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Original article

Open dumping site and health risks to proximate communities in Mumbai, India: A cross-sectional case-comparison study

Shri Kant Singh[a], Praveen Chokhandre[b,*], Pradeep S. Salve[c], Rahul Rajak[b]

[a] Department of Mathematical Demography & Statistics, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai, 400088, India
[b] International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai, 400088, India
[c] Population Research Centre, JSS Institute of Economic Research, Dharwad, Karnataka, 580004, India

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ABSTRACT

Aim: Solid waste management is growing concern particularly in developing countries due its ill health effects to proximate communities. Study assess health effects of dumping site among nearby community members and identifying potential risk factors.
Methods: A cross-sectional household survey was conducted using a case comparison design. Study population consisted of an exposed group and non-exposed group (nearby and a distant community respectively; n = 200 each) having similar socio-economic and living conditions. To assess the health effects of dumping site, data on selected morbidities has been analyzed using the Propensity Score Matching (PSM) method.
Results: The study findings suggest a relatively higher prevalence of selected morbidities among exposed group than non-exposed group particularly for respiratory illness (23% v 10%), eye irritation (20% v 9.5%) and for stomach problem (27% v 20%) respectively. Result from PSM suggest that exposure to the dumping site leads to a higher prevalence of respiratory illness (12%), eye irritation (8%) and stomach problems (7%). Multivariate analysis suggest respondents from the exposed group were significantly more likely to suffer from respiratory illness (OR 3.06, $p < 0.01$), eye infection (OR 2.39, $p < 0.01$) and stomach problems (OR 1.66, $p < 0.05$). Assessment of air-quality-index suggests poor levels of PM_{10} and $PM_{2.5}$ during fire broke-out in Deonar dumping site.
Conclusion: Study concludes that the prevalence of morbidities found to be significantly higher among the exposed group than non-exposed group particularly it is significantly higher for respiratory illness and eye infection. The propensity score matching methods reinstate that morbidities found to be significantly higher among exposed group than non-exposed group.

1. Introduction

Cities across the world generate 1.3 billion tons of solid waste approximately per year. This volume is expected to increase to 2.2 billion tons by 2025.[1] Effective solid waste management (SWM) is a major challenge in cities with high population density.[2] Furthermore, living near landfill sites is a known health hazard prompting recognition of environmental injustice.[3] Population residing and working in the vicinity of solid waste processing and disposal facilities, are exposed to environmental health risks.[4] This is due to emission of toxic gases and air pollutants (landfill gas containing methane, carbon dioxide, hydrogen sulphide and other contaminants including volatile organic compounds bioaresols and particulate matter) or to contaminated soil and water.[5] Across the cities, it is the urban poor that suffers most from the life-threatening conditions deriving from deficient SWM.[6] The health problems investigated from different literatures include respiratory diseases,[5] skin infection,[3] and eye irritation,[7] gastrointestinal problems,[8] Diarrhea.[9] In addition, solid waste dumping areas become sources of contamination because of the incubation and proliferation of flies, mosquitoes, and rodents.[10] Apart from that, practice of open burning results in many harmful public health and environmental effects. Improper and inefficient handling of waste disposal causes an adverse impact on the environment and human health.[11]

1.1. A case of Mumbai

Mumbai is the country's largest metropolis, with a population of approximately 12.5 million people residing in Greater Mumbai, and the

* Corresponding author.
E-mail addresses: sksingh31962@gmail.com (S.K. Singh), praveenchokhandre@gmail.com (P. Chokhandre), pradeep_salve@biari.brown.edu, pradeep8889@gmail.com (P.S. Salve), rajrahul0906@gmail.com (R. Rajak).

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Table 1
Est**imated growth of** municipal solid waste (MSW) **generation in Mumbai**.

