

Waste Management in Healthcare Facilities: A Review

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Abstract

Healthcare establishments generate a huge quantity of both hazardous and non-hazardous wastes. These wastes are generated as a result of diagnosis, treatment, and prevention of research on human and animal diseases. The hazardous wastes when inappropriately managed may compromise the quality of patient care. Additionally, the wastes present occupational health risks to those who generate, handle, package, store, transport, treat, and dispose of them. These wastes may enhance environmental pollution and the spread of infectious diseases, including acquired immunodeficiency syndrome (AIDS), hepatitis, tuberculosis, diphtheria, cholera, and many others. The concern is heightened by the newly emerging and re-emerging pathogens and for increased drug resistance among the re-emerging pathogens. Proper management of healthcare wastes can prevent cross infection, nosocomial infection, and the spread of epidemics of infectious diseases. Unfortunately, this aspect is completely ignored in Bangladesh. Typically, few individuals working in healthcare management are familiar with the elements of proper management of wastes. In many instances, waste-handling is left to lower-level workers who operate without any training, guidance, and supervision. Awareness and knowledge regarding the hazards of improper disposal of medical wastes is lacking at all levels. There is no proper healthcare waste-management facilities either in the government sector or in the private sector in the country. There is also a lack of funds to implement safe disposal of healthcare wastes effectively. The Bangladesh Environmental Protection Act, 1995 does not include any specific clause pertaining directly to management of healthcare wastes. An effective programme of healthcare waste management is an integral part of an infection-control programme, and is, therefore, critically linked to the quality of patient care and health and safety of staff of the healthcare establishments. Additionally, when properly implemented and enforced, effective waste management can have distinct economic benefits, such as cost saving linked to waste reduction and improved purchasing practices. This review will help assist healthcare providers and other support staff in establishing and implementing a programme for the effective management of healthcare wastes. Such a programme, when supported by committed healthcare management, will contribute to the improvement of patients care, promote health and safety of staff, and help improve the overall economy and operation of the facility. It will also enhance the image of health services with regard to the quality of patient care and protection of the environment.

Introduction

Healthcare wastes pose a serious public health problem. This is primarily caused by the diversity of the individual components of wastes, which constitute a risk to health if inadequately handled (1). Improper disposal of healthcare wastes aesthetically damages to the environment (2). Public awareness of healthcare wastes has grown in recent years, especially with the emergence of acquired immunodeficiency syndrome (AIDS) (3). In addition, the possibility that healthcare wastes could transmit human immunodeficiency virus (HIV), hepatitis B virus (HBV), and other agents associated with blood-borne diseases is also a major concern. However, the transmission modes of agents associated with blood-borne diseases are still not understood. Therefore, the disposal of healthcare wastes and their potential health impact are an important public health issue. Like other industries and institutes, healthcare facilities generate various kinds of wastes as a result of a variety of medical treatment and research. In the past 10 years, due to the increased number and size of healthcare facilities, medical services, and use of medical disposable products, the generation rate of healthcare wastes has increased rapidly (4).

This study was carried out to assess the status of management and handling of healthcare wastes in Bangladesh and in the global contexts. The purpose of this study was: (a) to provide information on the hazards and practices of management of healthcare wastes for formulating policies, enacting legislation, and developing technical guidelines; (b) to identify the waste-management practices and technologies that are safe, efficient, sustainable, economic, and culturally acceptable; (c) to enable the personnel associated with healthcare waste management to identify the systems suitable for their particular circumstances; (d) to raise awareness among those personnel who are involved in healthcare waste management about public health and environmental hazards that are associated with improper management of healthcare wastes; and (e) to enable administrators of healthcare establishments to develop appropriate waste-management plans.

Situation of Healthcare Waste Management

Global situation

Some characteristics of healthcare waste-management situations are presented here. There is a large difference among the hospitals; however, individual hospitals may have markedly better arrangements for reduction, management, treatment, and disposal of healthcare wastes, depending on hospital management and local disposal opportunities.

Africa: Waste-management systems are very limited in Africa. Some urban hospitals burn their wastes in the open air within the hospital premises; liquid wastes are sometimes treated but not disinfected. Whether there is an adequate classification and segregation of the different types of hazardous wastes at source seems to vary widely from country to country. However, available facilities, such as incineration, are limited, and wastes are otherwise thrown away into the municipal dustbins (5).

South-East Asia: In 1995, the Regional Office for South-East Asia of the World Health Organization (WHO) made a survey of healthcare waste management in 9 countries in the region with substantial responses from Indonesia, Myanmar, Sri Lanka, Thailand, and Bangladesh (6). Results of the survey show that most healthcare establishments do not have any waste-management plan or procedure. In several countries, there is no legislation at all (7). There is also a lack of waste-management guidelines. The responses on the types and segregation of wastes seem to indicate only a limited safe management of wastes with plenty of opportunity for mix-ups and disposal into the municipal dustbins. In Indonesia and Thailand, where legislation is in place, did better on most accounts. In November 1996, WHO arranged a regional consultation at Chiang Mai, Thailand, for outlining an action plan and for enacting legislation on waste management (8). In the meantime, India has made progress in enacting legislation, but there is still a long way to go. The periodical, *Down to Earth*, published by Centre for Science and Environment, India, in its February 29 issue reported, "none of the hospitals in the City's 39 wards (Patna, Bihar) have any facilities for the segregation and incineration of wastes generated by them. These wastes are disposed along the road sides in the same manner as domestic and commercial waste" (9).

