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RESEARCH ARTICLE

Evaluation of biomedical waste management practices in public and private sector of health care facilities in India

Aruna Devi[1] · Khaiwal Ravindra[1] · Manmeet Kaur[1] · Rajesh Kumar[1]

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Abstract

Proper management of biomedical waste (BMW) is required to avoid environmental and human health risks. The current study evaluated the BWM practices in public and private health care facilities of Fatehgarh Sahib District in Punjab, India. The study was conducted, using a modified World Health Organization (WHO) tool in 120 health care facilities randomly selected from rural and urban areas. At primary health care level, BMW management guidelines were followed in 67.2% of the public sector and 40.4% of the private sector facilities, whereas in secondary health care sectors both private and public sector follows 100% compliance. Health facilities were graded into different categories according to median score, i.e., scores less than < 2.5 was categorized as red (no credible BMW management system in place), scores between 2.5 to 7.5 as yellow (system present but needs major improvement) and scores > 7.5 as green (good system in place for BMW). It was observed that among primary health care facilities, 85% of the public sector and 64% of private sector facilities falls in the red category, whereas for secondary health care facilities only 8% fall in the red category. Logistic regression helped to identify the major factors that affect the performance of the health care facility, and it shows that regular training on BMW and improved infrastructure can improve the BMW management practices. Further, proper management of BMW requires multi-sectoral coordination, which can be better addressed through policies and by providing periodical training to all stakeholders.

Keywords Biomedical waste · Health care facilities · CBWTF · Logistic regression · Health hazards

Capsule: Health care facilities were categorized for the better management of biomedical waste and to reduce the public health risks

Highlights:

•*Poor BMW management poses a threat to health care workers and the public.*
•*It is the first study assessing BMW at rural/urban/public and private health facilities.*
•*Eighty-five percent of public and 64% of primary health care facilities fall in the red category.*
•*Eight percent of secondary health care facilities are classified under the red category.*
•*There is a need for proper BMW training for effective BMW management.*

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✉ Khaiwal Ravindra
Khaiwal@yahoo.com; Khaiwal.Ravindra@pgimer.edu.in

[1] Department of Community Medicine and School of Public Health, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh 160012, India

Introduction

World Health Organization (WHO) and several studies specify that 85% of the biomedical waste (BMW) is non-hazardous. About 15% BMW includes potentially infectious wastes such as HIV, hepatitis B, and C viruses, antibiotics, cytotoxic drugs, halogenated or non-halogenated solvents, heavy metals, and oxides, etc. This 15% fraction of hazardous waste need to be managed properly as it poses a great risk to workers as well as to the general population (Sharma et al. 2013a, b; Negi et al. 2018; Datta et al. 2018).

According to a WHO survey on health care waste management in 22 developing countries, only 18 to 24% of the health care facilities manage BMW inappropriately. It was estimated that in India, about 0.33 million tons of BMW is generated every year. Further, the BMW generation from hospital varies from 0.5 to 2.0 kg per bed per day (Patil and Shekdar 2001). Though BMW in urban locality accounts around 1% of total municipal waste but the mixing of BMW with municipal waste makes the entire municipal waste infective and dangerous (Prüss et al. 1999; Mor et al. 2006a, b; 2018; Ramachandra and Bachamanda 2007; Ravindra and Mor, 2019a). The problem of BMW management is further exacerbated by the waste workers who segregate health care waste in open without wearing personal protective equipments such as gloves, shoes (Ravindra et al. 2016).

Thus BMW should be managed safely in a sustainable manner to avoid deleterious effect on the human health and environment (Romero and Carnero 2019; Ravindra and Mor, 2019b) . However, despite regulations, most of the BMW is not handled properly in India (International Clinical Epidemiology Network 2014). Limited knowledge about health hazard and insufficient finances, including lack of trained human resources, were identified as major reasons for poor practices for BMW disposal (Tewary et al. 2014; Ravindra et al. 2015; Mor et al. 2016).

International Clinical Epidemiology Network - INCLEN (2014) study explored the prevailing BMW management practices in various health care facilities (HCFs) across 20 states in India, and they reported > 80% primary and 60% secondary HCFs do not follow reliable BMW management practices. Many studies have reported increasing the spread of hepatitis B, hepatitis C, HIV, and other infectious diseases due to the reuse of unsterilized syringes (Seetharam 2009; Hanumantha 2008; Sachan et al. 2012). Thus, safe disposal of BMW should be of prime importance to prevent diseases in HCFs and for the community at large.