Year	Projected Population (millions)	Projected MSW generation (tons per day)	Per capita waste generation (kg/person/day)
2001	11.9	5800	0.49
2010	14.6	7756	0.53
2015	16.3	9116	0.56
2020	18.2	10713	0.59

Source: *Bhada P., 2007* (Projected).[15]

highest density, standing at 21,000 inhabitants per square kilometer.[12] Mumbai city alone generates about 6256 Metric Tons (MT) of garbage per day with a per capita generation of 0.5 kg, higher than any other Indian city.[13] Table 1 clearly suggests the gravity of the issue as in the span of 20 years, the municipal solid waste (MSW) generation has nearly doubled during 2001–2020.[1] Open burning of MSW is the largest emitter of carbon monoxide (CO), particulate matter (PM), carcinogenic hydrocarbons (HC) and nitrous oxides (NOx) contributing around 19% of air pollution due to CO, PM, and HC in Mumbai.[14]

To date, there is little epidemiological evidence on health-risk assessment of dumping sites particularly in context of India. Many of these studies lack good individual exposure information and data on potential confounders, such as socio-economic status, hygiene behavior and information on substance use. The present study focuses on the relative risk of selected morbidities among the population resides near the dumping site. Further, an attempt has been made to identify the potential risk factors which enhanced health vulnerability of proximate community members.

2. Materials and methods

Deonar Dumping site in Mumbai is India's biggest waste dumping site receiving more than 8000 metric tons daily, and around 200 thousand population resides around it. This study is based on cross-sectional case-comparison sampling design, implemented in one of the oldest and biggest dumping ground in Asia, located near *Deonar*, Mumbai. *Cases of exposed **population*** include people staying in the vicinity of dumping ground within the radius of a kilometer for at least a year. A group of respondents from a distant community having similar socio-economic and living conditions were considered as a non-exposed group. In absence of any past studies based on health risk due to dumping site in Mumbai, study considered the prevalence of breathlessness (26%) as a p-value from the study based on workers involved in land filling at the dumping ground conducted by the Forum for Environmental Concern of Nirmala Niketan College of Social Work, Mumbai. The estimated sample size was 406 households with p value 0.26, response rate of 0.90 and design effect of 1.25. In order to perform case-comparison study, the total required sample was divided into two equal parts, cases (exposed group) and compare (non-exposed group). Finally, a total of 200 respondents from exposed and 200 respondents from non-exposed group were interviewed (with almost 99% response rate). Primary data collected from March to July 2014 and approved by the institute research committee.

2.1. Study tools and methods

Along with information on selected morbidities viz. respiratory illness, eye infections and gastro-intestine issues in the last six months, data on demographic characteristics, housing condition, hygiene behavior and information on substance abuse were collected from the respondents. The results were summarized in descriptive statistics. Prevalence of selected morbidities was calculated for the exposed and non-exposed. Differences in prevalence of morbidities among the groups were tested by Chi-square test.

3. Variables information

3.1. Risk factor of the morbidities

It is evident from the past studies that dumping site generates gases which may be harmful to the human beings and transfer through air, water and other modes and hence proximity to dumping site enhances health risk to the proximate community dwellers and is considered as potential risk factor.

3.2. Confounding risk factors of the morbidities

Health of the body dwindles with advancing years, hence given risks have different effects on the young and the old. Similarly, longer duration of exposure may increase the health risk and hence 'years of living in the community' considered as a confounding risk factor. Substance use and unhygienic behavior further aggravate the health condition and are considered as effect modifier, as it may increase health vulnerability of participants. Hygiene behavior index constitutes soap use while bath, before meal, after toilet and daily bath, observed nail cleanliness and washing hand before meal.