Europe: Wastes are properly segregated at the point of generation, although the disposal is expensive. Contaminated items are incinerated at source, although new technologies, such as microwave disinfections, etc., are gaining popularity. For effective waste management, the European Commission, in 1990, under the Environmental Protection Act, imposed strict controls and instituted statutory duties. Ignorance or defiance of these can result in severe fines and custodial sanction (10,11). In 1995, a legislation on incinerator plants to integrate pollution control was introduced. After 1996, the European Commission turned their attention to waste minimization by reuse, recycling, segregation, and better management with minimum impact on the environment and ecosystem. They are imposing strict laws to manage and control hospital wastes. In the European countries, the majority of wastes are incinerated, with stringent control of air pollution. There is a move from local incineration toward regional medical waste incinerators with better air pollution-control characteristics, but concerns about compliance with respect to management and disposal, and differentiation from countries to countries persist.

Latin America/Caribbean: Traditionally, attention has been given to clinical wastes, but more work needs to be done to reduce exposure by waste workers. A good understanding exists of the source of pathogenic, chemically hazardous, and regular solid wastes within a health facility. Law usually requires on-site incineration, but often facilities are defective, and wastes may end-up in special cells in a sanitary landfill (12).

North America: The U.S. Environmental Protection Agency has regulations and guidelines, but actual regulation is done at the state level (12). Most healthcare wastes are burnt in hospital incinerators, but these are also disposed of in landfills and public sewers. Other treatment methods include steam or gas sterilization, irradiation, and chemical disinfections. The privately-owned facilities compete to handle wastes. Some new technologies, such as bio-oxidation, gas-pyrolysis, plasma-treatment technology, microwave disinfecting, autoclaving, etc., are practised now.

Situation in Bangladesh

In Bangladesh, there are various types of hospitals with different bed capacity. At the district level, there are both 50-150-bedded and 200-250 bedded hospitals. In some district hospitals, there are also specialized hospitals. There are 500-1150-bedded specialized hospitals either as separate hospitals or are attached with medical college hospitals (13).

About 3,500 metric tons of garbage are generated per day in the Dhaka city, 200 tons of which are generated by the healthcare establishments, and 20% of which are infectious wastes (14). The amount is increasing day by day, with the rising number of healthcare establishments. Being a poor and highest population density country, it is a burden on the part of the Government of Bangladesh to handle the situation both economically and technically. In urban areas, about 40-50% of the total generated wastes are collected per day by the municipal authority, while the rest remains as uncollected wastes obviously degrading the environment and creating health hazards (14).

There are no guidelines for the proper management of healthcare wastes. There is no segregation of wastes at the point of generation. Most healthcare establishments dispose of their wastes to the nearest municipal dustbins. Some medical staff earn income by selling used syringes and other healthcare wastes. There is a lack of awareness, concern, and knowledge of appropriate handling and disposal methods of hospital wastes at all levels (7). The level of knowledge on the dangerous consequences of improper handling and disposal of hazardous hospital wastes is also very low at all levels. Most healthcare staff are not aware of the proper management of wastes. Adequate and effective waste-management facilities are absent. Besides, the budget is meagre to effectively implement safe disposal of hospital wastes. There is no specific clause pertaining directly to the handling, transportation, or disposal of healthcare wastes in the Bangladesh Environmental Protection Act, 1995. Consensus among the owners of private clinics and the policy-makers of the government and non-government organizations (NGOs) is also lacking which is crucial for healthy environment in the healthcare facilities (7,15). There is a lack of waste-management system in both government and non-government healthcare facilities.

Unfortunately, management of hazardous healthcare wastes is improper and inadequate which causes detrimental consequence to public health, environmental quality, and sustainability to the echo system.

Healthcare Wastes

Definitions of healthcare wastes

Healthcare wastes include all types of wastes generated by healthcare establishments, research facilities, and laboratories. In addition, the wastes include the wastes originating from minor or scattered sources, such as that produced in the course of healthcare undertaken in the home (dialysis, insulin injections, etc.). Seventy-five to 90% of wastes produced by the healthcare establishments are general or non-risk wastes comparable to domestic wastes. These wastes come mostly from the administrative and housekeeping functions of healthcare establishments, and may also include wastes generated during maintenance of healthcare premises. The remaining

10-25% of wastes are regarded as hazardous, and may pose a variety of health risks (12,16).

Hospital wastes mean all wastes, biological or non-biological, which are discarded and not intended for further use. About 85% of these wastes are actually non-hazardous wastes, 10% are infectious wastes, and 5% are non-infectious but hazardous wastes (16).

Medical wastes mean any wastes which are generated as a result of patient diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological materials (16).

Clinical wastes mean any wastes coming out of medical care provided in hospitals or in other medical care establishments (16).

Classification of healthcare wastes

Healthcare wastes include: (i) general or non-hazardous wastes, and (ii) hazardous wastes (5).

