REVIEWS

Quantitative assessment of mortuary waste: occupational safety and environmental health

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Abstract

Mismanagement of mortuary waste is a significant risk factor for disease transmission. Quantitative estimation of mortuary waste generation is needed to estimate the potential risk and as a basis for any waste treatment, disposal and management plan. Bangladesh, a developing country, is an example where there has been no rigorous estimation of mortuary waste generation and associated risk factors based on a thorough scientific study. The present study used a statistically designed sampling method of waste generation in a broad range to identify the factors associated with public health and environmental safety. The data gathering techniques included observation, formal structured interview, informal dialogue, and waste weighing.

The proportion of mortuary waste classified as hazardous by the World Health Organisation (WHO) guidelines was found to be high. The waste generation rate per dead body was found to be 9.00 ± 2.52kg and average waste generation per day was 918 ± 11kg among the surveyed mortuaries. Operatives dealing with the infectious waste were frequently found to be untrained, without even a basic understanding of the hazards involved. Personal protective equipment was inadequate in most cases, which led to frequent accidental injuries. None of the mortuaries were found to have adequate storage facilities for dead bodies as well as hazardous waste in the context of environmental health and safety. Hazardous waste was dumped into city corporation bins, and disposed of on general landfill sites. As well as exposing the waste to the environment, this could potentially contaminate ground water, soil and sediments, especially as the dumps were located in areas subject to frequent flooding. The significant factor of health and environmental risk was identified as decomposition of dead bodies. The degree to which dead bodies are decomposed is related to the time taken to bring them to the mortuary and to the duration of the autopsies. The delay was due to poor communication, low level of interest, transportation cost, and trying to avoid social harassment. This is the first study to attempt this type of thorough estimation of mortuary waste and assessment of risk on environmental health occupational safety.

Key words

Mortuary waste, Quantification, Environment, Environmental health and occupational safety, Bangladesh

1 Introduction

The safety and acceptability of many widely used medical waste management practices are of serious concern from a public health point of view. In spite of ever-increasing unnatural death, mortuary waste, one of the potential hazardous sources of medical waste, remains a prominent concern with regards to means of disposal and implied treatment.

Post-mortem assessment and examination of bodies to determine the cause of death is carried out in forensic departments attached to hospital mortuaries, where every step of corpse management generates waste, whether it is liquid, gaseous, or solid [1]. This is now an emergent concern in developing countries where medical waste has not been properly managed [2-8]. A study of sanitary issues relating to burial reported, that improper burial may contaminate the soil and ground water with leachates from the dead body, which obviously may present serious hazards [9]. In western countries, burial and cremation are very strictly regulated, and while there is an extensive literature on the environmental impact of cremation, very little has been published on environmental hazards arising from burial or from mortuary waste [10-13]. Burial is an appropriate method of disposal [14], and concluded that there is little evidence for microbiological contamination of groundwater from normal burial. None of the organisms associated mass fatalities (for example plague, cholera, typhoid, tuberculosis, anthrax or smallpox) is likely to survive for a long time in buried human remains, they made no claim that there was no risk of contamination in the short term [10].

2 Literature review

There have been a number of reports that individuals working with, or who come in contact with, dead bodies are exposed to potential hazards due to infectious agents. Funeral directors and mortuary workers involved in routine embalming of deceased tuberculosis (TB) patients in Florida, USA have an increased risk of TB [15]. Similarly, Healing [10] considered that the recently deceased present a hazard due to pathogens, in particular tuberculosis, group A streptococcal infection, gastrointestinal organisms, the agents that cause transmissible spongiform encephalopathies (such as Creutzfeldt-Jakob disease), hepatitis B and C viruses, HIV, and possibly meningitis and septicaemia. Mold spores present a great risk to those involved in exhumations [10]. Other risks to staff include exposure to chemicals such as formalin and alcohol, as well as substances whose real chemical nature may be unknown to staff (such as poisons and pesticides) and gases released due to the decomposition of body tissue or from poisoning cases [16]. Bhat [17] discussed a case of gynecomastia occurring in a mortician, reporting that it may have been caused by an embalming cream containing estrogens or estrogens-like compounds. Patel [18] considered that morbid anxiety about occupationally acquired HIV infection in the forensic practice has made mortuary workers in India unduly cautious, while Meel [16] and Brysiewicz [19] noted a significant risk of psychological stress, contributing to depression, anxiety and substance abuse amongst medical waste workers. Meel [16] also discussed ergonomic factors such as poor ventilation and light, extreme heat and cold, and inappropriate postures during lifting of bodies.