3.3. Response variables

Respondents who have reported symptoms of respiratory illness, eye infections and gastro-intestine problems in the past six months were considered and classified as morbid. There are numerous undifferentiated respiratory illnesses definition in general practice but for this study purpose we include symptoms like dust allergy, dyspnea, episodes of asthma, chronic cough, running nose, wheeze and breathlessness of an individual in the last six month considered as a respiratory illness. Similarly, bacterial, viral or other microbiological agents cause eye Infections. In this study, any respondents who have symptoms such as eye soreness/redness, watering of eyes, itching of eyes in the last six month consider as an eye infection. Gastro-Intestine includes conditions such as loose motion, nausea, episodes of gastro-intestine, and intestine pain in the last six months considered as Gastro-intestine disorder. It refers to the harmful or hazardous use of psychoactive substances, including alcohol and illicit drugs. We consider only those individuals who continuously intake these substances.

4. Methods

In order to assess the exposure of dumping site to the development of selected morbidities, the study has adopted the nearest neighborhood method of propensity score matching (PSM).[16,17] This approach gave an opportunity to assess the impact of exposure on outcomes through cross-sectional survey data.[18] This method allowed assessment of the impact of exposure on the outcomes using cross-sectional data. The propensity score was estimated with the logistic regression analysis with the dichotomous exposure variable, for instance 1 = exposed to dumping site and 0 = unexposed to dumping site, using associated observed demographic characteristics and used as predictor variables. The principle assumption of the PSM is that the observable characteristics of the exposed and the comparison groups have similar distribution. The propensity score was calculated using probability of exposure assignment given pre-exposure characteristics.

$$p(x) = \text{prob}\ (D = 1|xi) = E\ (D|\ xi)$$

where D = {0, 1} is the indicator of exposure and x is the multi-dimensional vector of pre-exposure characteristics. The average exposure effect among the exposed (AEEE) is defined as the conditional expectation of difference in the exposure effect for the exposed units only. After matching the propensity scores of exposed and counter-factual scores of compare group, we compared the outcomes between the groups.

$$AEEE = E(\Delta|\ p(x), D = 1) = E(y_1|p(x), D = 1) - E(y_0|p(x), D = 1)$$

To assess the impact of dumping site on the development of selected morbidities, the average effects in both the groups were weighted by the proportion of respondents in the two groups. The effect of risk factors on the incidence on selected morbidities among the respondents, has been established by applying multivariate logistic regression. Here, proximity to the dumping site was considered the exposure variable, the confounding factor were age of the respondents, duration of stay in the community and level of education of the respondents, whereas hygiene behavior and substance abuse were considered as effect modifiers and were controlled for. The whole analysis was performed using STATA 13.1 software. P values less than 0.05 were considered as significance level.

4.1. Dumping site and smoke break-out

The frequent smoke-breakout at the dumping site generates various health problems to the population coming in to the proximity of landfill area. The secondary data of various pollutant gases in the air collected from System of Air Quality and Weather Forecasting and Research" (SAFAR) data and analyses to observe the impact of smoke-breakout, during and after the smoke breakout. SAFAR provides location specific information on air quality in greater metropolitan cities for the first time in India. In order to depict the level of air quality before, during and after the smoke breakout, data from SAFAR during the 15th January to February 18, 2016, has been collected and analyzed. SAFAR data collected from Chembur air quality monitoring station (AQMS) situated at International Institute for Population Sciences, Deonar, Mumbai. The SAFAR project has 27 air quality indicators and accordingly the major air pollutants are Particulate Matters 10 (UG/M_3), Particulate Matters 2.5 (ug/M_3), Carbon Monoxide **CO** (PPM), Ozone $\mathbf{O_3}$ (PPB), Nitrogen Di-Oxide $\mathbf{NO_2}$ (PPB), Sulfur Di-Oxide SO_2 (PPB) and Ammonia $\mathbf{NH_3}$. The particles matter 10 and 2.5 have an adverse effect on human health, including the incidence of premature deaths, heart and lung disease, cardiovascular illness. Similarly, the high presence of ozone, carbon dioxide and sulfur dioxide cause difficulties in breathing, chest pain, nose nasal cavity, throat problems, asthma, cardiac and lung problems.