- I. General or non-hazardous wastes are those that are not contaminated with blood, body fluids, or other infectious agents or materials, such as latex gloves, papers, fabrics, glass, food residues, and containers.
- II. Healthcare wastes are considered hazardous due to actual or presumed biological and/or chemical contamination. About 10-25% of healthcare wastes are regarded as hazardous wastes. The basic categories of hazardous hospital wastes include:
 - a. **Infectious wastes:** Infectious wastes are suspected to contain pathogens, such as bacteria, viruses, parasites, or fungi, in sufficient concentration or quantity to cause disease in susceptible hosts. These include cultures and stocks of infectious agents from laboratory work; waste from surgery and autopsies on patients with infectious diseases, e.g. tissues and materials or equipment that have been in contact with blood or other body fluids; waste from infected patients in isolation wards, e.g. excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids; waste that has been in contact with infected patients undergoing haemodialysis, e.g. dialysis equipment, such as tubing and filters, disposable towels, gowns, aprons, gloves, and laboratory coats; infected animals from laboratories; any other instruments or materials that have been in contact with infected persons or animals.
 - b. **Pathological wastes:** These include human tissues, blood, body fluids, organs, body parts, human foetuses, and other similar wastes from surgeries, biopsies, autopsies; animal carcasses, organs, and tissues infected with human pathogens.
 - c. **Sharp wastes:** These include needles, syringes, scalpel blades, razors, infusion sets, contaminated broken glass, blood tubes, and other similar materials.
 - d. **Chemical wastes:** These include solid, liquid, or gaseous chemicals, such as solvents, film developer, ethylene oxide, and other chemicals that may be toxic, corrosive, flammable, explosive, or carcinogenic.

- e. **Pharmaceutical wastes:** These include drugs that are returned from wards, spilled and out-dated medications of all kinds, as well as residues of drugs used in chemotherapy that may be cytotoxic, genotoxic, teratogenic, or carcinogenic.
- f. **Radioactive wastes:** These include solid, liquid and pathological wastes that are contaminated with radioactive isotopes of any kind.
- g. **Wastes with high content of heavy metals:** These wastes are highly toxic. Mercury wastes are typically generated by spillage from broken clinical equipment, but their volume is decreasing with the substitution of solid-state electronic-sensing instruments, such as thermometers, blood pressure gauges, etc. Whenever possible, spilled drops of mercury should be removed. Residues from dentistry have a high mercury content. Cadmium waste comes from discarded batteries. Certain 'reinforced wood panels' containing lead are still used in radiation proofing of x-ray and diagnosis departments.
- h. **Pressurized containers:** Various types of gas are used in healthcare and are often stored in pressurized cylinders, cartridges, and aerosol cans. Many of these, once empty or of no further use (although they may still contain residues), are reusable, but certain types--notably aerosol cans--must be disposed of.

Sources of healthcare wastes

Healthcare wastes are generated from different sources (17,18).

- i. Major sources are: (a) hospitals, e.g. university hospital, general hospital, district hospital; (b) other healthcare establishments, e.g. emergency medical care services, healthcare centres and dispensaries, obstetric and maternity clinics, outpatient clinics, dialysis centres, first-aid posts and sick bays, long-term healthcare establishments and hospices, transfusion centres, military medical services; (c) related laboratories and research centres, e.g. medical and biomedical laboratories, biotechnology laboratories and institutions, medical research centres; (d) mortuary and autopsy centres; (e) animal research and testing facilities; (f) blood banks and blood-collection services; and (g) nursing homes for the elderly.
- ii. Minor sources are: (a) small healthcare establishments, e.g. physician's office, dental clinics, and acupuncturists; (b) specialized healthcare establishments and institutions with low waste generation, e.g. convalescent nursing homes, psychiatric hospitals, institutions for disabled persons; (c) non-health activities involving intravenous or subcutaneous interventions, e.g. cosmetic piercing and tattoo parlours; (d) funeral services; (e) ambulance services; and (f) home treatment.
- iii. Support service sources are: pharmacy, laundry, kitchen, engineering, administration, and patient's attendance.

Generation of healthcare wastes by region

Generation of wastes differs not only from country to country, but also within country (12). Generation of wastes depends on numerous factors, such as waste-management methods, type of healthcare establishments, hospital specializations, proportion of

reusable items employed in healthcare, and proportion of patients treated on a daily basis. Generation of wastes also varies according to the type of healthcare establishments (Table 1) (18). Results of surveys show that the total generation of healthcare wastes is different in different regions (19). The total generation of healthcare wastes in North America is 7-10 kg/bed. day, Latin America is 3 kg/bed. day, Western Europe is 3-6 kg/bed. day, Eastern Europe is 1.4-2 kg/bed. day, Middle East is 1.3-3 kg/bed. day, East Asia (high-income countries) is 2.5-4 kg/bed. day, and East Asia (middle-income countries) is 1.8-2.2 kg/bed. day.