The hazards to which mortuary staff and visitors may be exposed can be exacerbated by poor training and unhygienic conditions [12, 14, 20]. The use of appropriate protective clothing and the observance of Control of Substances Hazardous to Health regulations can help to protect those who handle cadavers [10]. Despite the availability of codes of practice, there remains a significant concern that there may be inadvertent risks of HIV or other serious infections from bodies that are assumed to be uninfected [18]. It is important that guidelines are reasonably simple and based on an assumption of hazard. An emphasis has also been laid on effective mortuary waste-disposal systems to control the spread of diseases [20]. In heavily populated, developing countries, for example India, Bangladesh and some parts of Africa like Mozambique, there may be no strict official control of burial and cremation [21]. This can be related to particular religious traditions.

There appears to have been little published on the hazards associated with this waste treatment and disposal in developing countries. The main objective of this study was to evaluate the potential risk factors associated with the hazardous waste generated from mortuary departments in a developing country by: (1) quantification of the waste generation, (2)

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post-mortem and waste generation procedures, (3) observation of the current disposal practices, and (3)the impact on mortuary employees and the wider environment.

3 Materials and methods

Study area and study sample

Government records show that there are 19 public medical college and medical college hospitals in Bangladesh and 17 have a morgue for post-mortem of deceased [22] which were considered for this study as the sample for infectious medical waste sources. All are enclosed and operated by the public medical college hospitals under the forensic department. All dead bodies, where death was not due to natural causes, are taken to these mortuaries within the surrounding area.

The researcher contacted the senior management of the selected mortuaries in the study area. A number of appointments were made to discuss the study purpose and ask for permission to carry out the research. After a number of appointments and discussions, the researcher received permission to start research activities. Informed consent was then obtained from the participants. Quantitative data was gathered through weighing waste generated in the mortuary by a hand held scale [2]. The data were recorded in SPSS (version 12) and analysed by descriptive statistical methods. Where data were found to be normally distributed, average values are given ± 95% confidence intervals. Other estimates of error are explained where they are given. Qualitative data were obtained by adopting an observational approach, including formal and informal interviews. The goal of qualitative inquiry is to determine and explain a pattern of relationships that may best be analyzed by grouping the data into conceptual categories, either predetermined or arrived at through the accumulation of data [19, 23, 24]. Manual line-by-line in-vivo microanalysis of the collected data was performed. A process of theoretical validation of the data was undertaken to ensure that the units of classification (themes, issues, concepts) were sensitive to the participants' description. Interpretive analysis was conducted by extraction from the transcripts, then extracted themes were categorised and organised. Finally, qualitative data were analysed by an interpretive research method [25] while interviewing this group of mortuary staff and exploring their reflections on their experiences.

4 Ethical considerations

Ethical approval for this study was obtained from the Ethics Committee of the Teesside University and permission to conduct the research was obtained from the management of the mortuaries involved. The participants were selected on a voluntary basis and their consent was obtained. Participants were briefed on all of the ethical issues relating to the study and informed of the research aims, procedures and confidentiality as well as their right to withdraw from the research at any time or the right not to answer any question. The research methodology was simple and non-invasive, and designed to avoid deception and physical or emotional harm to the participants. Participants were given a choice to remain anonymous.

5 Study population

Initial observation suggested three significant and distinct groups of participants:

1. **Group One:** Forensic physicians and support staff

   The total population of this group of hospital employees was determined from hospital records. The group included forensic experts and administrative forensic staff.

2. **Group Two:** Individuals involved in opening or dissecting dead bodies by cutting and reshaping again by suturing the body afterwards (mortuary assistant). Members of this group, defined by the local term '*dome*' [4], are

responsible for handling, storing, cleaning and opening the body prior to internal examination by medical or forensic experts, and then for embalming and closing, cleaning, and moving the body prior to handing it over to the deceased relatives. The group can be considered to consist of two types of workers; official *domes* and unofficial *domes.* The official *domes* are recruited and paid by the hospital. As the number of bodies to be processed can often be too many to be dealt with in a timely fashion by the official *domes*, unofficial *domes,* generally relatives of the official *domes* involved in this work by family tradition, can receive payment from relatives of the deceased in return for help in dealing with the body.

