) street sweepers and 56 (66.7%) door-to-door waste collectors had been trained within the month previous to the time of data collection time; only 4 street sweepers and 4 door-to-door waste collectors had received pre-employment training. Of all study participants, 38 (45.2%) street sweepers and 58 (69.0%) door-to-door waste collectors did not clean their PPE after using them. Of those street sweepers who didn't clean PPE after use, 22 (57.9%) had ARI and of the similar category of waste collectors, 25 (43.1%) had ARI (Table 2).

Housing conditions

There were 6 door-to-door waste collectors who were homeless. There were only 3 street sweepers and 1 door-to-door waste collector whose houses were built of cement. Study participants who had a cigarette smoker in their house included 7 street sweepers and 5 door-to-door waste collectors. Only 8 street sweepers and 3 door-to-door waste collectors had a chicken or farm animal in their house. Study participants who used coal/wood for cooking and also had ARI included 35 (54.7%) street sweepers and 24 (37.5%) door-to-door waste collectors (Table 3).

Behavioral factors

All participant street sweepers had never smoked cigarettes while 5 door-to-door waste collectors had ever smoked cigarettes. Of those door-to-door waste collectors who smoked cigarettes, 3 had ARI. Among street sweepers, only 2 had always chewed chat and both of them had ARI. Among door-to-door waste collectors, 11 had always chewed chat, of whom 6 had ARI. Participants who had always drunk alcohol included 3 street sweepers and 7 door-to-door waste collectors.

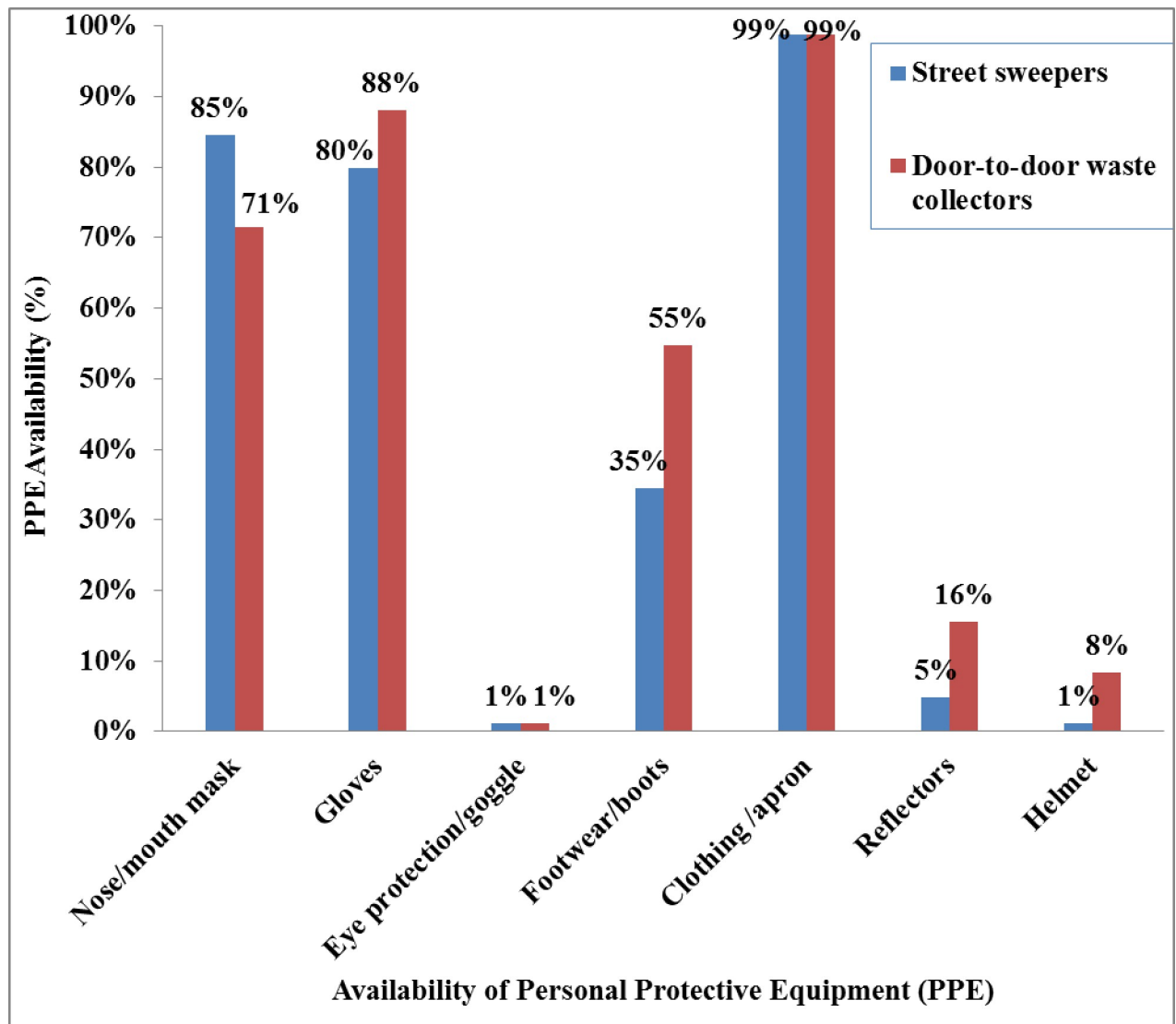


Fig 3. Availability of personal protective equipment among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia, March to May 2018.

