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Assessment of occupational and environmental safety associated with medical waste disposal in developing countries: A qualitative approach

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ABSTRACT

A carefully designed survey of medical waste management was undertaken in Dhaka, the capital city of Bangladesh. A range of sampling strategies and data gathering techniques were used. The data gathering techniques included observation, formal structured interview and informal dialogue. Sampling strategies included formal representative sampling for fixed populations and adaptive sampling for roaming populations was developed. Data were collected from healthcare establishments (HCEs) and other waste disposal operatives.

Operatives dealing with waste were frequently found to be untrained, and without even a basic understanding of the hazards involved. Personal protective equipment was inadequate in most cases which led to frequent accidental injuries. No HCE was found to have adequate storage facilities for hazardous waste. Thus scavengers were able to gain access to items such as syringes and expired medicines, which they repackaged and resold. The lack of correctly controlled internal storage may be linked to the observation that employees at many HCEs offered contaminated items for sale to scavengers and recycling operatives. In many cases there was no attempt at segregation, but in some cases there was segregation at the point of use, but subsequent remixing with general waste, indicating a lack of management and education rather than a lack of will. In either case, hazardous waste was dumped in city corporation bins, and disposed of on general landfill sites. As well as exposing the waste to scavengers, this could potentially contaminate ground water, especially as the dumps were located in areas subject to frequent flooding.

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1. Introduction

Medical waste may play an important role in the transmission and intensification of disease (Tsakona et al., 2007; Chaerul et al., 2008). This is a growing concern in developing countries (Shinee et al., 2008). Hazards associated with waste produced by healthcare establishments (HCEs), and the increased potential for infection and injury, have been frequently described (Marinkovic et al., 2008; Hoyos et al., 2008; WHO, 2004). There is particular concern that an informal sector dealing with the recycling of medical waste components may contribute to transmission of disease, especially among waste collectors, scavengers and recycle-operators.

Medical waste is defined as any solid or liquid waste that is generated from treatment of human beings in a hospital or clinic, from clinical diagnosis and pathological testing and from medical research (WHO, 2002). It comprises sharps, non-sharps, blood, body fluids, dressing materials, surgically removed body tissues, chemicals, pharmaceuticals, medical devices and radioactive materials (Lee and Huffman, 1996; WHO, 2002). The waste generated from HCEs both as hazardous and non-hazardous are considered as medical waste in this study.

Many countries maintain stringent management systems for handling and safe disposal of medical waste to minimize the risk (Chaerul et al., 2008; Woolridge et al., 2008; Duan et al., 2008; Zimmer and McKinley, 2008). In developed countries, technologies such as autoclaving and incineration are used for treatment and final disposal of medical waste. However, in developing countries, medical waste has not received adequate attention (Almuneef and Memish, 2003), particularly when it is disposed of together with the domestic waste (Patil and Pokhrel, 2004). As a consequence it may be a cause of disease amongst waste cleaners, waste pickers, collectors, and recycling waste operators (Becher and Lichtnecker, 2002). Furthermore, it has been reported that medical waste presents an increasingly high risk to doctors, nurses, technicians, drain cleaners, sweepers, hospital visitors and patients due to disorganized management (Massrouje, 2001). Risk minimization for medical waste has become a major concern worldwide. In most countries there is a growing awareness that the uncontrolled hazardous medical waste generation may create the potential for the spread of disease (Chen et al., 2006).

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The rapid growth of a disorganized healthcare sector in Dhaka City, Bangladesh has resulted in an environmental health hazard (Ahmed et al., 2006; Rahman et al., 2007; Patwary et al., 2009a,b). According to the Bangladesh Directorate General of Health (DG Health report, 2005), there are more than 840 healthcare establishments situated in Dhaka City. Patwary et al. (2009a) reported that 37 ± 5 tonnes of medical waste, including domestic and recyclable waste, is generated from hospitals, clinics and other healthcare establishments (HCEs) on a daily basis in Dhaka. A number of reports published by development agencies, such as the World Health Organization (WHO), and the International Centre for Diarrhoeal Disease and Research in Bangladesh (ICDDRB) have shown that there is a high incidence of cholera, typhoid, dysentery, infective hepatitis, polio and dengue among people who live in Dhaka (WHO, 2000; Anon, 2002; Ahmed and Chowdhury, 2003; Andersen and Pettersson, 2003). The incidence is higher in areas where a high number of hospitals, clinics and diagnostics centres are located, and Dhaka City Corporation (DCC) has thus recognized these areas as a "red zone" for these diseases (Rahman et al., 2008). The scale of problem is large and the need for detailed and accurate research is urgent.