Table 1. Generation of healthcare wastes according to type of establishments (high-income countries)

Source	Daily waste generation (kg/bed)
University hospital	4.1-8.7
General hospital	2.1-4.2
District hospital	0.5-1.8
Primary healthcare centre	0.05-0.2

Hazards of Healthcare Wastes

Exposure to hazardous healthcare wastes can result in diseases or injuries (20), and their hazardous nature may be due to one or more of the following characteristics:

- It contains infectious agents
- It is genotoxic
- It contains toxic or hazardous chemicals or pharmaceuticals
- It is radioactive
- It contains sharps

Persons at risk

All individuals exposed to hazardous wastes are potentially at risk, including those within establishments which generate hazardous wastes and those outside the sources who either handle such wastes or are exposed to it as a consequence of careless management (21).

The main groups of people at risk are the following:

- i. Medical doctors, nurses, healthcare auxiliaries, and hospital maintenance personnel
- ii. Patients in healthcare establishments or receiving home care
- iii. Visitors to healthcare establishments
- iv. Workers in support services allied to healthcare establishments, such as laundries, waste-handling, and transportation

- v. Workers in waste-disposal facilities, such as landfills or incinerators, including scavengers and others associated with recycling of hospital wastes.

Hazards from infectious wastes and sharps

Infectious wastes may contain a great variety of pathogenic microorganisms. These pathogens may enter the human body by a number of routes, such as:

- through a puncture, abrasion, or cut in the skin
- through the mucous membrane
- by inhalation
- by ingestion

There is a particular concern about infections due to HIV, HBV, and hepatitis C virus (HCV), which are generally transmitted through injuries from syringe needles contaminated by infected human blood. The existence in healthcare establishments of bacteria, resistant to antibiotics and chemical disinfectants may also contribute to the hazards created by poorly-managed wastes. It has been demonstrated that plasmids from laboratory strains contained in healthcare wastes are transferred to indigenous bacteria via the waste-disposal system (22). Moreover, antibiotic-resistant *Escherichia coli* have been shown to survive in an activated sludge plant, although there does not seem to be significant transfer of this organism under normal conditions of wastewater disposal and treatment. Concentrated cultures of pathogens and contaminated sharps, particularly hypodermic needles, are probably the waste items that represent the most acute potential hazards to health (23). Sharps may not only cause cuts or punctures but may also infect these wounds if they are contaminated with pathogens. Because of this, double risk of injury and transmission of disease exists. The principal concern is that infections may be transmitted by subcutaneous introduction of the causative agents, e.g. viral blood infections. Hypodermic needles constitute an important part of the sharps waste category and are particularly hazardous, because they are often contaminated with patient's blood.

Hazards from chemical and pharmaceutical wastes

Many chemicals and pharmaceuticals used in healthcare establishments are hazardous, e.g. toxic, genotoxic, corrosive, flammable, reactive, explosive, or shock-sensitive (21,24). These substances are commonly found in small quantities in the healthcare wastes; larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are disposed of. They may cause intoxication, either by acute or by chronic exposure and injuries, including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or the mucous membrane, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membrane of the airways can be caused by contact with flammable, corrosive, or reactive chemicals. The most common injuries are burns (21).

Disinfectants are used in large quantities, and are often corrosive. Reactive chemicals might form highly toxic secondary compounds. Chemical residues discharged into the sewerage system may have adverse effects on the operation of biological sewage-treatment plants or toxic effects on the natural ecosystems of receiving waters. Similar problems may be caused by pharmaceutical residues, which

may include antibiotics and other drugs, heavy metals, such as mercury, phenols, disinfectants, and antiseptics (24).

Hazards from radioactive wastes

The extent of exposure determines the type of disease caused by radioactive wastes. It can range from headache, dizziness, and vomiting to too much serious problems. Since radioactive wastes, like certain pharmaceutical wastes, are genotoxic, it may also affect genetic material. Handling of highly active sources, e.g. certain sealed sources from diagnostic instruments, may cause severe injuries, such as destruction of tissues, necessitating amputation of body parts, and should, therefore, be taken with utmost care (25). The hazards of low-activity wastes may arise from contamination of external surfaces of the containers or improper mode or duration of waste storage. Healthcare workers or waste-handling or cleaning personnel exposed to this radioactivity are at risk.

Hazards from genotoxic wastes

The severity of hazards among healthcare workers responsible for handling or disposal of this type of waste is governed by a combination of substance toxicity itself, and the extent and duration of exposure. Exposure to genotoxic substances in healthcare may also occur during the preparation of or treatment with particular drugs or chemicals. The main pathways of exposure are inhalation of dust or aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals, or wastes, and ingestion as a result of bad practice, such as mouth pipetting. Exposure may also occur through contact with body fluids and secretion of patients undergoing chemotherapy.

The cytotoxicity of many anti-neoplastic drugs is cell-cycle-specific, targeted on specific intracellular processes, such as DNA synthesis and mitosis. Other anti-neoplastics, such as alkylating agents, are not phase-specific, but cytotoxic at any point in the cell cycle. Experimental studies have shown that many anti-neoplastic drugs are carcinogenic and mutagenic; secondary neoplasia is shown to be associated with some forms of chemotherapy (26). Many toxic drugs are extremely irritable, and have harmful local effects after direct contact with skin or eyes (27). Special care in handling genotoxic wastes is absolutely essential; any discharge of such wastes into the environment could have disastrous ecological consequences.