<https://doi.org/10.1371/journal.pone.0251621.g003>

Past respiratory diseases history

This study showed that, among street sweepers, reports of a history of respiratory disease included bronchitis (1 person), asthma (6 persons), and pulmonary TB (4 four persons) and 2 reports of history of heart attack; while similar reports among door-to-door waste collectors included emphysema (1 person), asthma (3 persons), pulmonary TB (2 persons), pneumonia (4 persons), sinus problems (1 person) and 3 reports of history of heart attack (Table 4).

Prevalence and symptoms of ARI among street sweepers and door-to-door waste collectors

The prevalence of ARI among street sweepers was 48.8% with 95% CI (37.3, 64.8%) and among door-to-door waste collectors 36.9% with 95% CI (27.4, 46.4%). The overall prevalence of ARI among the studied population was 42.85% with 95% CI (35.1, 50.0%). The 95% CI

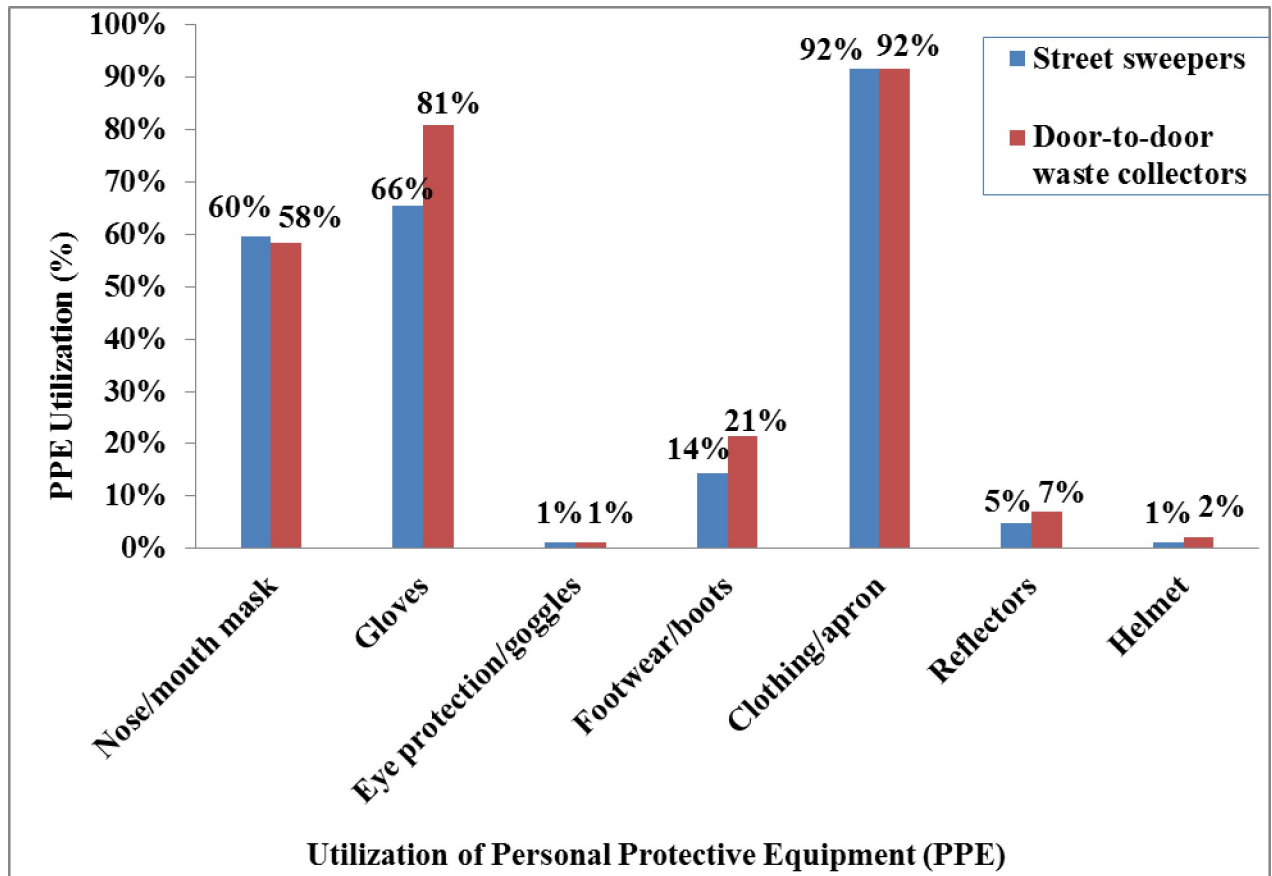


Fig 4. Utilization of personal protective equipment among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia, March to May 2018.