Most studies have been focused on quantification of medical waste generation. Few have addressed the environmental and behavioural context in developing countries and limited have done so in Bangladesh. We fill this gap by examining environmental context and occupational safety amongst medical waste operatives, in Dhaka, Bangladesh. Previous research typically has not been focused on relationships between occupational safety and behavioural context using a qualitative approach combined with an environmental interpretation and explanation. The aim of this research was to observe the processes for waste disposal in Dhaka and to investigate the potential risks to environmental safety, particularly for the individuals who are working with medical waste.

2. Methodology

Qualitative research methods were applied to examine the behaviours of workers involved in the control and disposal of medical waste. Data were obtained using an observational approach and informal dialogue. In some cases (as described below) this was followed up by the use of a questionnaire and in-depth interview with closed and open questions (Hague, 1993) in an attempt to study the skills and knowledge that inform the observed behaviours.

Fieldwork was started by social network mapping, adopting an observational approach (Jorgensen, 1989), over a 5 months period in 2006. This technique is normally used in field based data collection procedures to elucidate relationships between a community and its environment. Initial observation suggested three significant and distinct target groups:

1. Employees of the various departments in the Health Care Establishments. This group comprises three significant subgroups.
   (a) Individuals working directly or indirectly involved in patient care. This includes medical unit staff, laboratory staff, Ambulance staff, HCE kitchen staff, and other support staff.
   (b) Individuals transferring waste from inside bins to road side bins.
   (c) Individuals working for mortuary departments.
2. DCC waste collectors, employed by DCC to collect waste from road side bins and to transport it to designated dumping places.
3. Operators and other support staff at official medical waste treatment centres.

Having identified these potentially significant groups, each group was sampled according to a sampling plan appropriate to that type of population.

2.1. Group one

The population of HCEs in Dhaka was defined by a list supplied by the Directorate General of Health. A representative sample of 69 HCEs was chosen as described in Patwary et al. (2009a). A total of 168 questionnaires were administered at 69 HCEs. One key participant was chosen at each of 21 clinics and 44 diagnostic centres. A sample of participants was chosen from different wards and departments at each of the four hospitals included in the study based on the size of the hospital (public hospital A: $n = 60$; public hospital B: $n = 29$; private hospital A: $n = 9$; private hospital B: $n = 5$). Knowledgeable key informants were selected within each HCE or department, based on their willingness to participate, and on their expertise and position (Rich and Ginsburg, 1999). Informed consent was obtained from each participant.

2.2. Group two

This is a large and diverse group. An "adaptive sampling for roaming population" approach was developed which was developed by a combination of 'adaptive sampling' (Thompson and Collins, 2002; Chaudhuri et al., 2004) and a street-based sampling (Clements et al., 1997; McMahon et al., 2003) approach to study this group. Most of the group members would be expected to have little no regular contact with medical waste, so a purposive/authoritative sampling technique was chosen, focusing on those operators working mainly with roadside bins adjacent to the HCEs. Twelve participants were selected and interviewed following a similar approach to that used for HCEs.

2.3. Group three

The total population of this small group was found to be 8 employees. All of these agreed to be participants and gave informed consent and were interviewed following a similar approach to that used for HCEs.

Thus a total of 188 participants were surveyed across the three groups.

3. Precaution of data collection and ethical issues

Ethical considerations are essential to any form of data collection in a humanitarian operation. Collecting information for any purpose, including monitoring, assessments or surveys, can put people at risk not only because of the sensitive nature of the information collected, but also because simply participating in the process may cause people to be targeted. The risks can range from physical violence to social marginalization and are often unknown to the individual soliciting the information. Therefore, participants were treated fairly and with dignity. Because the research involved an intrusion into the private lives of the participants, the researcher and FIs were always respectful, polite and reliable to the respondents. This helped to built rapport between interviewer and respondents.