The management of BMW is an emerging public health issue (Sharma 2014; Verma et al. 2008; Yadav 2001). There are several studies, which focus on knowledge attitude, beliefs, and practices being followed by the health care workers for BMW management (Gupta et al. 2015; Nema et al. 2015; Datta et al. 2018). Sharma et al. (2013a, b) and Chudasama et al. (2017) reported inadequate and inappropriate knowledge about BMW management practices among HCFs workers in India. The lack of awareness has led the HCFs for spreading various infectious diseases. However, the current position of the BMW management is not very well known in primary HCFs, especially in rural areas, including the strengths and weaknesses of the operating system. BMW management involves different departments and organizations, both in public and private sectors.

It is also important to understand how the linkages are working between different departments, which may weaken the overall performance of the system. Hence, a comprehensive evaluation of BMW management practices was conducted to propose both short-term and long-term solution to the problems in BMW management. This is probably the first study covering public and private, rural and urban, and formal and informal practitioners.

Materials and methods

Study design and sample size

A cross-sectional study was conducted in Fatehgarh Sahib district of Punjab State, India, from January 2015 to December 2015. The sample size was calculated using the following formula:

$$\text{Sample size} = \left[(4 \times P \times Q)/D^2\right]$$
$$= (4 \times 50 \times 50)/10 \times 10 = 100.$$

Where P is prevalence, Q is (100-P), and D is precision of the estimate. Based on the International Clinical Epidemiology Network study (2014), it was assumed that about 50% of the HCFs would have better BMW system. Final sample size calculated was 120 HCFs considering 20% refusals during the survey. Fatehgarh Sahib District has 115 government HCFs. All three HCFs (district hospitals, sub-divisional hospital, and rural hospital), three community health centers (CHCs), two block primary health centers (BPHCs), 11 primary health centers (PHCs), 23 subsidiary health centers (SHCs) where medical officers (MOs) provided clinical care were selected, and a random sample of 18 sub centers (SCs) from the list of 73 sub-centers where auxiliary nurse midwife (ANM) provide primary care were selected for the study. Thus, a total of 61 government HCFs were included in this study. A list of private hospitals and clinics was prepared from the same locality where the sampled government health facilities were located, and an equal number (61) of comparable level hospitals and clinics were sampled. Thus, a total of 122 health facilities were selected for the study (61 government HCFs and 61 private HCFs).

Four district level officers, one each from the pollution control board, district health authority, rural, and urban local bodies, were also selected to study their perspective about the BMW management in the district.

Study tools

The study was conducted following health-care waste management health facility tools by WHO which were adapted under INCLEN program evaluation network study. These tools include generic observation checklist to observe and quantify the methods used in the collection, segregation, transportation, and disposal of BMW, Questionnaires for an interview with medical officer/paramedical staff responsible for waste management in a HCF and an official from pollution control board. Key points related to BMW management were listed and used as a tool to initiate a discussion with officials from the health authority, municipality, urban, and rural local bodies.

Study process

The study was conducted using an observation checklist, as mention in section study tools and had items that were grouped under nine domains. There was a total of 31 questions, which were divided into three major domains, the first domain focus on health system capacities, whereas second domain assesses available resources and third domain examine the process. Major domains were categorized further into nine sub-domains. These sub-domains include one sub-domain for system capacity assessment, four sub-domains to study resource, and processes. These sub-domains helped to generate data on segregation practices, management of sharp objects, transportation, storage within the sector, including BMW record keeping.

Initial eight questions have only two options, i.e., no compliance and full compliance, and the remaining 22 questions provide three options as follows: no compliance, partial compliance, and full compliance. Each response of every question was ranked as no compliance or absence of particular response, partial compliance, and full compliance with score 0 points, 5 points, and 10 points respectively. The maximum and minimum score for an HCF was 0 and 10.

The observation checklist had columns for seven generation points. There were no minimum number of generation points fixed but a maximum of observation of seven generation points, if available was followed during the study. In the case of sub-centers, only one observation point was available, and only one observation was made in those facilities. Averages of the scores were calculated according to the number of generation points observed in that health facility to arrive at the domain score for the individual health facility.