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prevalence of ARI among street sweepers and door-to-door waste collectors was overlapping, which indicated that there was no statistically significant difference in ARI between the two groups (Fig 5). The presence of fever was found in 28 (33.3%) among street sweepers and 16 (19.0%) door-door waste collectors. The prevalence of chest tightness among street sweepers

Table 2. Cleaning personal protective equipment (PPE), taking shower after work and training among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia March to May 2018.

Variable	Category	ARI among street sweepers (N = 84)		ARI among door-to-door waste collectors (N = 84)	
		Yes	No	Yes	No
		n (%)	n (%)	n (%)	n (%)
Takes shower after work	No	22 (51.2)	21 (48.8)	21 (35.7)	25 (54.3)
	Yes	19 (36.3)	22 (53.7)	10 (36.3)	28 (73.7)
Cleans PPE after using it	No	22 (57.9)	16 (42.1)	25 (43.1)	33 (56.9)
	Yes	19 (41.3)	27 (58.7)	6 (23.1)	20 (76.9)
Health and safety training received	No	12 (41.4)	17 (58.6)	12 (60.0)	8 (40.0)
	Yes	29 (52.7)	26 (47.3)	19 (29.7)	45 (70.3)
Who gave training	Health professionals	19 (48.9)	21 (52.5)	13 (24.5)	40 (75.5)
	Our boss	10 (66.7)	5 (33.3)	6 (54.5)	5 (45.5)

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Table 3. Housing conditions among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia March to May 2018.

Variable	ARI among street sweepers (N = 84)		ARI among door-to-door waste collectors (N = 84)	
	Yes	No	Yes	No
	n (%)	n (%)	n (%)	n (%)
Fuel used at home	6 (37.5)	14(62.5)	4 (28.6)	10 (71.4)
	35 (54.7)	29 (45.3)	24 (37.5)	40 (62.5)
Floor material	5 (50.0)	5 (50.0)	3 (42.8)	4 (57.1)
	36 (48.6)	38 (51.4)	25 (35.1)	46 (64.8)
Kitchen location	34 (48.6)	36 (51.4)	25 (37.3)	42 (62.7)
	7 (50.0)	7 (50.0)	3 (27.3)	8 (72.7)
Bedroom window	21 (53.8)	18 (46.2)	17 (37.8)	28 (62.2)
	20 (54.4)	25 (55.6)	11 (33.7)	22 (66.7)
Pets (dog or cat) in house	31 (48.4)	33 (51.6)	7 (37.7)	43 (62.3)
	10 (50.0)	10 (50.0)	2 (23.2)	26 (77.8)
Persons per room	11 (52.4)	10 (47.6)	9 (25.7)	26 (74.3)
	30 (47.6)	33 (52.4)	19 (44.2)	24 (55.8)

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was 15 (17.9%), twice as high as among door-to-door waste collectors 7 (8.3%). The prevalence of cough among street sweepers was 18 (21.4%) and among door-to-door waste collectors 16 (19.0%) (Table 5).

Factors associated with ARI among street sweepers

From the multivariable analysis of data about street sweepers only, we found that street sweepers who had not cleaned PPE after use were more likely to develop ARI (AOR: 2.40; 95% CI: 1.15, 5.51) than those who cleaned PPE after use. Furthermore, we also found that those street sweepers who used coal/wood for cooking were more likely to develop ARI (AOR: 3.95; 95% CI: 1.52, 7.89) than those who used electricity for cooking (Table 6).

Factors associated with ARI among door-to-door waste collectors

From the multivariable analysis of using data about door-to-door waste collectors only, we found that door-to-door waste collectors who did not use a nose/mouth mask while on duty were more likely to have ARI (AOR: 5.57; 95% CI: 1.39, 9.32) than those who used a nose/mouth mask. Door-to-door waste collectors, who had not received training about health and

Table 4. History of past respiratory disease among street sweepers and door-to-door waste collectors in Dessie City, March to May 2018.