Proper training of field personnel represents a critical aspect of quality control. Before conducting the study, ten Field Investigators (FI) were recruited from different universities based upon their previous experience regarding the field level data collection. It was noted that almost all of the FIs had already received training on the use of standardized protocols to ensure safe and ethical collection of data, and to ensure compatibility among different

groups. Never-the-less, an extensive training program was organized mainly focused on the procedures of data collection and ethical issues. A proper procedure to manage the selected informants was followed at all times. In addition, previous experience of the researcher's was described concerning to the possible problems they would be faced and how to tackle the issue.

The fieldworkers were required to sign a statement that they would not reveal identifying information to anyone outside the research. Furthermore, code names were used in all field notes. A master key was retained for un-coding the personal data at the end of the study, at which time all keys were destroyed. In some cases, interviews took place in a quiet confidential area in a mutually convenient location particularly for roaming population. Possible precautions were taken to minimize the risks during the survey. Personal protective equipment (PPE) was used as appropriate (gloves, mask, safety glasses, disinfectant soap and cream, safety shoes, safety hat, first aid kit). The use of PPE was rigorously enforced. FIs were strictly advised to wash their hands before eating during the survey. After the completion of everyday fieldwork, FIs were encouraged to change their clothes and wash themselves thoroughly. If they exhibited any disease symptom or suffered any accidental injury, they were screened and diagnosed clinically by physician an emergency basis. Emergency situation either physical violence or accidental problems were minimized to contact with the main researcher as appropriate. All of them were issued with a letter of reference by the Teesside University. This was used as a proof of identity. If they faced either physical violence or accidental problems they were advised to contact the nearest police or responsible person. In addition, as FIs were always in contact with the main researcher by mobile telephone, the main researcher can easily reached them if emergency arise and solved the problem. A Tk20 (BDT) remuneration (£0.20 approximately) was given as compensation to each respondent as appropriate who took part in the face-to-face interview previously suggested (Clements et al., 1997; Auerswald et al., 2006).

4. Data collection

4.1. Observational approach

An observational approach was adopted as it reduces the effects of the data collection process on the behaviours of the observed population (Jorgensen, 1989). The investigator joined in the contacts and watched actions and behaviours of selected participants in their usual settings, noting the routine aspects of daily life and nature of work activities. During the observational approach, photographic data was also collected, using a digital camera, on different activities of HCEs, treatment facilities, recycling activities, scavenging activities and other phenomena related to medical waste in the study area. Collected photographic data was interpreted and illustrated to analyse the research findings.

4.2. Formal interview

A number of formal interviews (including both closed and open questions) were arranged, as judged appropriate in each individual circumstance.

4.3. Informal dialogue

A number of informal dialogue approaches were used in situations where the formal technique was not judged to be appropriate. For example group four and five. The dialogue approach involved face-to-face interviews between the researcher and selected informants at times and places where the participant's interest could be obtained and retained; interviews were conducted in tea-stalls or in hotels, near to a road side bin or in a road, at waste collection time or in any free time, during the day or at night, in good weather or bad. Quantitative data was recorded in SPSS (version 15) and analyzed by descriptive statistical methods, and then illustrated and interpreted with a range of qualitative mode of analysis.

5. Results

5.1. Estimation of total waste and waste segregation system used in the study area

Table 1 shows estimated total generated waste at source and Table 2 shows total estimated composition of waste in the study area use of extrapolation from our another study findings (Patwary et al., 2009a) which the first part of this study. Table 3 shows that only 10% of the surveyed HCEs followed proper disposal procedures, as specified in the WHO Code of Practice (WHO, 2004), to collect and manage medical waste and 25% were followed partial disposal procedure. The remaining HCEs (65%) collected their waste without any segregation and placed it in DCC bins, where the majority was collected by DCC from bins and road sides near the HCEs. In these HCEs, employees were observed using unsuitable and unlabelled containers and plastic bags, without colour codes or biohazard signs, contrary to the WHO Code of Practice (WHO, 2004). Medical waste from these establishments was mixed with municipal waste even when the waste was blood-stained and potentially infectious.