On January 27, 2016 a fire broke out at the Deonar dumping ground in Mumbai city which spread across 326 acres, resulting in smog in the air in neighbouring areas of Govandi, Chembur, Mankhurd, Wadala, Sion and Ghatkopar.[19] The first massive fire breakout led to a continuous fire for almost half a month and emitted a huge amount of smoke. Burning MSW can release hexchlorobenzene (HCB) to the environment. HCB is a probable human carcinogen, and long-term, low-level exposures to HCB can damage a developing fetus, lead to kidney and liver damage, and cause fatigue and skin and eye irritation.[20] Open burning emissions enter the lower level breathing zone of the atmosphere, increasing direct exposure to humans.[21]

5. Results

5.1. Socio-demographic characteristics of study groups

Table 2 provides the socio-demographic and health behavior characteristics for both exposed and non-exposed group. Overall, the characteristics such as age, education and duration of stay among exposed group were comparable with non-exposed group according to their mean. A higher proportion (45%) of exposed group and (37%) of non-exposed group was in the age group 18–30 years. The mean age for both the groups emerged as about 35–37 years with standard deviation of a little over eleven years. Similarly, education, hygiene behaviors and substance abuse found similar for both the groups. Prevalence of selected morbidities by background characteristics is also depicted in the Table.

5.2. Prevalence of morbidities

Table 3 shows the prevalence of selected morbidities among exposed and non-exposed group. Overall, the prevalence of morbidities had been found to be significantly higher among the exposed group than the non-exposed group. For instance, prevalence of respiratory illness (23%–10%), eye infection (20%–10%), stomach problem (27%–20%) and headache/fever (30%–25%) respectively among exposed and non-exposed group. Substantial difference was found in the reporting of respiratory illness and eye infections among exposed and non-exposed group.

5.3. Morbidities caused due to dumping site

Results from Table 4 show the average exposure effect (AEE) of the dumping site for selected morbidities during the last six months. Findings suggested that, overall, the selected morbidities were found to be higher among exposed group. For instance, respiratory illness (12%), eye infection (8%) and stomach problem (7%) found significantly higher among exposed group than non-exposed group. By and large, a similar pattern was found while looking at the results of average exposure effect on those exposed (AEEE).

5.4. Factors associated with morbidities

Table 5 describes the relationship between risk factors for morbidities with adjustment for age, education and years of living with effect modifier as consumption of substance abuse and personal hygiene of the respondents. Significantly, respondents from the exposed group were more likely to report respiratory illness (OR 3.06, $p < 0.01$), eye infection (OR 2.39, $p < 0.01$) and stomach problem (OR 1.66, $p < 0.01$) compared to the non-exposed group.

Similarly, it is observed that with the increase in age was directly correlated with the increase in complaints of morbidities. For instance, respondents above the age of forty were more likely to suffer from respiratory illness (OR 3.35, $p < 0.01$) and stomach problem (OR 2.18, $p < 0.05$) compared to those in the age group 18–30 years. Duration of stay comes out to be a significant predictor as respondents staying more than 20 years were more likely to report eye infections (OR 1.74, $p < 0.1$) and stomach problems (OR 1.92, $p < 0.05$) when compared to those living up to 10 years.

5.5. Dumping site during smoke-break out

According to Air Quality Index standards, the observed average level of PM_{10} found to be poor (between 251 and 350 $\mu g/m^3$) during the fire that broke out in Deonar dumping site started from 28th February and smoke lasted to a week. Similarly, the observed average level of $PM_{2.5}$ found to be severe (between the range of 251–350 $\mu g/m^3$) during the mentioned period. The health effects of inhalable PM causes respiratory and cardiovascular morbidity, such as aggravation of asthma, respiratory symptoms and an increase in hospital admissions. Long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6–13% per 10 $\mu g/m_3$ of $PM_{2.5}$.[22,23] (see Figs. 1 and 2)

An explorative community level study on Deonar dumping site recorded the people outrage at the time of smoke broke-out and its implications on health and living conditions of community dwellers residing near dumping site suggest that people were helpless and unable to breath properly and were feeling eye-irritation at the time of smoke break-out.[24] Many of the respondents reported headache during the period. People around the dumping ground reported that the fire on

Table 2
Percent distribution and prevalence of selected morbidities by background characteristics among exposed and non-exposed study groups.