The individual health facility was graded into different categories according to median scores. Scores less than < 2.5 is categorized as red which means "No credible BMW management system in place," scores between 2.5 to 7.5 as yellow that is "System present but needs major improvement" and HCF with scores > 7.5 as green that is "Good system in place for BMW."

Statistical analysis

Data was entered using Epi data entry v3.1 (Epidata Association, Odense, Denmark). Statistical package for the social sciences (SPSS) version 16.0 for Windows was used for data analysis. Bivariate analysis was done to determine the association of factors such as staff training, knowledge, availability of equipment and supplies, etc. with the BMW grading of HCFs. Chi-square test helped to discuss the statistical significance. Logistic regression was applied to examine the independent effect of these factors. A spontaneous discourse analysis was done for an open discussion held with officials from the health authority, municipality, urban, and rural local bodies.

Data sharing statement A MD thesis is available on the topic and can be provided through e-mail by Dr. Ravindra Khaiwal.

Results

Knowledge and practice of healthcare personal about BMW management

Among the respondents in the public sector, BMW training status was 100% for doctors and nurses but found lacking in the case of pharmacists (60%). In private sector, 100% doctors and nurses had received training, 22% of Ayush doctors (Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy) and none of the informal health practitioner and pharmacist had training. At the primary health care level, BMW management guidelines were enforced in 67.2% of the public and 40.4% of the private sector health facilities. In secondary HCF, guidelines were enforced in 100% of the health facilities in the public and private sectors.

Knowledge and practices about the disposal of different types of wastes were assessed using interview scheduled with medical officers/paramedics responsible for BMW management in a HCF. The respondent was asked to identify the appropriate color-coded bag for a specified type of BMW. Only 68.8% from the public sector and 54.4% from private sector answered correctly regarding disposal of infected plastic waste (container with red/blue bags) and infected non-plastic wastes (containers with yellow bags). In the public sector, 85% and 60% in the private sector responded with an appropriate answer. Sharp wastes are to be disposed of in white puncture-proof container with 1% hypochlorite solution; in public sector 80% and private sector 47.5% replied correctly about it.

Regarding segregation of BMW, 91.8% of respondents in the public sector and 44.2% in the private sector thought that wastes have to be segregated. Sixteen percent of respondents in the private sector did not respond to this question; four (6.5%) of them told that needles/syringes are to be sold to a rag picker. Respondents were questioned about the choice of an alternate method of BMW disposal in-case of system failure; 35.2% chosen an open fire, 27.8% chose open fire and deep burial, 18% chose only deep burial, and 9.8% said they do not know what to do.

As shown in Table 1, primary HCFs in both the public and private sector lacked the BMW management system for collection and storage. An organized system to transport BMW was missing at all levels in both public and private sector. Designated area for storing BMW before disposal was present in 21% of public HCF and 39.3% of the private HCF.

In public sector, 26.2% of HCFs disposed BMW using the services of a private common biomedical waste treatment facilities (CBWTF's) and remaining 73.7% transported to other public HCFs disposing BMW through CBWTF's. In the private sector, 54.6% disposed BMW through CBWTF's, and 11% sold BMW to rag pickers, and 34.4% threw wastes outside HCF.

Table 1 Health care facilities having organized system to monitor generation, collection, storage, and transport of BMW

System for monitoring BMW management	Public		Private	
	Primary care $n = 55$ (%)	Secondary care $n = 6$ (%)	Primary care $n = 42$ (%)	Secondary care $n = 19$ (%)
Generation and segregation of BMW	35 (63.6)	6 (100)	18 (42.8)	19 (100)
Collection and safe storage of BMW	12 (21.8)	6 (100)	12 (28.7)	17 (89.4)
Safe transport of BMW	15 (27.2)	4 (66.6)	9 (21.4)	15 (78.9)

In the public sector, 26.2% and 39.3% of private sector workers did not use any personal protective equipment during BMW management. Mask and gloves were used by 60.6% of the public sector and 22.9% of private sector staff. Mask, gloves, and boots were used by 6.5% of public HCF workers. The effluent was openly disposed of without disinfection in 32.7% of the HCFs, let into the septic tank after disinfection with hypochlorite in 27% of the HCF, let into a septic tank without disinfection in 17.2% and 19.6% did not have infrastructure like wash-basin for effluent production.