Public Health Impact of Healthcare Wastes

Impact of infectious wastes and sharps

Strong epidemiological evidence suggests that HIV/AIDS virus is transmitted through infectious healthcare wastes, and more often, HBV and HCV through injuries caused by syringes, needles contaminated by human blood. Healthcare workers, particularly nurses, are at a greatest risk of infection. Other hospital workers and waste-management operators outside healthcare establishments are also at significant risk, as are individuals who scavenge on waste-disposal sites.

The annual rate of injuries among healthcare and sanitary service personnel from sharps in medical wastes, within and outside hospitals, was estimated by the U.S. Agency for Toxic Substances and Diseases Register (ATSDR) in their report to the Congress on medical wastes (Table 2) (28). The workers who are most frequently injured in healthcare establishments are nurses, house-keeping and maintenance personnel, and food-preparation workers. The annual injury rates for these occupations vary from 10 to 20 per 1,000 workers. Cleaning personnel and waste handlers are subjected to the highest rates of occupational injuries among all workers who may be exposed to healthcare wastes. The annual rate in the USA is 180 per 1,000. Although most work-related injuries among healthcare workers and refuse collectors are sprains and strains caused by over-exertion, a significant percentage is cuts and punctures from discarded sharps. Many injuries are caused by recapping hypodermic needles before disposal into containers, by unnecessary opening of these containers, and by the use of materials that are not puncture-proof for construction of containers (21).

Table 2. Viral hepatitis B infections caused by occupational injuries from sharps (USA)

Professional category	Annual number of people injured by sharps	Annual number of HBV infections caused by injury
Nurses		
In hospital	17,700- 22,200	56-96
Outside hospital	28,000-48,000	26-45
Hospital laboratory workers	800-7 500	2-15
Hospital housekeepers	11,700-45,300	23-91
Hospital technicians	12,200	24
Physicians and dentists in hospital	100-400	<1
Physicians outside hospital	500-1,700	1-3
Dentists outside hospital	100-300	<1
Dental assistants outside hospital	2,600-3,900	5-8
Emergency medical personnel outside hospital	12,000	24
Waste workers outside hospital	500-7,300	1-15

The Centers for Disease Control and Prevention (CDC) estimates that 5,100 healthcare workers with frequent occupational blood contact are infected each year with HBV (Miriam Altar, unpublished data). Occupational exposure from needles or other sharp objects remains an issue of great concern to healthcare workers (29-32). The risk of hepatitis B or HIV transmission from such exposure has added to this concern (33-35). The CDC reported that 37 healthcare workers were infected with HIV through occupational exposure. The majority of this exposure was due to sharp objects (36). It has been reported that 7-31% of sharp injuries are related to the disposal of needles, excluding recapping (37-40). Needle-stick injuries (NSIs) are among the greatest occupational hazards of hospital personnel (41), posing a risk for transmission of hepatitis B (42), hepatitis C (43,44), and HIV (33,45). Some studies suggest that injuries during the practice of recapping needles account for 12-18% of such injuries; and errors that occur during or after needle disposal account for up to 40% (32,46). Another survey found that recapping, the most common mechanism of injury, accounted for 30% of NSIs, whereas 13% resulted during or after needle disposal (38). A study performed at the University of Wisconsin found that although 60% of all NSIs occurred in nursing personnel, with an annual rate of 92.6 NSIs per 1,000 employees, house-keeping personnel had the highest incidence of NSIs (127 NSIs per 1,000 employees) (32).

It has been reported that, in France, by 1992, eight cases of HIV infection were recognized as occupational infections. Two of these cases, involving transmission through wounds, occurred in waste handlers (12). It has also been reported that, in the USA, by June 1994, 39 cases of HIV infection were recognized by the CDC as occupational infections. By June 1996, the cumulative recognized cases of occupational HIV infection had risen to 51. All cases were nurses, medical doctors, and laboratory assistants. HIV has extremely limited viability outside a living host, although the live virus-survival time may depend upon the environment and the concentration of virus.

Therefore, except for those persons within healthcare establishments, the potential to develop HIV infection from medical waste contact is remote. Because HBV remains viable for an extended time in the environment, the potential for HBV-associated infection following contact with medical wastes is likely to be higher than that associated with HIV (47). It has been showed that, in Japan, the risk of infection after hypodermic needle puncture is as follows: HIV is 0.3%, HBV is 3%, and HCV is 3-5% (12).

A report on medical wastes by the U.S. Environmental Protection Agency to the Congress estimated the annual number of HBV infections resulting from sharp injuries among medical personnel and waste-management workers (Table 1). Of an overall yearly total of 300,000 cases, the annual number of HBV-related infections in the USA resulting from exposure to healthcare wastes is between 162 and 321 (12).

Impact of chemical and pharmaceutical wastes

Many cases of injury or intoxication resulting from the improper handling of chemicals and pharmaceuticals in healthcare establishments have been found (24,48). Pharmacists, anesthetists, nursing, and maintenance personnel may be at risk of respiratory and dermal diseases caused by exposure to such substances, such as vapor, aerosols, and liquids. To minimize this type of occupational risk, less-hazardous chemicals should be substituted whenever possible, and protective equipment should be used by personnel likely to be exposed. Premises where hazardous chemicals are used should be properly ventilated, and personnel at risk should be trained in preventive measures and in emergency care in case of accident.