Background characteristics	Exposed group	Non-exposed group	Respiratory illness		Eye infections		Stomach problem		Headache/fever	
			Exposed group	Non-exposed group	Exposed group	Non-exposed group	Exposed group	Non-exposed group	Exposed group	Non-exposed group
Age										
18–30	44.5	36.5	16.9	9.6	16.9	15.1	19.1	27.4	25.8	27.4
31–40	33.5	36.0	14.9	11.1	23.9	8.3	28.4	19.4	32.8	25.0
Above 40 years	22.0	27.5	27.3	21.8	13.6	12.7	20.5	27.3	34.1	20.0
Education										
Not literate	49.0	40.5	23.5	17.3	21.4	16.1	21.4	27.2	26.5	24.7
Up to 5 yrs of education	18.0	23.0	8.3	15.2	13.9	6.5	19.4	21.7	36.1	13.0
Above 5 yrs of education	33.0	36.5	16.7	8.2	16.7	11.0	25.8	23.3	31.8	31.5
Duration of stay in community										
Up to 10 years	35.0	35.0	12.9	12.9	14.3	10.0	20.0	25.7	32.9	22.9
11–20 years	39.5	32.5	25.3	10.8	19.0	18.5	21.5	23.1	31.7	26.2
Above 20 years	25.5	32.5	15.7	16.9	23.5	7.7	27.5	24.6	23.5	24.6
Place of work										
Within community	62.5	68.5	19.2	13.1	20.0	13.1	26.4	24.1	27.2	20.4
Outside community	37.5	31.5	17.3	14.3	16.0	9.5	16.0	25.4	34.7	33.3
Hygiene behavior										
Low	47.0	45.0	11.7	15.6	17.0	13.3	20.2	31.1	36.2	23.3
High	53.0	55.0	24.5	11.8	19.8	10.9	24.5	19.1	24.5	25.5
Substance abuse	32.0	30.0	17.2	20.0	15.6	5.0	25.0	26.7	26.6	26.7

Table 3
Prevalence of symptoms of selected morbidities in the past 6 months among exposed and non-exposed group.

Symptoms of selected morbidities	Exposed (n = 200)	Non-exposed (n = 200)
Respiratory illness	22.5	10.0
	$chi^2 = 11.5$; $p < 0.001$	
Dust allergy	4.5	1.5
Dyspnea	11.5	5.5
Episodes of asthma	3.5	2.0
Chronic cough	5.0	2.0
Running nose	6.0	2.5
Wheeze and breathlessness	7.0	3.5
Eye infections	**20.0**	**9.5**
	$chi^2 = 8.76$; $p < 0.001$	
Eye soreness/redness	9.5	6.0
Watering of eyes	13.5	7.5
Itching of eyes	3.0	1.5
Stomach problem	**27.0**	**19.5**
	$chi^2 = 3.15$; $p < 0.05$	
Loose motion	10.5	11.5
Episodes of gastro-intestine	9.5	7.0
Nausea	5.5	4.5
Intestine pain	13.0	10.5
Headache/fever	**30.0**	**24.5**
	$chi^2 = 1.52$; $p = 0.217$	

Table 4
Average exposure effect (AEE) and average exposure effect among exposed (AEEE) to dumping ground on selected morbidities in the past 6 months.