The HCEs authority frequently handled and disposed of their medical waste, along with litter, in domestic bins, drains, general sewerage systems or even in canals. It was observed that sometimes surgically removed anatomical body parts are also dumped into road side bins. Although, not part of the main focus of this study, it was at the same time observed that liquid waste and wastewater of HCEs was discharged into the general sewerage system without the necessary precautions. A small proportion of medical waste was observed to be collected and managed by 'non-governmental organizations' (NGOs) in separate containers and transported by specially designated vehicles for final disposal.

5.2. Occupational health risks to waste workers exposed to medical waste

HCE waste cleaners and collectors collect the medical waste and hand it over to DCC waste operators for disposal. Waste scavengers

Table 1
Medical waste generation in Dhaka City kg day^{-1}.

Source of waste	Estimated generated waste at source in Dhaka kg day^{-1}	Percentage (%)
Administration/ support service	3082	8.85
Patient service/ward	6308	18.10
Laboratories/research	617	1.7
Operation theatre	1632	4.69
House keeping	435	1.25
Disinfecting activities	1849	5.31
Emergency	508	1.45
Blood bank	290	0.83
Pharmacy	653	1.87
Laundry	290	0.83
Kitchen	17,582	50.46
Engineering	508	1.45
Public areas	1088	3.12
Total	**34,842 ± 5**	**100**

Table 2
Composition of waste generated in surveyed HCEs kg day^{-1}.

Types of waste		Estimated type of waste generates in Dhaka kg day^{-1}	Percentage (%)
Non-	hazardous	General	28,715
82.41			
Hazardous	Pathological	1668	4.78
	Infectious	870	2.49
	Pharmaceuticals	688	1.97
	Chemical	875	2.51
	Sharps	1011	2.90
	Toxic	833	2.39
	Radioactive	182	0.40
Total		**34,842 ± 5**	**100**

Table 3
Disposal practice in the surveyed HCEs.

HCEs	Disposal			
	Proper	Partial	Without	Total
Private hospital	0	2	0	2
Public hospital	0	0	2	2
Private clinic	4	7	10	21
Pathology/diagnostic	3	9	32	44
Total	7 (10 %)	17 (25%)	45 (65 %)	69 (100%)

Proper: disposal according to medical waste management guide (WHO, 2004) through NGO;
Partial: disposal of waste, but without proper guidance and;
Without: disposal along with general municipal waste.

then scavenge the waste at the disposal sites. They sort through the waste, searching for saleable items like syringes, saline bag, plastic materials, cans, metals etc. from medical waste. The items are collected, washed, repacked and resold to the public.

Of the HCEs that disposed of all of their waste into the general DCC domestic waste bins located outside the premises, it was observed that in each case, this followed a period of temporary storage, sometimes in an open space within the hospital, clinic or pathological centre premises, sometimes in a room along with stationery and medical supplies. Storage areas for medical waste were not well secured and sharps containers and other 'recyclable' waste were frequently taken by scavengers to be recycled. In the study area, most of the HCEs stored infectious sharps containers in general utility areas without any proper labelling or other precaution; this practice may also result in contaminated injection equipment being scavenged and reused.

No external storage was found in any of the surveyed HCEs. When preparing the study area plans it became obvious that small and medium sized HCEs were generally situated with limited space within densely populated residential areas.

In the present study, it was observed that most of the waste workers were unconcerned about potential injuries. Working with medical waste for long hours may cause physical problems, such as skin disease through dermal contact (Kuusisto et al., 2007), respiratory disorders from inhaling dust (Nielsen et al., 1997), gastrointestinal disorders such as diarrhoea, dysentery and food poisoning through ingestion (Ivens et al., 1997). This seemed to reflect the attitudes of their employers, none of whom implemented a monitoring program of waste workers' occupational health and safety. Waste management, and the control of infections and accidents arising from contaminated waste, are not considered the main activities of HCEs. Therefore, no record was kept of waste workers' illness or accidents related to waste management.