Impact of genotoxic wastes

Few data on the long-term health impacts of genotoxic healthcare wastes are available, partly due to the difficulty in assessing human exposure to this type of compound. A study found a significant correlation between foetal loss and occupational exposure to anti-neoplastic drugs during the first three months of pregnancy (49). It has been reported that potential health hazards are associated with the handling of anti-neoplastic drugs, manifested by increased urinary levels of mutagenic compounds in exposed workers and an increased risk of abortion (26,50). A study has demonstrated that exposure of personnel who clean urinals exceeded that of nurses and pharmacists (51). These individuals were less aware of the danger, and took fewer precautions.

Healthcare Waste-management Planning

The important factor for improving healthcare waste management at the national, regional and local levels is to formulate objectives and to plan for their achievement (52). Planning requires the definition of a strategy that will facilitate careful implementation of necessary measures and appropriate allocation of resources according to the identified priorities. This is important for motivating the authorities, healthcare workers, and the public, and for defining further actions that may be needed (52).

International recommendations for management of wastes

The United Nations Conference on the Environment and Development (UNCED), in 1992, had adopted the Agenda 21, which recommends a set of measures for waste management. The set of recommendations includes:

- Prevention and minimization of production of wastes
- Reuse or recycling of wastes to the extent possible
- Treatment of wastes by safe and environmentally-sound methods
- Disposal of final residues by landfill in confined and carefully-designed sites

The Agenda 21 also stresses that waste producers should be made responsible for the treatment and final disposal of its own wastes; where possible, each community should dispose of its wastes within its own boundaries.

National plans for management of healthcare wastes

Purpose of a management plan

A national management plan will permit healthcare waste-management options to be optimized on a national scale. A national survey relating to disposal of healthcare waste-management system will provide the relevant agency with a basis for identifying actions on a district and national basis, taking into account conditions, needs, and possibilities at each level (52). An appropriate, safe, and cost-effective strategy should concern principally with treatment, recycling, transport, and disposal options.

Action plan for development of a national programme

A national programme of healthcare waste management can be developed through a seven-step action plan (52).

1. **Establishment of policy commitment and responsibility:** Before an action plan is implemented, there must be commitment to develop a national policy, and the responsibility must be delegated to the appropriate government authority. The Ministry of Health will usually serve as the principal authority. The designated authority will cooperate with other ministries, the private sector, NGOs, and professional organizations, as necessary, to ensure implementation of the action plan. Policy commitment should be reflected in appropriate budgetary allocations at different government levels. Guidance from the central government should lead to maximum efficiency in the use of available resources of healthcare establishments.
2. **Conduct of a national survey:** The national agency responsible for the disposal of healthcare wastes should be fully aware of the current level of waste production and of national waste-management practices. A comprehensive survey is essential for planning an effective waste-management programme.
3. **Development of national guidelines:** The foundation for a national programme for healthcare waste management is the technical guidelines and the legal framework that support them. This step, thus, includes the formulation of a national policy document and technical guidelines based on the results of the

national survey; the two may be brought together in one comprehensive document.

4. **Development of a policy on regional and cooperative methods:** The designated government agency should identify resources to ensure a national network of disposal facilities for healthcare wastes, accessible by hospitals, and other healthcare facilities. The national policy should also include technical specifications for the processes and equipment involved in acceptable treatment options. There are three basic options for managing the treatment of healthcare wastes, which are as follows:
 - Option 1. On-site treatment facilities in each healthcare establishment.
 - Option 2. Regional or cooperative healthcare waste-treatment facilities supplemented by individual facilities for outlying hospitals.
 - Option 3. Treatment of healthcare wastes in existing industrial or municipal treatment facilities, where these exist.
5. **Legislations, regulations and standards:** Once developed, the policy and guidelines should be supported by legislation that regulates their application. This law is usually based on international agreement and underlying principles of waste management.
6. **Institution of a national training programme:** To achieve acceptable practices in healthcare waste management and compliance with regulations, it is essential for all managers and other personnel involved to receive appropriate training. To this end, the central government should assist in the preparation of "train the trainer" activities, and competent institutions for the trainers' programme should be identified.
7. **Review of the national programme after implementation:** The national programme for management of healthcare wastes should be viewed as a continuous process with provision for periodic monitoring and assessment by the responsible national government agency. In addition, the recommendations on waste-treatment methods should be regularly updated to keep pace with new developments. The national agency will base its assessment primarily on reports from healthcare establishments on their success in implementing the waste-management plans. It should review annual reports submitted by heads of establishments, and make random visits to carry out audits of the waste-management systems. Any deficiencies in the waste-management systems should be pointed out to the head of the establishment in writing, together with recommendations for remedial measures. The time limit for implementing the remedial measures should be specified, and the head of the establishment should be informed of the follow-up date. In the case of off-site waste-treatment facilities, incinerator operators, road haulage contractors, and landfill operators should also be audited. Periodic reviews of waste-management practices by both national government agency and healthcare establishments should result in both improved protection of occupational and public health and enhanced cost effectiveness of waste disposal.