Past history of respiratory disease	Street sweepers (N = 84)	Door-to-door waste collectors (N = 84)
	N	n
Bronchitis	1	0
Asthma	6	3
Pulmonary TB	4	2
Heart attack	4	3
Emphysema	0	1
Pneumonia	0	4
Sinus problems	0	1

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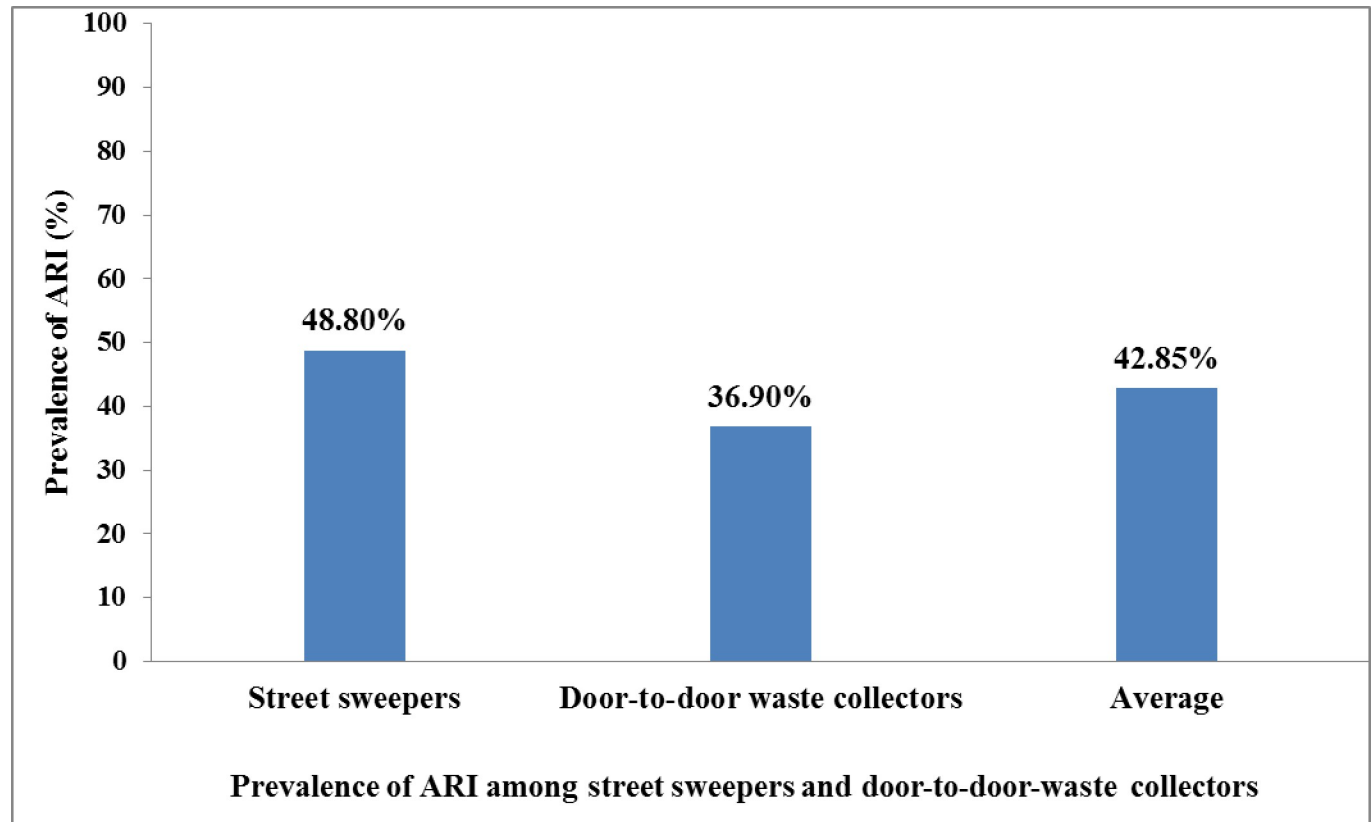


Fig 5. Prevalence of acute respiratory infection among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia, March to May 2018.

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safety were more likely to develop ARI (AOR: 3.82; 95% CI: 1.14–7.03) than those who had received training about health and safety (Table 7).

Factors associated with ARI among both street sweepers and door-to door waste collectors from pooled multivariable analysis

From the pooled analysis of both street sweepers and door-to-door waste collectors, we found that not using a nose/mouth mask while on duty and using coal/wood for home cooking were statistically associated with ARI for both street sweepers and door-to-door waste collectors.

Table 5. Symptoms of ARI among street sweepers and door-to-door waste collectors in Dessie city, Ethiopia, March to May 2018.

ARI symptoms*	Street sweepers (N = 84)	Door-to-door waste collectors (N = 84)
	n (%)	n (%)
Runny nose	26 (31.0)	20 (23.8)
Cough	18 (21.4)	16 (19.0)
Fever	28 (33.3)	16 (19.0)
Sore throat	21 (25.0)	20 (23.8)
Chest tightness	15 (17.9)	7 (8.3)
Wheezing	16 (19)	4 (4.8)

*Study participants may have more than one symptom.

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Table 6. Factors associated with ARI among street sweepers from multivariable logistic regression analysis in Dessie City, Ethiopia, March to May 2018.