In this study it was observed that cleaners and waste collectors working in most of the HCEs within the patient wards or in the mortuary department usually did not wear sufficient PPE during waste handling. This was also true of DCC waste workers and workers at treatment facilities This was supported when participants were questioned about their understanding of occupational health; 78% reported that they did not use any chemicals or detergents during the cleaning of equipment, while 73% of participants did not regularly wear PPE during waste handling, and only 18% wear PPE daily during waste handling. DCC and most HCEs failed to provide any PPE to employees, while scavengers and other unofficial waste handlers had no opportunity to obtain PPE. A small proportion (7%) of HCE and DCC waste workers indicated that they had heard about protective uniforms, but had never seen them. Of the 9% who reported that they occasionally use PPE, most mentioned that they only do so when required to, often due to an official visit by external dignitaries.

As might be expected, this lack of suitable precautions seems to result in a significant number of potentially serious injuries, and most waste workers (94%) reported that they had experienced accidental injury within the previous month, mostly from used needles and other sharps, and of these 28% were considered serious by the respondents according to their self-reported disease symptoms. When questioned, they were found not to be aware of hazards arising from needles or sharps. Only 23% of participants reported that they had received even basic introductory information on occupational safety related to medical waste management, and most of these indicated that this information was provided by an NGO PRISM Bangladesh. Possibly as a result of this lack of training, many respondents reported that they did not follow basic hygiene practices following exposure to medical waste, including potentially hazardous waste. This supports the previous observation of Ahmed et al. (2006) who found that 70% of HCEs did not offer any training. As an illustration of the issues arising from a lack of training, some respondents reported that some members of the community use some of the waste receptacles, such as sharps containers, to store food, while some HCE staffs were observed giving out used hazardous waste bin bags to patients to carry their personal belongings.

5.3. Incineration

No proper functioning incineration facilities were observed in the study area. The incinerators found in the study area, used for incineration of medical waste did not meet the required standard. The example shown was operated manually, all types of waste being burnt on site using kerosene, with the residues disposed of into the adjacent area. Two potentially more effective incinerators were not being used at the time of the survey due to the lack of a suitable operative.

5.4. Dumping and threat to communities and environment

This study has focused on threats to HCE and waste workers, who may be at high risk. There is also a risk to the general population, for whom contact with hazardous medical wastes is more likely to occur after it has been dispersed in the environment. Environmental risks have arisen due to poor knowledge of waste operatives and their improper activities. However, no HCE was found to have an EMP and few (23 from 168) respondents were aware of WHO guidelines. Even senior management (35 from 69) had no knowledge of their establishment's requirement to have an EMP. The lack of appropriate or improper medical waste disposal facilities in Dhaka is largely due to inadequate resources and legislation. This leads to the persistence of inappropriate practices such as the discharge of chemical waste into the general sewerage system or dumping into or near agricultural land. Chemical waste in the form of pharmaceutical waste (e.g., antibiotics and other drugs), heavy

metals such as mercury, phenols and derivatives and other chemicals used in hospital laboratories were found to have been discharged into the general sewerage systems. There is evidence that these chemicals interrupt the natural ecosystems and cause toxic effects in plants (Blenkharn, 2006). Hazardous waste was found to have been dumped in city corporation bins, and finally disposed of on general landfill sites, which may contaminate ground water, especially low-lying areas subject to frequent flooding. In the present study, it was observed that, during the rainy season, leachate from dumps used for medical waste infiltrated into water that was being used for washing and household purposes as well as for agriculture.

6. Discussion

In the present study, waste was classified according to WHO (1999) guidelines. The mean percentage of the source and composition of medical waste generation was found in the order of *kitchen > patient service/ward > administration/support service > laboratories/research > disinfecting activities > operating theatre > harmacy > public areas > housekeeping > emergency > engineering > laundry > blood bank*. Hazardous waste composition was found in the order of pathological > infectious > pharmaceuticals > sharps > chemical > toxic > radioactive waste. This proportion of the source and composition of medical waste generation is comparable to those observed by other studies in Saudi Arabia (Almuneef and Memish, 2003), Mauritius (Mohee, 2005), Croatia (Marinkovic et al., 2008) and Indonesia (Chaerul et al., 2008).