Programmes for Management of Healthcare Wastes

Basic principles: The absence of management measures to prevent exposure to hazardous healthcare wastes results in the maximum health risk to the general public, patients, healthcare personnel, and other staff. It is, therefore, emphasized that even very limited waste-management measures can substantially reduce this risk. Effective confinement of waste- and safe-handling measures provides significant health protection (17). For example, burning hazardous healthcare wastes in open trenches or small furnaces are better than uncontrolled dumping, and reducing the amount of hazardous wastes by segregation is better than accumulating large quantities. Good stock management of chemicals and pharmaceuticals not only reduces waste quantities but also saves purchase cost; proper identification of waste packages warns healthcare personnel and waste handlers about their contents. All these measures to reduce risk are relatively simple and cheap, and should be considered by healthcare establishments. The basic elements of programmes of healthcare waste management are the following (17):

- Establishment of internal rules for waste handling (storage, colour coding, collection frequency, etc.)
- Assignment of responsibilities within healthcare establishment
- Quantitative and qualitative assessment of waste production
- Segregation of healthcare wastes from general wastes
- Evaluation of local treatment and disposal options
- Choice of suitable or better treatment and disposal options

Minimization, recycling, and reuse of healthcare wastes

Waste minimization: Implementation of certain policies and practices can significantly reduce the wastes generated by healthcare establishments and research facilities. The policies and practices are as follows:

1. Source reduction

- Reduction of purchasing: selection of supplies that are less wasteful or less hazardous
- Use of physical rather than chemical cleaning methods, e.g. steam disinfections instead of chemical disinfections
- Prevention of wastage products, e.g. in nursing and cleaning activities

2. Management and control measures at the hospital level

- Centralized purchasing of hazardous chemicals
- Monitoring of chemical flows within the health facility from receipt as raw materials to disposal as hazardous wastes

3. Stock management of chemical and pharmaceutical products

- Frequent ordering of relatively small quantities rather than large amounts at one time
- Use of the oldest batch of a product first

- Use of all the contents of each container
- Checking of the expiry date of all products at the time of delivery

Careful management of stores can prevent the accumulation of large quantities of outdated chemicals or pharmaceuticals, and can limit wastes to the packaging (boxes, bottles, etc.) plus residues of products remaining in containers. These small amounts of chemical and pharmaceutical wastes can be disposed of easily and relatively cheaply, whereas larger amounts require costly and specialized treatment, which underlines the importance of waste minimization.

Waste minimization usually benefits waste producers. Costs for both purchases of goods and waste treatment and disposal are reduced, and the liabilities associated with the disposal of hazardous wastes are lessened. All health-service employees have a role to play in this process, and should, therefore, be trained in waste minimization and in the management of hazardous materials. This is particularly important for the staff of those departments, which generate large quantities of hazardous wastes.

Suppliers of chemicals and pharmaceuticals can also become responsible partners in wastes-minimization programmes. The healthcare service facilities can encourage this by ordering only from suppliers who provide rapid delivery of small orders, who accept the return of unopened stock, and who offer off-site waste-management facilities for hazardous wastes. Reducing the toxicity of products is also beneficial, i.e. by reducing the problems associated with its treatment or disposal. For example, the Supply Officer can investigate the possibilities of purchasing PVC-free plastics that may be recycled, or goods supplied without unnecessary packaging.

Safe reuse and recycling: Medical and other equipment used in a healthcare establishment may be reused provided that they are designed for the purpose, and withstand the sterilization process. Reusable items may include certain sharps, such as scalpels, needles, glass bottles, containers, etc. After use, these should be collected separately from the non-reusable items, carefully and properly washed, and may then be disinfected by thermal and chemical sterilization. Although the reuse of hypodermic needles is not recommended, it may be necessary for establishments, which can not afford disposable syringes and needles. Plastic syringes and catheters should not be thermally or chemically sterilized; they must be discarded.

Certain types of containers may be reused provided that they are carefully and properly washed and disinfected. Containers of pressurized gas, however, should generally be sent to specialized centres to be refilled. Containers that once held detergent or other liquids might be reused as containers for sharp wastes provided that they are puncture-proof, and are correctly and clearly marked on all sides.

Recycling is usually not practised by healthcare facilities, apart, perhaps, from the recovery of silver from fixing-baths used in processing x-ray films. However, recycling of materials, such as metals, paper, glass, and plastics, can result in savings for the healthcare facility either through reduced disposal costs or through payments made by the recycling company. In determining the economic viability of recycling, it is important to take into account the cost of alternative disposal methods and not just the cost of the recycling process and the value of the reclaimed material.

Handling and storage of healthcare wastes

Waste segregation and packaging: The key to minimization and effective management of healthcare wastes is their segregation (separation) and identification (53). Appropriate handling, treatment, and disposal of wastes by type reduces costs, and does much to protect public health. Segregation should always be the responsibility of waste producers, should take place as close as possible to where the waste is generated, and should be maintained in storage areas and during transport. The most appropriate way of identifying the categories of healthcare wastes is by sorting these wastes into colour-coded plastic bags or containers. The recommended colour coding of containers are: (a) Yellow--Infectious, highly infectious wastes and sharps; (b) Brown--Chemicals and pharmaceutical wastes; and (c) Black--General healthcare wastes.