Variable	Category	Frequency <i>n</i> (%)	Model I: Street sweepers			
			ARI		COR (95% CI)	AOR (95% CI)
			Yes <i>n</i>	No <i>n</i>		
Sex	Female	73 (86.9)	38	35	2.90 (0.71, 11.79)	7.68 (0.48, 23.46)
	Male	11 (13.1)	3	8	1	1
Age (years)	18–35	34 (40.5)	18	16	1	1
	36–45	35 (41.7)	20	15	1.19 (0.46, 3.06)	3.14 (0.60, 16.40)
	46–61	15 (17.8)	3	12	0.22 (0.05, 0.93)	0.11 (0.01, 2.01)
Educational status	Cannot read and write	47 (56.0)	18	29	0.18 (0.06, 0.58)	0.16 (0.02, 1.09)
	Can read and write	15 (17.8)	6	9	0.20 (0.05, 0.82)	0.64 (0.051, 7.57)
	Primary school or above	22(26.2)	17	5	1	1
Takes shower after work	No	43 (51.2)	22	21	1.21 (0.52, 2.86)	0.18 (0.02, 1.66)
	Yes	41 (48.8)	19	22	1	1
Cleaning PPE after use	No	38 (45.2)	22	16	1.95 (0.98, 4.67)	2.40 (1.15, 5.51)
	Yes	46 (54.8)	19	27	1	1
Home used energy	Coal(wood)	64 (76.2)	35	29	2.92 (1.96, 8.26)	3.95 (1.52, 7.98)
	Electricity	16 (23.8)	6	10	1	1

1, reference category.

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Street sweepers and door-to-door waste collectors who did not use a nose/mouth mask while on duty were more likely to have ARI (AOR: 2.19; 95% CI: 1.16, 4.53) than those who used a nose/mouth mask. Those street sweepers and door-to-door waste collectors who used coal/wood for cooking were more likely to have ARI (AOR: 2.74; 95% CI: 1.18, 6.95) than those who used electricity for cooking (Table 8).

Table 7. Factors associated with ARI among door-to-door waste collectors from multivariable logistic regression analysis in Dessie City, Ethiopia, March to May 2018.

Variable	Category	Frequency <i>n</i> (%)	Model II: Door -to-door waste collectors			
			ARI		COR (95% CI)	AOR (95% CI)
			Yes <i>n</i>	No <i>n</i>		
Family size (persons)	≤ 2	35 (41.7)	9	26	1	1
	3–4	39 (46.4)	17	22	2.23 (0.83, 5.99)	2.08 (0.67, 6.46)
	≥ 5	10 (11.9)	5	5	2.89 (0.68, 12.35)	4.50 (0.84, 24.07)
Has nose/mouth masks	No	26 (31.0)	12	14	1.76 (0.68, 4.53)	0.32 (0.07, 1.43)
	Yes	58 (69.0)	19	39	1	1
Uses nose/mouth mask	No	35 (41.7)	20	15	4.61 (1.79, 11.89)	5.57 (1.39, 9.32)
	Yes	49 (58.3)	11	38	1	1
Takes shower after work	No	46 (54.8)	21	25	2.35 (0.93, 5.94)	1.67 (0.57, 4.92)
	Yes	38 (45.2)	10	28	1	1
Cleans PPE after use	No	58 (69.0)	25	33	2.53 (0.88, 7.22)	1.23 (0.36, 4.24)
	Yes	26 (31.0)	6	20	1	1
Received health and safety training	No	20 (23.8)	12	8	3.55 (1.25, 10.08)	3.82 (1.14, 7.03)
	Yes	64 (76.2)	19	45	1	1

1, reference category.

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Table 8. Factors associated with ARI among both street sweepers and door-to-door waste collectors from pooled analysis of the multivariable logistic regression analysis in Dessie City, Ethiopia, March to May 2018.

Variable	Category	Model III: Pooled analysis (combined)			
		ARI		COR (95% CI)	AOR (95% CI)
		Yes	No		
		<i>n</i>	<i>n</i>		
Occupation	Street sweepers	41 (48.8)	43 (51.2)	1.63 (0.88, 3.02)	1.44 (0.59, 3.50)
	Door-to-door waste collectors	31 (36.9)	53 (63.1)		
Family size (persons)	≤ 2	13 (31.0)	29 (69.0)	1	1
	3–4	40 (44.4)	50 (55.6)	1.79 (0.82, 3.88)	2.48 (0.66, 9.33)
	≥ 5	19 (52.8)	17 (47.2)	2.49 (0.99, 6.29)	3.74 (0.84, 16.70)
Working hour per week	> 48	7 (29.2)	17 (70.8)	0.50 (0.20, 1.28)	0.46 (0.15, 1.42)
	≤ 48	65 (45.1)	79 (54.9)	1	1
Duration of occupation (years)	≤ 5	43 (39.4)	66 (60.6)	1	1
	> 5	29 (49.2)	30 (50.8)	1.48 (0.78, 2.81)	1.10 (0.47, 2.55)
Uses nose/mouth mask	No	38 (55.1)	31 (44.9)	2.34 (1.25, 4.40)	2.19 (1.16, 4.53)
	Yes	34 (34.3)	65 (65.9)	1	1
Takes shower after work	No	43 (48.9)	45 (51.1)	1.68 (0.91, 3.12)	1.13 (0.52, 2.47)
	Yes	29 (36.3)	51 (63.8)	1	1
Cleans PPE after use	No	47 (49.0)	49 (51.0)	1.80 (0.96, 3.38)	1.81 (0.82, 3.99)
	Yes	25 (34.7)	47 (65.3)	1	1
Chews chat	Yes	8 (61.5)	5 (38.5)	2.28 (0.71, 7.27)	1.70 (0.36, 7.96)
	No	64 (41.3)	91 (58.7)	1	1
Type of fuel used at home	Coal (wood)	59 (46.1)	69 (53.9)	2.05 (1.41, 4.64)	2.74 (1.18, 6.95)
	Electricity	10 (29.4)	24 (70.6)	1	1
Ratio of number of persons per room	1–2.4	20 (35.7)	36 (64.3)	1	1
	≥ 2.5	49 (46.2)	57 (53.8)	1.55 (0.79, 3.04)	0.67 (0.23, 2.01)