Selected morbidities	Average exposure effect		Average exposure effect among exposed	
	Coef.	95% CI	Coef.	95% CI
Respiratory illness	0.12***	(0.044–0.201)	0.10**	(0.014–0.184)
Eye infections	0.08**	(-0.002 to 0.153)	0.07*	(-0.01 to 0.171)
Stomach problem	0.07*	(-0.028 to 0.175)	0.05	(-0.07 to 0.166)
Fever/headache	0.05	(-0.05 to 0.155)	0.02	(-0.09 to 0.136)

Table 5
Results of logistic regression analysis examining the effects of potential predictors on selected morbidities in the last six months.

Characteristics	Respiratory symptoms[a]	Eye infections[a]	Stomach problem[b]	Headache/ fever[b]
Groups				
Non-exposed group®				
Exposed group	3.06*** (1.66–5.64)	2.39*** (1.31–4.36)	1.66** (1.02–2.70)	1.33 (0.85–2.09)
Duration of stay				
Up to 10 years®				
11–20 years	1.14 (0.55–2.34)	1.26 (0.62–2.57)	1.32 (0.71–2.44)	1.07 (0.63–1.83)
Above 20 years	1.46 (0.69–3.07)	1.74* (0.83–3.65)	1.92** (1.02–3.59)	0.83 (0.46–1.49)
Age				
18-30®				
31–40	0.92 (0.43–1.98)	1.18 (0.59–2.35)	1.82** (1.00–3.32)	1.28 (0.75–2.19)
Above 40 years	3.35*** (1.61–6.96)	1.05 (0.48–2.31)	2.18** (1.13–4.20)	1.19 (0.64–2.21)
Education				
Not literate®				
Up to 5 yrs.	0.74 (0.36–1.53)	0.56 (0.25–1.24)	0.77 (0.40–1.50)	0.92 (0.49–1.71)
Above 5 yrs.	0.44** (0.22–0.91)	0.58* (0.29–1.14)	1.12 (0.64–1.96)	1.52* (0.90–2.56)

® reference category.
Values are ORs and 95% CIs, $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.
[a] Model is adjusted for substance abuse.
[b] Model is adjusted for substance abuse and personal hygiene.

landfill area and smoky situation is common but the intensity of smoke breakout in November to March 2016 was intense. Considering the smoke break-out effects on human health, the situations described by the people were grievous. Study also reported that fire breakout worsened the health condition of those who were already sick before the fire breakout. Those who were already suffering from asthma became more critical and were given further medical attention to avoid encounters with fatal situations which caused out of pocket medical expenses in most of the families.

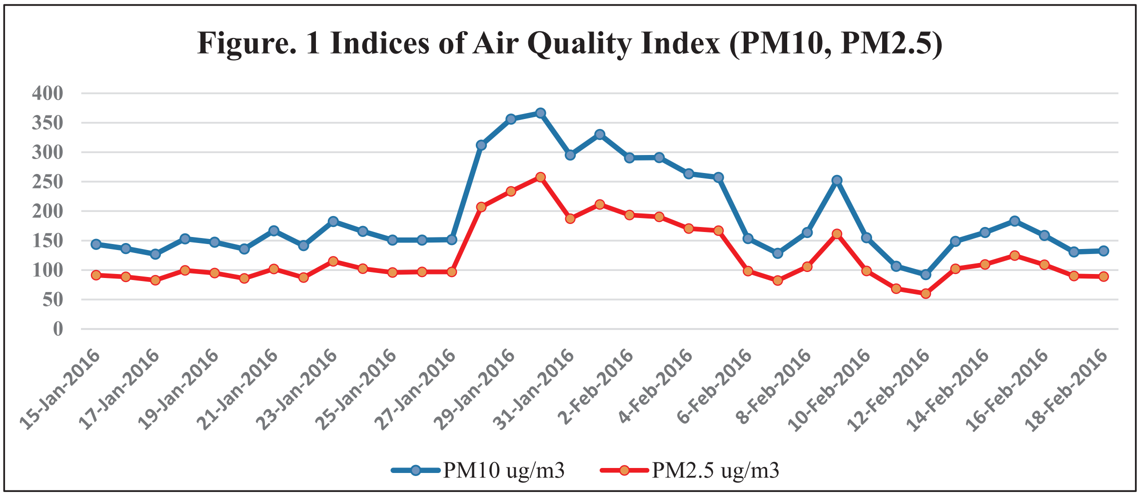

Fig. 1. Indices of Air Quality Index (PM10, PM2.5)
Source: Data collected from Chembur Air Quality Monitoring Station (15 January – 18 February 2016).