3. **Group Three:** Individuals who are responsible for the external physical examination of bodies from the police department where there were suspicious circumstances. A number of police individuals were not interested in being participants as they thought they would be disciplined by their superior authority.

A sample of participants was chosen from different morgues at each of the seventeen morgues included in the study based on the convenience of the study population. Thus a total of 115 participants were surveyed across the three groups (Group One n = 23; Group Two n = 72 and Group Three n = 20), each participant was given a unique number (1-115) and questionnaires were administered. Knowledgeable key informants were selected within each morgue and forensic department, based on their willingness to participate, and on their expertise and position**.**

6 Data collection

6.1 Qualitative data

Observation: An observational approach was adopted to identify the risk factors associated with involvement in the mortuary. The investigation started with observations to create a social network map [2]. Observation was continued on day and night shifts. The approach was applied to the different sections of the each mortuary and activities of individuals.

Interview: Participants from Groups One, Two and Three were then chosen for formal or informal interview. Semi-structured interviews were used, using open questions intended to draw out respondents' experiences of working in the mortuary, their perception of their personal exposure to risk and their view of potential environmental hazards associated with mortuary waste. Where possible the interviews were formally prearranged, but in some cases it was necessary to take up informal opportunities due to limited availability of some participants. The significance of this methodology is discussed further below.

6.2 Quantitative data

Waste generation data were collected on three days (two weekdays, one weekend) in a randomly chosen week at all of the mortuaries in the study area. Data were recorded for each post-mortem carried out in the sample period. Three categories of waste were collected and their weights recorded.

1. The weight of contaminated clothing, fabrics and other materials used to wrap the body was recorded before each autopsy commenced.

2. Hazardous waste (as designated in WHO guidelines [26]) generated by the autopsy was collected by arranging for waste to be deposited in a suitable plastic bag.

3. At the same time, another bag was used to collect non-hazardous waste generated during the autopsy.

The bags were individually weighed using a hand held scale and the data was recorded on a prescribed form.

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7 Results and findings: waste generation and risk factors

7.1 Pragmatic aspects

Table 1. The manner of autopsy cases identified during the study period (n = 306)

	Accidental	Suicidal	Homicidal	Total
Traffic accidents	116 (72%)	6 (9%)	7 (9%)	129 (42%)
Poisoning	6 (4%)	28 (41%)	11 (14%)	45 (15%)
Burns	5 (3%)	8 (11%)	9 (12%)	22 (7%)
Fall	4 (3%)	4 (6%)	6 (8%)	14 (5%)
Hanging	2 (1%)	16 (23%)	5 (6%)	23 (7%)
Drowning	23 (14%)	7 (10%)	7 (10%)	37 (12%)
Assault	5 (3%)	0	31 (41%)	36 (12%)
Total	161 (52%)	69 (23%)	76 (25%)	306 (100%)

Data were collected in three different days (2 weekdays and one weekend).

The composition and source of the mortuary waste mainly depends on the number of dead bodies, type of death, duration before being brought to the mortuary and the management activity. Table 1 shows the manner of death in the study area. The number of accidental deaths was found to be high (52%) in the present study due to high 'traffic accidents' (TA) (42%) in the study area, which may contribute to more mortuary waste generation. TA death rate is also reported to be higher in Istanbul, Turkey and Chandigarh, India [27, 28]. The second highest manner of death was found to be homicide and then suicide. Islam and Islam [29] discussed the cause of the suicides and confirmed that most of the suicide cases were by poisoning, which is similar to other studies [28]. A study reported that 90.9% cases in terms of poisoning used organo-chlorine, organo-phosphorus and carbamate compounds because of the easy availability as insecticides [29]. The use of these toxic chemicals in suicides contributes highly toxic waste.

Table 2. The duration time to bring dead bodies to the mortuary (n = 306)

Duration	Number of corpse	Percentage
Within the day	111	36%
1 day	122	40%
2 days	23	8%
3 days	20	7%
4 days	15	5%
5+ days	15	5%
Total	306	100

Data were collected on three different days (2 weekdays and one weekend).