Status of BMW management

The urban and rural difference in private primary HCFs was observed. Primary HCF produced averagely 1.524 kg/day, and infectious wastes constituted 0.76 kg/ day. Secondary HCFs produced 4.4 kg/day of infectious wastes, and the median proportion of infectious wastes to total wastes is 41%. BMW management was not good in the district (median score- 3.7, 25th percentile—2.13, and 75th percentile—6.17). Overall scores were distributed along with the three categories, as shown in Table 2. It depicts that 76% of primary care facilities fall in the red category. Among the primary HCFs, 85% of the public sector and 64.2% of private sector HCFs were in the red category. Only 8% of secondary HCFs were in the red category. Table 2 shows the distribution of the overall score of HCFs according to grading. Urban-rural differences in the overall health facility scores are shown in Table 3. It shows that there is a notable difference in rural area primary HCF between public and private sectors.

Overall performance of BMW management was also assessed according to domain score at different levels of HCFs (Table 4). It shows that performance in resources domain was better than any other domain in primary HCFs because the availability of resources for segregation of BMW and resources for the management of sharp waste such as hub cutter were available in almost all public primary HCFs. However, resources and standard process were not available to transport BMW. HCFs also lack storage facilities for BMW, and record keeping was found poor in the observed health facilities.

Factors associated with BMW management

There are several factors that can be associated with better BMW management (Table 5). The factors shown in Table 5 are those factors that were not included in measuring the overall performance of HCF. Factors associated with good BMW management (score > 5) (yellow and green category) were considered for further analysis. Logistic regression was also

Table 2 The distribution of median BMW management scores according to the level of health facilities in the public and private sector

Grade of BMW scores and color category	Level of care	*n*	Median score (25th, 75th percentile)	Type of health facility	*n*	Median score (25th, 75th percentile)
0– < 5.0 Red	Primary	75	2.41 (0.65, 3.55)	Public	46	3.06 (2.42, 3.71)
				Private	29	0.64 (0.32, 1.29)
	Secondary	2	4.47 (4.26, 4.68)	Public	1	4.26
				Private	1	4.68
5.0 – < 7.5 Yellow	Primary	19	6.45 (5.8, 6.78)	Public	8	5.88 (5.64, 6.62)
				Private	11	6.61 (6.12, 6.77)
	Secondary	14	6.49 (5.32, 7.11)	Public	1	6.27
				Private	13	6.49 (5.37, 6.92)
≥ 7.5 Green	Primary	4	7.78 (7.74, 8.13)	Public	1	8.22
				Private	3	7.74 (7.74, 7.82)
	Secondary	8	7.97 (7.82, 8.29)	Public	4	7.93 (7.82, 8.46)
				Private	4	8.09 (7.66, 8.3)

Table 3 Distribution of BMWM scores at a different level of health facilities in urban and rural settings

Level of care and location	Type of hospital	*n*-122	Median score (25th, 75th percentile) (*n*)
Primary urban	Public	0	–
	Private	12	6.45 (4.19, 7.58)
Primary rural	Public	55	3.49 (2.42, 4.35)
	Private	30	0.64 (.32, 2.18)
Secondary care urban	Public	5	7.83 (6.04, 8.32)
	Private	16	6.51 (5.35, 7.44)
Secondary care rural	Public	1	6.27
	Private	3	7.50 (7.11, 7.9)

applied to find the association of the factors with the performance of the HCF score above 5. Two factors, training, and type of hospitals were found to be associated with better BMW management, as shown in Table 6.

Perception of key stakeholders about BMW management

Stakeholders should perceive the problems to bring about a solution (Lal et al., 2018; Ravindra et al., 2019). Majority of the respondents from public HCF expressed their apathy towards improper management of BMW, and that is evident from the suggestions provided by them. They expressed the need for the better infrastructure facilities by the government and proper linkage between different departments and stakeholders for optimum functioning of BMW management. In the private sector, more than 50% of the respondents did not perceive that there is a problem in BMW management, and most were satisfied with the current functioning. However, they expected some grants or functioning through the public sector for disposal of BMW. This indicates the lack of full responsibility of the private sector towards BMW management.