6. Discussion

The present study was driven by the frequent demand for closure of Deonar dumping site by proximate community residence due to frequent fire and bad smelling. The present study attempts to assess the health effects of dumping site to proximate communities by comparing with a distant community having similar socio-economic and living conditions. Self-reported symptoms of morbidities such as respiratory infection, eye irritation, headache and stomach problems were recorded through cross-sectional survey of research. Additionally, data from SAFAR has been analyzed and presented during the period when smoke breakout in Deonar dumping site during 28th January to February 6, 2016.

Results from the study suggests that the prevalence of morbidities found to be significantly higher among the exposed group than non-exposed group particularly it is significantly higher for respiratory illness (23%–10%), eye infection (20%–10%) respectively. Further, the results of propensity score matching attested that the selected morbidities were found to be higher among exposed group than non-exposed group. For instance, respiratory illness (12%) and eye infection (8%) found significantly higher among exposed group than non-exposed group. Several studies including the present study have highlighted that long term exposure of the population who resided in the area surrounding dumping sites has led to negative health impacts on people. For instance, a study noticed that people living near the dumping site reported a higher prevalence of prolonged asthma (40.74%), nose irritation (25.93%) and respiratory problems (33.33%).[25] It is confirming from other studies that people who lived in nearby (500 m–1 km) to the dumping sites have more likely to health problems as compared to those maintain a safe distance from dumping sites.[9,25,26]

There is enough evidence that duration of stay, advancing age of the respondents and level of education significantly contribute in the health effects of dumping site.[27–30] Recent study revealed that those with secondary and tertiary levels of education were less likely to suffer from health effects as compared to those with primary education.[27] These findings support the view that the individuals who had higher educational levels and working outside the community are more likely to avoid health risks. The current study showed that respondents age ≤40 years are more likely to report respiratory illness (OR 3.35, $p < 0.01$), and stomach problem (OR 2.18, $p < 0.01$) compared to the younger age group. Another study indicated that participants who have stayed longer, up to 20 years, in the proximity to a landfill site, experience higher forms of odour, annoyance and suffer from medical conditions