During the present study, the dead bodies included those who were murdered, severely injured in TA, recovered from water several days after an accidental death or a murder, and poisoning death cases that were either a homicide or a suicide. It was observed and supported by the study survey that most of the bodies are brought to the mortuaries in decomposed forms. Decomposed dead bodies contain viruses and bacteria [11], which generate pathogenic waste. The degree to which dead bodies are decomposed is related to the time taken to bring them to the mortuary and to the duration of the autopsies. The delay was due to poor communication, low level of interest, transportation cost and trying to avoid social harassment. Road traffic is one of the major problems in the study area. Therefore, in some cases, it is not possible to bring the dead body to the mortuary within a short period after death. Because of the social hazard, there is less interest in conducting

post-mortem, which is another major factor contributing to delays. In some cases, relatives of the deceased are not able to afford the carrying cost and therefore, wait for police, who will carry the dead body to the mortuary. Recovery from water or any other hiding place, several days after the murder or death, is another factor in delays. Table 2 shows the duration time for dead bodies to be brought to the mortuary. Most of the corpses (40%) are brought to the mortuary within 2 days of death.

7.2 Procedure of post-mortem and waste generation

The process of post-mortem waste generation: The dead bodies were received by a medical examiner either covered or uncovered. There were two parts to the physical examination of the body: the external and internal examination.

External examination: The body was first photographed after being received. External examination was done by a person from the police department. A general description and idea of the body with regards to sex, age, hair length, eye colour and other distinguishing features were identified and/or assumed and recorded. The body was then cleaned, weighed and measured by the dome in preparation for the internal examination.

Internal examination: The internal examination consists of investigating the internal organs of the dead body for evidence of trauma or other indications of the cause of death. At this stage the organs were uncovered and examined. Usually, the organs were removed in a systematic way, weighed and tissue samples in the form of slices were taken. Major blood vessels were cut open and inspected at this stage. Therefore, this stage may contribute large amounts of infectious waste. In some cases, large amounts of dust were created when the bone was cut by the saw. Shears were used to open the chest cavity, which may be considered a significant risk.

Quantification: The quantity of mortuary waste is presented in terms of kg day^{-1} and kg corpse^{-1}, separately and combined. This data were used to determine the quantities of waste generated by each autopsy and then generalised to estimate the total waste generation in a day, calculated by the following equations.

$$Y_{tw\_autopsy} = \frac{\sum \{ (TW_{ba}) + (TW_{aa}) \}_1 + ... + \{ (T W_{ba}) + (T W_{aa}) \}_n}{N}$$

$$Y_{tw\_day\_1} = \{ (T W_{ba}) + (T W_{aa}) \}_1 + ... + \{ (T W_{ba}) + (T W_{aa}) \}_n$$

Where $Y_{tw\_sutopsy}$ = total waste generated per autopsy

Y_{tw_day1}= average waste generated in day

TW_{ba} = total waste generated before dissection

TW_{aa}= total waste generated after dissection

N= total number of autopsies in a day

Errors in the estimates

TW_{ba} The weight per autopsy was estimated from the weights recorded before autopsy on different sampling days at each mortuary. The total weight and the standard error in the total weight are given in Table 3.

W_{aa} The weight per dead body was estimated from the weights recorded after autopsy per dead body on different sampling days at each mortuary. The total weight and the standard error in the total weight are given in Table 3.

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N The total number of dead bodies recorded was based on an estimate during the field survey day, in each mortuary. The total number of dead bodies and the standard error in the total number are given in Table 3.

The amount of mortuary waste generated is tabulated by categories in Table 3, showing that the highest percentage of solid waste generation (by weight) in corpse autopsies is due to clothes textiles (20%) and plastic (14%). Unless it becomes stained with body fluids, blood, poisons or other toxic chemicals and pathogens this waste is mostly non-hazardous. In the study area, this may be hazardous because decomposed dead bodies, body fluids and blood were observed in contact with the cover and clothes. Usually, we found the dead bodies to be wrapped in a non-hazardous mat (locally made out of bamboo cane, jute or plastic). However, due to contact with the dead body it also turned into hazardous waste. The data in Table 3 shows that the surveyed mortuaries generate large volumes of liquid waste, no doubt largely due to the cleaning of the dead bodies on each dissection. Among the surveyed morgues, 'Dhaka medical college hospital morgue' (DMCHM) generates more waste than other mortuaries due to more autopsy cases. The waste generation rate per dead body was found to be 9.00 ± 2.52kg and average waste generation per day was 918 ± 11kg among the surveyed mortuaries.