Interview with pollution control board authority revealed that they were satisfied with the current BMW management practices. Interview with the civil surgeon of Fatehgarh Sahib district, showed that funds could not be allotted for buying minimum needs like dustbins, color-coded bags, and

Table 4 Overall performances of BMW management according to domains scores at different levels of health facilities

Domains of BMWM performances	Primary care settings median (25th, 75th percentile) (*n*-97)	Secondary care settings median (25th, 75th percentile) (*n*-25)
A. System capacity for optimum BMWM system (guidelines or charts for BMW, location of charts, appropriateness and readability of contents, a specific person or MO with clear roles and responsibilities for BMWM, designated waste routes in hospital, personal protectives for waste handlers, designated per for waste storage areas, weighing machine in storage areas)	2.8 (1.4, 5.7)	6.8 (1.4, 2.5)
B. Resources	3.7 (1.2, 5)	8.2 (6.2, 8.6)
B1-resources for segregation of BMW (specific person/MO/nurse to monitor segregation, appropriate containers with colored bags)	5 (5, 10)	10 (9.5, 10)
B2-resources for management of sharps (functional needle destroyer/ hub cutter, white puncture proof translucent containers)	10 (0, 9.5)	10 (8.61, 10)
B3-resources for in- house transport of BMW (containers, trolleys or equipment for transport, specific route, log book or register at source)	0 (0, 1.8)	5 (3.3, 5.2)
B4-resources for storage and house-keeping (centralized area for storing BMW, log book and register at storage site)	0 (0, 0)	9.1 (4, 10)
C. Processes	2.6 (1.2, 5.4)	5.1 (4.3, 7.9)
C1-process for segregation of BMW (segregation at source, bio-hazard labels in equipment, bags removed before 3/4th full, plastic wastes in blue/red bags, disinfection of plastic wastes)	2 (0, 6)	7.1 (6, 8)
C2-process of management of sharps (needles/plungers destroyed after injections, biohazard labels for white translucent containers, syringe plungers in red/blue bags)	3.3 (0, 6.6)	6.9 (3.89, 7.4)
C3-process for in- house transport of BMW (frequency of removal for BMW, specific time for removing infectious wastes, clean, and labeled trolleys)	5 (0, 5)	5 (2.5, 7.5)
C4-process for storage and record keeping (lock and key for waste storage area, color-coded bags stored separately, tied and labeled, general cleanliness)	1.6 (0, 3.3)	6.6 (1.6, 10)

B1–B4 sub-domains of resources; C1–C4 sub-domains of processes; MO-medical officer

Table 5 Factors associated with biomedical waste management

Factors		*N*	Red* (*n*) (%)	Yellow* (*n*) (%)	Green* (*n*)(%)	*P* value
Location of HCF	Rural	88	71(80.6)	15 (17.0)	2 (2.2)	< 0.001
	Urban	34	5 (14.7)	19 (55.8)	10 (29.4)	
Level of care	Primary	97	73 (75.2)	19 (19.5)	5 (5.1)	< 0.001
	Secondary	25	2(8)	16 (64)	7 (28)	
BMW training status	Untrained	47	45(93.5)	2(4.2)	0	< 0.001
	Trained	75	31(41.3)	32 (42.6)	12(16)	
Type of HCF	Public	61	47 (77.7)	9 (14.7)	5 (8.1)	0.003
	Private	61	29 (47.5)	25 (40.9)	7 (11.4)	

*Scores less than < 2.5 was categorized as red, scores between 2.5 to 7.5 as yellow, and scores > 7.5 as green

construction of wash-basins, for improving the BMW management in primary HCFs because of their remote location. One of the major factors found to be associated with better BMW management is training, and hence information of training sessions held by pollution control board should be brought in the notice of civil surgeon. The link between two departments (health and pollution control board) mainly involved in BMW management was missing. The civil surgeon did not perceive that BMW management in rural primary HCFs is also equally important. Interview with chairman of member of council found that they perceive BMW management good in the city as BMW was never found mixed with municipal wastes in their experience. He also stated that actions against traditional medical practitioner were taken whenever they receive complaints.