In the present study, a partial segregation procedure was observed in 25% of HCEs, but this was generally ineffective, as in these establishments the segregated wastes were subsequently mixed together as they were collected from the site of production and taken for temporary storage. It seems likely that it should be relatively straightforward to achieve complete segregation in these HCEs if some additional training were available to operatives. This mixing of hazardous materials with general waste makes the total waste infectious and represents a serious hazard to workers and the general public. This is similar to the findings of Sabour et al. (2007) who studied the mixing of infectious waste with non-hazardous medical waste in Jordan. Akter and Trankler (2003), in a study focusing primarily on hospitals in Dhaka and Khulna, noted indiscriminate disposal of medical waste into open city corporation bins, along with household and general municipal waste. The present study has confirmed and extended this observation, showing that the situation is similar among a larger sample of clinics and diagnostic centres.

Most of the HCEs have insufficient space to setup secure temporary storage for waste, or to install appropriate equipment for decontamination or final disposal of hazardous waste. In the case of the smallest facilities, the space required for even basic provision would significantly reduce the number of beds or tests that the facility could support, and so reduce profitability. The lack of correctly controlled storage may be linked to the observation that employees at many HCEs offered contaminated items for sale to scavengers and recycling operatives, mostly to melt down plastics for recycling, but sometimes for repackaging and resale (Patwary et al., 2011b). The scavenged items which are repacked and resold to the public may create a cycle of disease transmission (Borg, 2005). According to a WHO report (2004), injections with contaminated syringes in a single year (2000) caused 21 million hepatitis B virus (HBV) infections (32% of all new infections), 2 million hepatitis C virus (HCV) infections (40% of all new infections), and at least 260,000 HIV infections (5% of all new infections) in the world (WHO, 2004). Hazardous waste containers are capable of nosocomial diseases transmission in individuals who are exposed to medical waste (Neely et al., 2003). WHO (1999) reported that injuries to the skin, eyes or mucous membranes are frequently caused by contact with flammable, corrosive or reactive chemicals which may result in headaches, eye irritation, dizziness, difficulties in concentration, fatigue, respiratory function disruption and many other symptoms.

Reported accidental injuries are much higher than the rates observed in other countries. Rahman and Ali (2000) reported that in Japan 67% of HCE staff reported accidental injuries, compared with 50% in Peru and 18% in USA. It is possible that the difference is even greater than it seems as there is no possibility of compensation for injuries suffered in Bangladesh, and so no incentive to remember or report an injury. Many of the injuries reported in this study involve foot injuries resulting from standing on sharps, or hand injuries from handling sharps. These could easily be addressed by provision of PPE. The provision of education and training would also help to address the issue (Adegboye et al., 1994).

DCC waste workers, treatment workers and others involved in collection and disposal of general waste are exposed to an additional risk do to contamination of materials in city bins with hazardous waste. This places an additional requirement to supply training and PPE to these workers. This requirement is not being met. DCC workers were not found to be aware of hazards, and were not supplied with any PPE. Even if the general city waste were not contaminated with medical waste, this would be unacceptable, but given the levels of contamination found in this study, the situation is especially serious.

The WHO Code of Practice recognises incineration of medical waste as a commonly used, and effective, method of disposal, and lays down minimum standards for temperature and chimney height. It was apparent that there was only partial burning of waste which has previously been described to constitute a health risk (Agramunt et al., 2003). Partial burning of plastic materials and other organic compounds lead to emissions of a number of toxic chemicals including vinyl chloride (VC), carbon monoxide, particulate matter, hydrogen chloride, poly-cyclic aromatic hydrocarbons (PAHs), dioxins (polychlorodibenzo-*p*-dioxin (PCDD)) and furans (polychlorodibenzofuran (PCDF)) (Hoyos et al., 2008; Javied et al., 2008; Kao et al., 2008; Marinkovic et al., 2008; Wang et al., 2008; Zhao et al., 2008). The emission of heavy metals and organic substances from improperly operated incinerators may introduce a high risk to the environment and hence the community (Agramunt et al., 2004). The main dumping zone used for medical waste lies within a region recorded as being subject to frequent flooding. This is likely to disperse the hazard, vastly increasing the number of people potentially exposed.