Table 3. The rate of average waste generation kg corpse^{-1} (p <0.05)

Type of waste	Types of waste	Percentages (%)
Solid waste		
Pathological	0.67 ± 0.29	7
Sharps and glass	1.17 ± 0.29	13
Chemical	0.67 ± 0.29	7
Plastics	1.25 ± 0.43	14
Cotton, bandage material	0.50 ± 0.00	6
Clothes textiles	1.83 ± 0.58	20
Others	0.92 ± 0.14	10
Liquid	2.00 ± 0.50	22
Total	9.00 ± 2.52	
Data were collected on three different days (2 weekdays and one weekend).		

Liquid Waste: Liquid waste was not extensively studied as part of this phase of the project. However, liquid waste produced depends on the type of dead bodies from which it comes. After dissection, water is normally use for cleaning. Initial observations support the supposition that the surveyed mortuaries discharged their liquid waste and wastewater into the general sewerage system along with chemical and pharmaceutical waste (antibiotics and other drugs), heavy metal (mercury, nickel, iron, arsenic) phenols, derivatives and other chemicals. This may create potential for disease and disturbance of the natural ecosystem due to toxic effects [30]. Some of mortuaries even discharged their liquid waste directly to the adjacent natural water bodies which provided a risk to aquatic species. In the present study respondents answered that as the drainage and storage system is poor, a number of the dead bodies get literally flooded with water during the rainy reason. This type of practice is potentially massively significant, and requires urgent consideration. Therefore, it will be further studied in the next phase of the research.

7.3 Disposal of human corpses

As well as the body, which is normally disposed of in traditional ways, such as burial or cremation, mortuary departments must dispose of waste, either solid (such as body parts and body tissues, disposable equipment, sharps, and clothes or other materials used for wrapping the body) or liquid (for example body fluids and water used for cleaning) with safety precautions. In the present study, it was found that dead bodies were usually handed over to relatives for final disposal (funerals) after post-mortem. Unidentified dead bodies were handed over to the social service agencies. This is the general scenario to avoid and reduce any sort of pollution by burial and hygienic sanitary consequences. Anatomical wastes were generally disposed of into open road side bins (Figure 1), liquid wastes were discharged into general sewerage and stained wastes were burned in an open space on the mortuary premises using kerosene or other fuel in all of the mortuaries

indiscriminately along with general medical waste. Any undesirable situation may lead to the flowing back of gases or liquids generated by the onset of the decomposition process [1]. The main gases from the decomposition process with odours are: aromatic amines, CH_4, H_2S, mercaptans, NH_3, and PH_3, hence it has been suggested that a proper burial should use a layer of soil, of suitable thickness to detain such gases.