Discussion

The status of BMW management was found to be poor (red category) in 64% of health facilities. Though training status was found to be good, knowledge and practices in BMW management were poor generally. The most important factors found to be associated with better BMW management are professional training on waste management and type of health facility (public or private health facility). Secondary HCF in the public sector were found to be distributed in urban areas, and primary HCF were found to be distributed in rural areas. This difference was not found in private HCFs. In the private sector, only 22% of Ayush doctors were trained in BMW, and none of the traditional medical practitioners were trained for BMW management. Hence, efforts should be taken to include BMW management training in the curriculum of Ayush doctors.

Several studies show that infectious waste load can be decreased by proper training (Nandwani 2010; Tabash et al. 2016) and segregation at source (Hegde et al. 2007; Seymour Block 2001). Further, Romero and Carnero (2019) also show the application of a multi-criteria model to minimize the impact of hazardous hospital waste. Personal protective equipment prevents the workers from the occupational risk of obtaining dangerous infections like HIV, hepatitis B, and C, and many more (Ravindra et al. 2015; Sharma et al. 2019). Availability of personal protective equipment not only enhance professional commitment but also the confidence of the workers engaged in the health care sector (Kumar et al. 2015; Green-McKenzie et al. 2001). Hence, strict compliance of personal protective equipment should be ensured, including routine training of all the staff involved in BMW management.

Public HCFs had a contract with the common biomedical waste treatment facilities (CBWTF) (26.2%), or the hospital can dispose of the waste through another hospital having a contract with CBWTF (73.7%). That is 26.2% of HCFs disposed of directly and 73.7% disposed indirectly to CBWTFs. In private HCFs 54.6% had a contract with CBWTFs, 11% admitted that they sold BMW to rag pickers and 34.4% throw away out BMW along with common wastes. This is a very important finding as many people get exposed to infectious biomedical waste like municipal solid waste handlers, rag pickers, children

Table 6 Factors associated with good BMW management (score > 5)

Factors		*N*	Adjusted odds ratio (95% CI)	*P* value
Location of HCF	Rural	88	5.61 (1.05, 30.07)	0.04
	Urban	34	1	
Level of care	Primary	97	3.85 (0.58, 25.4)	0.16
	Secondary	25	1	
BMW training status	Untrained	47	49.87 (7.2341.9)	< 0.001
	Trained	75	1	
Type of HCF	Public	61	7.07 (1.59, 31.49)	0.01
	Private	61	1	

playing around and animals. Hence, as suggested by El-Sallamy et al. (2018), health and safety training of all healthcare workers should be mandatory in hospitals. Further, disposal of BMW through CBWTF's should be mandatory for all HCFs.

In general, poor segregation of BMW at the point of generation, inappropriate collection methods, unsafe storage practices of waste, limited funding and lack of trained human resources, intermittent supply of appropriate personal protective equipment, lack of routine training and shared responsibilities among the departments involved lead to poor BMW management (El-Salam 2010; Hossain et al. 2011; Velpandian et al. 2018). BMW management is a multi-sectoral function that requires collaboration between policymakers, all level of implementers from national, state, and local governing bodies to medical professionals, private hospitals including CBWTFs. A frequent meeting of the stakeholder could help to overcome some of the barriers to better manage BMW in HCFs as shown by Ravindra et al (2016) in other cases.

Conclusions

Current study assessed the status of the BMW system in Fatehgarh Sahib district of Punjab, for better management at all levels of care in urban and rural areas. It was observed that only 4% of primary HCFs and 33% of secondary HCFs had good BMW management system. Nineteen percent of primary HCFs and 58.3% of secondary HCFs had a system for BMW management system but needed additional efforts for major improvement. Infrastructure in hospitals should be improved to collect, store, and transport BMW safely. Further, from subcenter and subsidiary health centers, there is a need for safe collection and transportation to another center. Two factors, type of hospital and BMW training status of nodal officer-in-charge were found significant for effective management of BMW. Further, BMW management requires sustained cooperation among all key actors for its safe disposal.

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Authors contribution AD and KR designed/conceptualized the study and conducted the field work. MK and RK helped to enhance the intellectual content of the protocol and manuscript, including review/editing.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests.

Ethical approval The study protocol was approved by the Institute Ethical Committee via letter number INT/IEC/2018/535 dated 23 April 2018. Permission from Punjab Pollution Control Board (PPCB) and Directorate Health and Family Welfare, Punjab, were also received via letter number EPA/2015/3768 dated 5 Nov 2015 and DHS.BMW-PB-15-01 dated 16 Jan 2015, respectively.

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