1, reference category.

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Discussion

We conducted a comparative cross-sectional study among street sweepers and door-to-door waste collectors to examine the prevalence of ARI and associated factors. Our findings showed that the prevalence of ARI among street sweepers was 48.80% and among door-to-door waste collectors 36.90%. Our findings also indicated that there was no statistically significant difference of the prevalence of ARI between the two groups. From the pooled analysis, we found that not using a nose/mouth mask while on duty and using coal/wood for cooking were factors significantly associated with ARI for both street sweepers and door-to-door waste collectors.

The overall prevalence of ARI in this study was 42.9 percent. The prevalence of ARI is higher in children than adults [12], however the result of this study was in line with a related study conducted in school-aged children in Sohag and Qena governorates, Upper Egypt, which was 44.86% [14] and even higher than the prevalence of ARI in children under five years of age in rural and urban areas of Kancheepuram district, south India, which was 27.0% [13]. This indicates that those groups are highly vulnerable to ARI. A study conducted in Addis Ababa found the prevalence of street sweepers with respiratory symptoms was 68.9% [10], which is higher than our study. This may be due to socio-demographic factor differences and the fact that that study was on respiratory symptoms and not specifically on ARI.

The prevalence of ARI among street sweepers and among door-to-door waste collectors was not statistically different. This might be due to the fact that both study groups were

employed by the same institutions therefore their training, provision of PPE number of working days and their salary fairly similar. In addition to this, both groups were exposed to similar types of waste since people dispose of waste on the road-side. Educational status and housing conditions of both groups were similar. Furthermore, a lack of statistically significant differences in prevalence of ARI among the two groups might be due to similarity in study settings, environmental factors, the basic infrastructure of waste collectors, and similar characteristics of socio-demographic factors.

From the multivariable logistic regression analysis, we found that study participants who used coal/wood for cooking and who never used a facemask on duty were more likely to have ARI among both street sweepers and door-to-door waste collectors. This result is consistent with a previous study done in Ethiopia on respiratory symptoms among solid waste collectors, which indicated that those who did not use a facemask while on duty were more likely to have ARI [5, 24]. This might be because the nose/mouth mask prevented the entrance of pathogens and dust into the respiratory tract. Similar findings were found in a study conducted on prevalence of ARI among school-aged children in Egypt, in which children who lived in a house with the presence of a source of smoke were more likely to have ARI than children who lived in a house without any source of smoke [14].

A study conducted among young children in developing countries found, a significant increase in risk of ARI among those exposed to smoke or smokey fuels at home compared those in households that used cleaner fuels or were otherwise less exposed [20]. Other studies also found that use of biofuel for cooking is a risk factor associated with ARI [13, 15, 16, 22]. Cooking in the living room imposes a high level of indoor air pollution and suffocation that could increase the incidence ARI. Therefore, cooking in a separate kitchen appears to be important for preventing of ARI. Our findings are also supported by studies in Este Town in northwestern Ethiopia [17], Wolayta-Sodo in southern Ethiopia [25], and northeast Brazil [26] despite these studies being conducted among under-five children about pneumonia. The use of traditional cooking fuels also may increase indoor air pollution, which may increase the incidence of ARI. A study among under-five children about pneumonia in peri-urban areas of Dessie city also found that domestic fuel as the energy source for cooking was a factor associated with pneumonia [27]. Although the two studies' findings are exactly comparable, they showed a common factor with our study in Dessie.

Limitations of the study and gaps for further research

That this study could not find the cause-and-effect relationship between the factors and ARI was considered one of its limitations. Another limitation was that study was based on symptoms that were not based on clinical diagnosis by a physician but were reported by the study participants recall of the two weeks before the interview, which might have underestimated or overestimated the prevalence of ARI. Our study may over-report some variables due to social desirability bias during self-reporting. For instance, participants' recall bias might have influenced the result history of past medical illness. Further studies are recommended that consider avoiding these limitations through a follow-up study in order to obtain more valid findings.