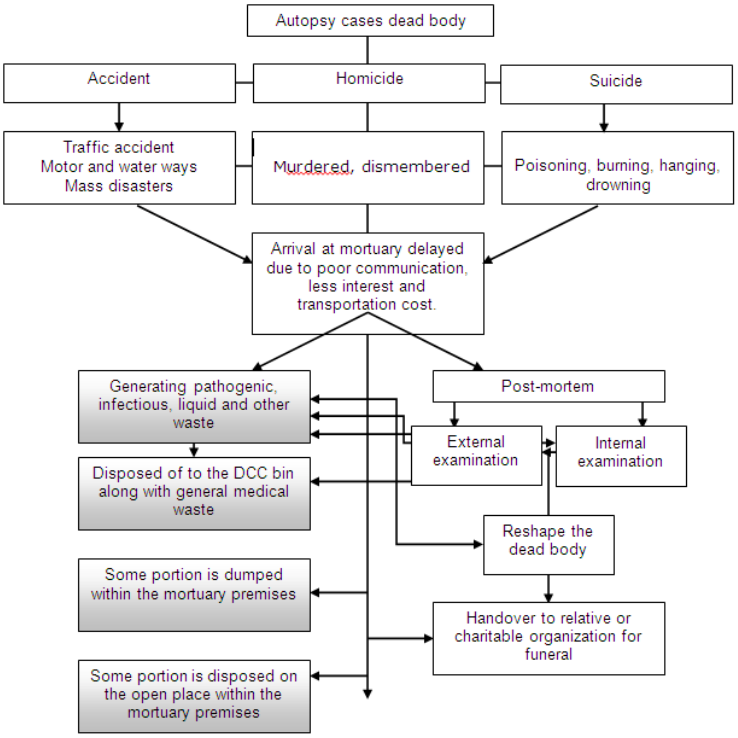

Figure 1. State of the mortuary waste in the study area

7.4 Occupational health risks

Mortuary staff mostly worked with manual equipment. All of the mortuaries surveyed were not regularly cleaned or tidied, with used sharp instruments left on tables and floors, creating a risk of accidental injury and a chance of acquiring a blood borne infection such as hepatitis B virus (HBV) or human immunodeficiency virus (HIV). Additional dangers arise due to slippery floors. Pathogens may be acquired by inhalation ingestion, inoculation, and through the mucous membranes [12]. Consequently, occupationally acquired infections, particularly risk infections, can have a devastating impact on the mortuary worker. It has also been described that autopsy is a potential source of infection with other organisms, notably *Streptococcus pyogenes*, gastrointestinal organisms (including hepatitis A), and potentially *Neisseria meningitides* [12].

It was observed that individuals working in the mortuaries usually did not wear sufficient personal protective equipment (PPE) during the autopsy. When interviewed using an in-depth approach, a few waste workers indicated that they had heard about protective uniforms, but had never seen them and many stated that they were not aware of the hazards arising from infectious dead bodies and autopsy equipment. None had training in any aspect of mortuary care, and learned what to do by being shown by the staff before them. Thus the information has been passed down verbally; "through the generations" stated most of the *domes* and most have just used what works for them after many years of experience in the mortuary. They also mentioned that a forensic staff member is always with them to show the procedures. The results of this study show a substantial variation in the handling of dead bodies that pose a risk of infection to mortuary individuals. Comments from many (forensic staff) of the respondents illustrated that '*there are no policies on this issue*', '*hospitals often fail to inform us of infection'*, and (group two *domes*) '*not always informed by the authority of risk of infection*.' They were frequently made aware of an infection hazard after embalming.

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The mortuary environment is also very dehumanising for the staff that work there as they were faced with various stresses which include unpleasant smells, the sight of bodies which were burned or mutilated and the sounds which occur during an autopsy [4] such as the saw cutting through bone or a head hitting the table. Stress effects can be either physiological or psychological (cognitive effects) and these effects can present a mechanism to disturb health and behavior [31, 32]. Behavioral disinhibition and behavioral inhibition/anxiety may serve as individual difference pathways for genetic influence on alcohol abuse and dependence [33], and also criminal activities [8]. The staff emphasized that many of the practices being carried out were not ideal, but were being done due to a lack of resources. Most of the respondents answered during the study that this is the first time that someone had taken an interest on their working conditions.

7.5 Current situation threat to the environment

The surveyed morgues were observed to be poorly equipped in terms of performing post-mortem examinations. The surveyed morgues usually carry out post-mortem examinations of average 102 ± 3 dead bodies in a day. The room cannot be cooled as required as the insufficient air conditioner hardly works due to a technical glitch in each morgue. In some cases the air conditioning system was not setup according to the relevant regulations. For the lack of space, freezer for preserving corpses was kept in a corridor for a long time in different morgues during the survey period. On an average, a number of dead bodies were kept in the corridor of the morgue every day in each of the sampled morgue. Besides polluting the air with foul odours, the decomposed bodies were turning unidentifiable without a working refrigerator. In absence of a safe and secure storage room, all of the plastic pots containing viscera were kept haphazardly on the floor beside the freezer. People frequently pass by and are exposed to this hazard. All of the dead bodies had to be dumped into a designated small room. In some case, storerooms and staff rooms was used to keep the decomposed bodies and, in the absence of air-conditioning, an unbearable stench always hangs in the air, permeating even the clothes of the doctors and staff who work at the morgue. More seriously there is a risk of infection, particularly if the deceased was placed in an open area.

8 Discussion

Untreated mortuary waste streams frequently contain components that have the potential to cause infectious diseases. The level of this potential remains largely unassessed, but no current treatment process can either totally or consistently eliminate such risks. All point to a lack of resources allocated to mortuary waste management. This contrasts with the situation in developed countries where mortuary waste is treated with extreme caution. No doubt this partly reflects the increased healthcare budget, but some of the findings of the present study also suggest that other factors are obvious in the study area. The significant factor of the health and environmental risk from mortuary waste was identified is decomposition of dead bodies. The degree to which dead bodies are decomposed is related to the time taken to bring them to the mortuary and to the duration of the autopsies. The delay was due to poor communication, low level of interest, transportation costs, and trying to avoid social harassment. The observations made in this case study echo and extend the risk factors of mortuary waste identified by other researchers [28, 29].