Improper disposal and dumping of medical waste to the general waste dumping site may presence environmental hazards through groundwater and soil pollution, (Tsakona et al., 2007) as it contains highly toxic chemicals and heavy metals. Wastewater discharged from healthcare establishments (HCEs) is a multifaceted mixture, which can present a source of potential environmental problems in water and soil, as it is 5–15 times more toxic than conventional urban effluents (Mohee, 2005; Tsakona et al., 2007). Soil pollution has become an important environmental concern in developing countries due to changes in land use patterns (urbanization, industrialization, infrastructure development, hazardous waste disposal as contaminants) over the last few decades. In developing countries, such as Bangladesh, HCEs often dump medical waste along with general municipal waste adjacent to agricultural land (Patwary et al., 2009a,b, 2010), possibly causing groundwater and soil contamination. The potential increase of heavy metals in agricultural soils through hazardous waste dumping may not only result in soil contamination, but also lead to elevated heavy metal concentration in food crops and plants (Muchuweti et al., 2006). This is one of the significant pathways for the entry of these toxic pol-

lutants into the human body (Khan et al., 2008). The metal-contaminated food can seriously deplete some important nutrients in the human body which may cause weakening of immunological defences, intrauterine growth retardation, impaired psycho-social faculties, disabilities with malnutrition and a high frequency of upper gastrointestinal cancer rates (Iyengar and Nair, 2000; Türkdogan et al., 2003). To consider the health risks, it is necessary to identify the potential source of risk agents in the soil. The contamination of soil where medical waste has dumped not been assessed previously. While such exposure is of immediate scientific concern, it is incumbent on researchers to determine the impact of long-term irrigation of agricultural soil with contaminated water, in order to minimize the threat of environmental contamination.

The purpose of this qualitative study was to gather and consider the behaviour of different medical waste workers in Dhaka, Bangladesh. The unique circumstances faced by medical waste workers, particularly in developing countries, exacerbate the likelihood of their lack of knowledge on medical waste handling. Poor knowledge of waste segregation due to the lack of adequate training of waste workers, general misunderstanding of the composition of medical waste and related risks by most waste workers creates further problems. The poor understanding or lack of knowledge of the waste workers resulted in mismanagement of medical waste. This study reveals many examples of organisational lack of awareness similar to findings reported by Patwary et al. (2011a). It is important to look critically at the terminology used in the medical waste management sector and to ensure that all individuals and groups concerned are not only aware of such terminology but also understand their application. The public health hazard is not only threat in the study area but in all other city like Dhaka where untrained people are forced to work with this hazardous waste for their livelihood.

Dhaka district is located in the middle part of Bangladesh. About more than 60% of this population resides in metropolitan area making the city most densely populated in the world (BBS, 2007). Although its urban infrastructure is the most developed in the country, Dhaka suffers from different urban problems such as pollution, congestion, and lack of adequate public services which may similar like other cities in the world. These similarities vary on geographical, demographical, economical, infrastructural, societal and cultural aspects. Developing countries are trying to develop new efforts for more comprehensive schemes regarding eco-friendly medical waste management, Dhaka being among them. These countries have learned much from the experience of forerunners on medical waste management such as USA, Sweden and Canada. However, countries should not directly adopt the approaches used by others; they must learn from forerunners and develop a proper medical waste management plan according to country perspective. The management plan adopted must take into account in political, scientific, technical, social, and economic aspects. The social, economic, and political barriers characteristic of megacity problems will need to be recognized and analyzed. Considering of the results of this study, the risks related to medical waste could be identified and minimized not only in Dhaka city, but in all of the cities in the developing and developed countries who are at similar risks from medical waste.

6.1. Constraints

There are a number of issues which could potentially limit participation or introduce bias to the results.