Longitudinal studies covering different seasons may provide a better understanding of the occurrence of ARI among street sweepers and door-to-door waste collectors in Dessie City, which will help to design programs to prevent ARI. Further studies are essential to confirm ARI by clinical examination. A more detailed study that examines several occupation related diseases using clinical examination is urgently needed in order to identify all types of disease that may be caused as result of their solid waste collection work. Such type of study is helpful

for proper intervention purposes. We used some studies about children for discussion since there is a lack of studies among adult populations, which would provide more comparable details and a stronger discussion. Therefore, we notice that several studies should be conducted with the goal of preventing ARI among adults.

Implication of the study to practice/policy

Urban sanitation is a concern for the government in Ethiopia in order to maintain and improve the health of urban residents and to attract visitors to urban areas. This is part of the United Nations Sustainable Development Goal 6 regarding clean water and sanitation for all, to ensure availability and sustainable management of water and sanitation for all, and Goal 11 about sustainable cities and communities, to make cities inclusive, safe, resilient and sustainable. To this end, solid waste collectors employed by urban municipality played an immense role in realizing proper urban sanitation through proper solid waste management, which in turn makes a city beautiful and attractive. As part of achieving these types of goals, the health and safety of solid waste collectors (street sweepers and door-to-door waste collectors) must be considered, including but not experiencing disease due to their work.

Availability of PPE, not using wood/coal as source of home energy, a good working environment, optimum work load, sufficient payment and healthy living/housing conditions might play an immense role in making waste collectors healthy and happy in their work. Our study will provide an input for health managers, municipalities, and policy makers to prioritize areas to be improved in order to prevent ARI among urban municipality waste collectors. Furthermore, considering the prevalence of ARI among street sweepers and door-to-door waste collectors, the Dessie City municipality in collaboration with governmental and non-governmental organizations, could further scale up programs that will help waste collectors themselves in trying to prevent ARI and other occupation related disease in a sustainable manner.

Conclusions

The study revealed that the overall prevalence of ARI among street sweepers and door-to-door waste collectors was 42.85%. The identified significant factors for ARI among street sweepers and door-to-door waste collectors were not using a nose/mouth mask while on duty and using coal and wood for household cooking. We recommend that the municipality regularly provide these workers with adequate and quality PPE and motivate and monitor the workers use of PPE while they are on duty. We also recommend that street sweepers and door-to-door waste collectors use nose/mouth masks while on duty and use a clean energy source such as electricity, biogas and solar energy for cooking at home.

Supporting information

S1 Questionnaire. English version of the questionnaire. Survey of prevalence and associated factors of acute respiratory infection among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia.

(DOCX)

S2 Questionnaire. Amharic (local language) version of the questionnaire. Survey of prevalence and associated factors of acute respiratory infection among street sweepers and door-to-door waste collectors in Dessie City, Ethiopia.

(DOCX)

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References

- Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2012; 380(9859):2095–128. [https://doi.org/10.1016/S0140-6736\(12\)61728-0](https://doi.org/10.1016/S0140-6736(12)61728-0) PMID: 23245604
- Denny FW Jr. The clinical impact of human respiratory virus infections. *Am J Respir Crit Care Med*. 1995; 152(4):S4. https://doi.org/10.1164/ajrccm/152.4_Pt_2.S4 PMID: 7551411
- Monto AS. Occurrence of respiratory virus: time, place and person. *Pediatr Infect Dis J*. 2004; 23(1): S58–S64. <https://doi.org/10.1097/01.inf.0000108193.91607.34> PMID: 14730271
- Dall'Agnol CM, Fernandes FdS. Health and self-care among garbage collectors: Work experiences in a recyclable garbage cooperative. *Rev Lat Am Enfermagem* 2007; 15(SPE):729–35. <https://doi.org/10.1590/s0104-11692007000700003> PMID: 17934577
- Cointreau S. Occupational and environmental health issues of solid waste management: Special emphasis on middle-and lower-income countries. *Urban Papers*. 2006; 2.
- Heldal K, Eduard W, Bergum M. Bioaerosol exposure during handling of source separated household waste. *Ann Agric Environ Med*. 1997; 4:45–52.
- Nielsen EM, Nielsen BH, Breum NO. Occupational bioaerosol exposure during collection of household waste. *Ann Agric Environ Med*. 1995; 2:53–9.
- Wouters I, Hilhorst S, Kleppe P, Doekes G, Douwes J, Peretz C, et al. Upper airway inflammation and respiratory symptoms in domestic waste collectors. *Occup Environ Med*. 2002; 59(2):106–12. <https://doi.org/10.1136/oem.59.2.106> PMID: 11850553
- Abou-EiWafa HS, El-Bestar SF, El-Gilany A-H, Awad El-Toraby EE-S. Respiratory disorders among municipal solid waste collectors in Mansoura, Egypt: A comparative study. *Arch Environ Occup Health*. 2014; 69(2):100–6. <https://doi.org/10.1080/19338244.2012.744737> PMID: 24205961
- Abraha MT. Occupational Respiratory Health Symptoms and Associated Factors among Street Sweepers in Addis Ababa, Ethiopia. MPH Thesis, School of Public Health, Africa Medical College, Addis Ababa, Ethiopia *J Public Health Dev Ctries*. 2016.
- Bogale D, Tefera W. Assessment of occupational injuries among Addis Ababa city municipal solid waste collectors: A cross-sectional study. *BMC Public Health*. 2014; 14(169).
- Chen Y, Williams E, Kirk M. Risk factors for acute respiratory infection in the Australian community. *PLoS ONE*. 2014; 9(7):e101440. <https://doi.org/10.1371/journal.pone.0101440> PMID: 25032810
- Sharma D, Kuppusamy K, Bhoorasamy A. Prevalence of acute respiratory infections (ARI) and their determinants in under five children in urban and rural areas of Kancheepuram district, South India. *Ann Trop Med PH*. 2013; 6(5):513–18.