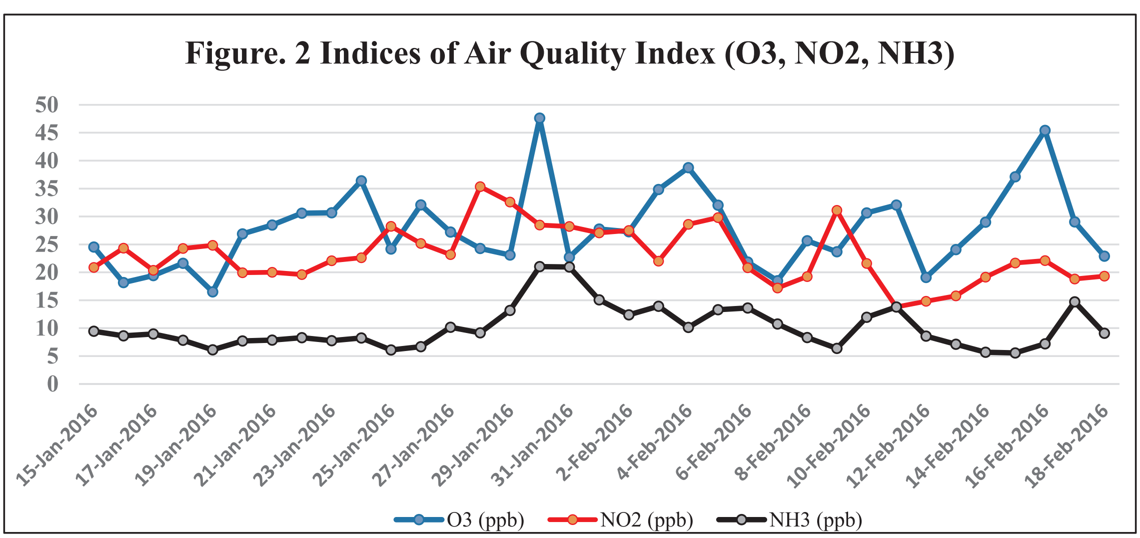

Fig. 2. Indices of Air Quality Index (O3, NO2, NH3)
Source: Data collected from Chembur Air Quality Monitoring Station (15 January – 18 February 2016).

such as asthma, diarrhea, stomach pain and skin infections compared to those lived for less than 1–20 years.[31] Therefore, the relationship of risk factors for morbidities with adjustment for age, education and years of living with effect modifier as consumption of substance abuse and personal hygiene of the respondents has been analyzed. Significantly, respondents from the exposed group were more likely to report respiratory illness (OR 3.06, $p < 0.01$), eye infection (OR 2.39, $p < 0.01$) and stomach problem (OR 1.66, $p < 0.01$) compared to the non-exposed group. A similar result found from the cross sectional study that residents of near landfills areas reported significantly higher frequencies of ill-health like, extreme fatigue, skin problems/irritations, stomach discomfort, eye irritation/tears[3].

The findings of air quality index analyzed from SAFAR project data during January 15, to February 18, 2016 shows that the levels of levels of PM10, PM2.5, NO2 and the CO levels in the atmosphere in areas near the Deonar dumping site has sharply gone up. The health effects of inhalable PM are well documented causes respiratory and cardiovascular morbidity, such as aggravation of asthma and respiratory symptoms. It has also been observed from our study that with the increase in age and duration of stay comes out to be a significant predictor correlated with the increase in complaints of morbidities particularly respiratory and eye infections. This is consistent with the finding analyzing distance between a community and dumpsite reduces the occurrence of increased illnesses.[9,26] This study suggests that people should maintain a distance from the boundary of the solid waste processing and disposal facility (sanitary landfill) at least 500 m.[25] Self-reported data for morbidities were collected and hence results may be used with caveat.

7. Conclusion and recommendations

Recent work has suggested that improper handling of solid wastes can be potential risks to human health, especially for those who settled proximity to landfill sites. It is projected that by the year 2031 the solid waste generation will increase to 165 million tons and to 436 million tons by 2050. If Indian cities continue to dump the waste at the present rate, it will need 1240 ha of land per year.[32] An urgent need to move to more sustainable SWM and requires innovative solid waste management systems. The waste management as it presently involves many stakeholders for whom it is a source of livelihood. Clear policy directions towards recycling will not only help in resource conservation but also strengthen the role played by the waste-pickers/RAG pickers, ensuring their livelihood.[33] A considerable amount of money is involved in waste collection and disposal and demands a fresh look from mere management to an economic model for SWM and hence concentrated efforts required for economic return and resource saving measures.

Availability of data and materials

The data used for the study is primarily collected for the PhD thesis work during March to July 2014 in Mumbai. The ethics statement and consent for publication is applicable of the Ethical approval of the institute research committee.

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Informed consent

Respondent oral and written consent was applicable.

Authors contribution

Shri Kant Singh: Conceptualization, Methodology. **Praveen Chokhandre**: Develop questionnaire, collected data, Data analysis. **Pradeep Salve**: Secondary data collection, Data analysis, Write-up **Rahul Rajak**: Manuscript writing, Review and edited manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors have declared that no competing interest exists.

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