The first of these may arise because HCEs were initially concerned that any data collected as part of this study might be used against the HCE to assess official penalties or to jeopardise the image of HCE. To address this concern, a series of meetings was organized with appropriate authorities from the HCE and with the selected respondents to reassure them that confidentiality would be strictly observed, and that the data was to be collected only for academic research purposes. Following this process, HCEs generally agreed to participate; a substitution procedure (as described in Patwary et al. (2009a) was adopted for those HCEs (7) for which consent could not be obtained.

Another constraint arose because many operatives were concerned that participation would lead to prosecution for involvement with illegal activities, or that their identity would be published. Some initially hid to avoid contact with the investigators. This was addressed by adopting an extended, informal, dialogue approach by which the researcher attempted to establish contact and develop trust, allowing the purpose and conduct of the survey to be explained.

7. Conclusion

The WHO has issued detailed guidelines for control and disposal of health care waste (WHO, 2002) in recognition of the serious hazards to HCE workers, waste workers, and the general public. These hazards have been studied by many groups (Becher and Lichtnecker, 2002; Chen et al., 2006; Marinkovic et al., 2008; Tsakona et al., 2007; Chaerul et al., 2008). Observation and survey of current practice in Dhaka has revealed many examples of failure to follow these guidelines.

In some cases poor waste management practice was due to a lack of resources. No HCE was found to have an adequate budget allocated to waste management. Cleaners and waste workers were rarely issued with PPE, and respondents often claimed that this was due to a lack of funds. While less affluent HCEs have limited resources, many respondents, including those at the more successful HCEs, also suggested that the problem was linked to a lack of rigorously enforced Government regulations.

In some cases the problems arose from a lack of planning. This is best illustrated in the HCEs which were found to segregate waste, but then allowed it to be remixed with general waste. This indicated a willingness to allocate some resources to proper waste management, but that the understanding required to follow this through to an effective final safe disposal was lacking. National legislation (The Environment Conservation Rules, 1997) requires each HCE to have an Environmental Management Plan (EMP) which, if properly monitored, would probably have revealed the problem. The situation becomes still more serious outside the formal HCE and DCC operations. Because of the poor management and disposal of waste, there is a significant illicit economy of scavenging, repackaging and reselling of extremely hazardous items, including medicines and used syringes. Alongside this is a more ambiguous economy where materials, often plastics, are recycled by individuals working in poorly controlled conditions. These individuals may obtain their raw materials from scavengers, or by purchasing them directly from HCE employees. While the hazards associated with these products are considerably less than with repackaged syringes, there are still serious risks to the operators and their suppliers. In each case the present study found that the individuals involved did not understand these risks.

In order to prevent or reduce the identified problems and risks the following general remedial measures are proposed, which are suitable for a developing country;

1. Promote proper segregation of waste as guided by WHO, including promotional activities and behavioural awareness dealing with the risks presented by medical waste, both to HCE and waste workers and to the general population.

2. Proper and secure storage facility for hazardous waste followed up by appropriate safe final disposal.

In order to achieve these, it would seem that additional investment and training are required. To ensure that waste is properly segregated at the point of its generation, that it does not subsequently become mixed with general waste, that any required transport and storage are secure, and that final disposal is safe and environmentally appropriate, it is important that this investment and training is consistently applied across all HCEs, the DCC and the various treatment facilities. Waste handling needs to be secure at every point in the chain.

This study revealed that there may be a layered arrangement of networks that inform the actions of actors involved in medical waste disposal. Different networks may operate at each level from national governance (DCC) to waste operatives. Interaction between the networks does not appear to be constructive, with evidence of corruption. The most effective attempts have been based on the efforts of NGOs working within specific localities and communities. Their initiative has partially succeeded precisely because they are integrated within a particular layer, but they are not in a position to disseminate their message to higher or lower layers, or beyond the locality in which they operate. Thus, to minimize the potential risks associated with medical waste it is necessary not only to identify the structured network, but also identify how the network is structured to a plan for socio-cultural and organisational acceptance from top to bottom in the environmental context. Therefore, need to identify the behavioural socio-cultural aspects towards structured network which may influence psycho-social networks.

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