14. Yousef FM, Hamed AF. Prevalence of acute respiratory infection and related risk factors in school-age children in Egypt: A cross-sectional study. *Int J Curr Res Med Sci.* 2016; 2(7):50–8.
15. Taksande AM, Yeole M. Risk factors of acute respiratory infection (ARI) in under-fives in a rural hospital of Central India. *J Pediatric Neonatal Individ Medicine.* 2016; 5(1):e050105–e.
16. Ujunwa F, Ezeonu C. Risk factors for acute respiratory tract infections in under-five children in enugu Southeast Nigeria. *Ann Med Health Sci Res* 2014; 4(1):95–9. <https://doi.org/10.4103/2141-9248.126610> PMID: 24669339
17. Fekadu GA, Terefe MW, Alemie GA. Prevalence of pneumonia among under-five children in Este Town and the surrounding rural Kebeles, Northwest Ethiopia: A community based cross sectional study. *Sci J Public Heal.* 2014; 2(3):150–5.
18. Goel K, Ahmad S, Agarwal G, Goel P. A cross sectional study on prevalence of acute respiratory infections (ARI) in under-five children of Meerut District. *India J Community Med Health Educ.* 2012; 2(176):2161–0711.1000176.
19. Kumar SG, Majumdar A, Kumar V, Naik BN, Selvaraj K, Balajee K. Prevalence of acute respiratory infection among under-five children in urban and rural areas of puducherry, India. *J Nat Sci Biol Med.* 2015; 6(1):3. <https://doi.org/10.4103/0976-9668.149069> PMID: 25810626
20. Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax.* 2000; 55(6):518–32. <https://doi.org/10.1136/thorax.55.6.518> PMID: 10817802
21. Suguna E, Kumar SG, Roy G. Prevalence and risk factors of acute respiratory infection among school children in coastal South India. *J Glob Infect Dis.* 2014; 6(3):95–8. <https://doi.org/10.4103/0974-777X.138498> PMID: 25191048
22. DN S, K M, H C, A H, M J, J K, et al. The prevalence of acute respiratory infections and the associated risk factors: A study of children under five years of age in Kibera Lindi village, Nairobi, Kenya. *J Natl Inst Public Health.* 2002; 51(1):67–72.
23. Hosmer J, Lemeshow S, Sturdivant R. *Applied logistic regression.* 3rd ed. Hoboken, NJ: John Wiley and Sons 2013.
24. Emiru Z, Gezu M, Chichiabellu TY, Dessalegn L, Anjulo AA. Assessment of respiratory symptoms and associated factors among solid waste collectors in Yeka Sub City, Addis Ababa, Ethiopia. *J Public Health Epidemiol.* 2017; 9(6):189–97.
25. Admasie A, Kumie A, Worku A. Children under five from houses of unclean fuel sources and poorly ventilated houses have higher odds of suffering from acute respiratory infection in Wolaita-Sodo, Southern Ethiopia: A case-control study. *Int J Environ Res Public Health.* 2018; 2018. <https://doi.org/10.1155/2018/9320603> PMID: 29743893
26. Fonseca W, Kirkwood BR, Misago C. Factors related to child care increase the risk of pneumonia among children living in a poor community in northeast Brazil. *J Trop Med.* 1997; 43(2):123–4.
27. Keleb A, Sisay T, Alemu K, Ademas A, Lingerew M, Kloos H, et al. Pneumonia remains a leading public health problem among under-five children in peri-urban areas of north-eastern Ethiopia. *PLoS ONE.* 2020; 15(9):e0235818. <https://doi.org/10.1371/journal.pone.0235818> PMID: 32915807