The lack of secure storage and final disposal presents a serious hazard to mortuary workers, visitors and the wider environment. To improve safety for employees and others, and to ensure that waste is not exposed to the environment, there needs to be secure storage of dead bodies and safe disposal of mortuary waste. However, an even more serious risk arises from the repacking and resale of mortuary waste by the scavengers. These risks were discussed elsewhere [6].

The management and the mortuary workers in hospitals each failed to demonstrate an understanding of the importance of correct procedures. This results in a lack of awareness among the staff, leading to disposal of insecure mortuary waste along with domestic waste (presenting a serious hazard to the general population) as well as frequent injuries to the mortuary workers. Authority did not seem to recognise a duty of care to protect their employees from accidents. While, Patwary et al., [8] explained that "*they claimed that occupational accidents on their premises were merely due to fate,*

beyond their control and no different from any other accident". It is apparent that a number of conditions of inertia and resistance explain the sluggish response to the risk from mortuary waste.

A substantial amount of mortuary waste is potentially hazardous to the environment and is extremely dangerous to the exposed individuals. There is more than enough evidence that improper disposal of such hazardous (mortuary) waste may cause contamination of air (via volatilization and fugitive dust emissions); surface water (from surface runoff or overland flow and groundwater seepage); ground water (through leaching/infiltration); soils (due to erosion, including fugitive dust generation/deposition and tracking); sediments (from surface runoff/overland flow seepage and leaching) and biota (due to biological uptake and bioaccumulation).

However, the situation is more complex with this hazardous waste, and total storage, disposal or utilization is not feasible within the premises in the long run. Such waste needs special collection and treatment. The concern of management is complicated by the heterogeneity of the waste in terms of composition, chemistry, bioavailability and toxicity. It is important to recognize the fact that there are varying degrees of hazards associated with this dangerous mortuary waste stream and also to identify the compatibilities and/or non-compatibilities of the chemical constituents of waste streams for development of effective waste management programmes.

Inadequacies in such dangerous mortuary waste management practices can therefore create potentially hazardous situations and pose significant risks of concern to the wider environment. If dumped unsystematically in any environmental ground, hazardous waste may have both short and long term effects on both human and ecological systems. In addition, improper treatment, storage, and disposal of mortuary waste can result in contamination during possible exposures, and potential adverse health and environmental impacts. Any chemical can cause severe health impairment or even death if taken by humans in effectively large amounts. On the other hand, there are those chemicals of potential concern which, even in small doses, can cause adverse health impacts. Adverse health effects in individuals exposed to hazardous waste may involve any organ system, depending on the specific chemicals contacted, the extent of exposure, the characteristics of the exposed individual (e.g. age, sex, and genetic makeup), the metabolism of the chemical involved, and presence or absence of confounding variables such as other diseases.

Limitations: The estimate given in the current study is based on a measurement of mortuary waste generation kg day^{-1} and kg $corpse^{-1}$. These values were then multiplied by the total number of dead bodies during the study period to get an overall estimate. There is a problem with this approach; the estimate of the number of dead bodies is unpredictable. There is a tendency to underestimate the number of dead bodies. However, the chosen method was designed to achieve this, and so is considered to give the best possible estimate, given the resources available.

9 Conclusion

This study is the first to attempt an estimation of mortuary waste generation and to identify possible risk factors in a developing country. A review of the literature suggests that the proportion of waste produced in mortuaries in developing countries has not previously been observed and considered as a source of infectious waste. It, too, may have significance in planning and environmental management. Detailed analysis of the make-up and sources of waste from mortuaries has shown that a major proportion is initially hazardous, and total waste becomes hazardous due to mixing with this hazardous waste. Thus, almost all of the waste produced by the mortuaries was considered hazardous.

The individuals involved in the mortuary should be aware of the hazards and risks associated with such work not only for them, but also for public health and for the environment. There is a significant need to take steps to minimise these risks. The hazards present within a body are often unknown at the start of the autopsy. This hazard may transfer through the mismanagement of generated waste during autopsy. Careful practice in all cases, and not just those where a risk was identified, is essential. The principal risks related to the acquisition of occupationally acquired infections were either by

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sharp injury or by inhalation. Local health and safety policies should be made available to all staff involved in the mortuary, and should be followed. Specialist suggestions may be needed in exceptional cases.

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