The following practices are also recommended, in addition to the colour coding of containers for healthcare wastes:

- General waste should be mixed with the stream of domestic refuse for disposal.
- Sharps should be collected together, regardless of whether or not they are contaminated. Containers should be puncture-proof and fitted with covers. They should be rigid and impermeable, so that they safely retain not only the sharps but also any residual liquids from syringes. To discourage abuse, containers should be tamper-proof, and needles and syringes should be rendered unusable. Where plastic or metal containers are not available or too costly, containers made of dense cardboard are recommended.
- Bags and containers for infectious wastes should be marked with the international infectious substance symbol.
- Highly infectious wastes should, whenever possible, be sterilized immediately by autoclaving. The wastes should be packaged in bags that are compatible with the proposed treatment process.
- Cytotoxic wastes, most of which are produced in major hospital or research facilities, should be collected in strong, leak-proof containers clearly labelled as "cytotoxic wastes".
- Small amount of chemical or pharmaceutical wastes may be collected together with infectious wastes.
- Large quantities of expired pharmaceuticals stored in hospital wards or departments should be returned to the respective pharmacy for disposal. Other pharmaceutical wastes generated at this level, such as spilled or contaminated drugs or packaging containing drug residues, should not be returned because of the risk of contaminating the pharmacy; these should be deposited in the correct container at the point of production.
- Large quantities of chemical wastes should be packed in chemical-resistant containers and sent to specialized treatment facilities. Identity of the chemicals should be clearly marked on the containers; hazardous chemical wastes of various types should never be mixed.

- Wastes with a high content of heavy metals, e.g. cadmium or mercury, should be collected separately.
- Aerosol containers may be collected with general healthcare wastes once they are completely empty, provided that the wastes are not destined for incineration.
- Low-level radioactive infectious wastes, e.g. swabs and syringes for diagnostic or therapeutic use, may be collected in yellow bags or containers for infectious wastes if these are destined for incineration.

Since the cost of safe treatment and disposal of hazardous wastes is typically more than that of general wastes, all general, i.e. non-hazardous wastes, should be handled in the same of domestic refuse and collected in black bags. Sharps should be deposited in sharp containers. Measures of this sort help minimize the cost of collection and treatment of wastes. When a disposable syringe is used, the package should be placed in the general wastebin and the used syringe in the yellow sharp container. In most circumstances, the needle should not be removed from the syringe because of the risk of injury; if removal of the needle is required, special care must be taken. Appropriate containers or bag holders should be placed in all locations where particular categories of wastes are generated. Instructions on waste separation and identification should be posted at each waste-collection point to remind staff of the waste-handling procedures. Containers should be removed when they are three-quarters full. Cultural and religious constraints in certain countries make it unacceptable for anatomical wastes to be collected in the usual yellow bags; such wastes should be disposed of in accordance with the local custom, which commonly specifies burial.

Collection of wastes: The nursing and other clinical staff should ensure that the waste bags are tightly closed when they are about three-quarters full. Sealed sharp containers should be placed in a labelled, yellow infectious healthcare waste bag before removal from healthcare establishments. Wastes should not be allowed to accumulate at the point of generation. A routine programme for their collection should be established as part of the waste-management plan. The ancillary workers in charge of waste collection should follow certain recommendations as follows:

- Wastes should be collected daily and transported to the designated central storage site.
- No bags should be removed unless they are labelled with their point of production and contents.
- The bags or containers should be replaced immediately with new ones of the same type.

Storage of wastes: A storage area for wastes should be designated inside the establishment or research facility. The wastes, in bags or containers, should be stored in a separate area or in a room of a size appropriate to the quantities of waste produced and the frequency of collection. The followings are the recommendations for the storage area and equipment:

- The storage area should have an impermeable, hard standing floor with good drainage; it should be easy to clean and disinfect.
- There should be water supply for cleaning purposes.
- The storage area should have facility for easy access for staff in charge of handling wastes.
- The store should be kept under lock and key to prevent access by unauthorized persons.
- Easy access to waste-collection vehicles is essential.
- There should be protection from the sun light.
- The storage area should be inaccessible for animals, insects, and birds.
- There should be good lighting and at least passive ventilation.
- The storage area should not be situated in the proximity of fresh food stores or food-preparation areas.
- A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area.

Transportation of healthcare wastes

On-site transportation of wastes: Healthcare wastes should be transported within healthcare establishments by means of wheeled trolleys, containers, or carts that are not used for any other purpose, and meet the following specifications:

- Easy to load and unload
- No sharp edges that could damage waste bags or containers during loading and unloading
- Easy to clean

The vehicles should be cleaned and disinfected daily with an appropriate disinfectant. All waste bag seals should be in place and intact at the end of transportation.

Off-site transportation of wastes: The healthcare waste producer is responsible for safe packaging and adequate labelling of wastes to be transported off-site and for authorization of its destination. Packaging and labelling should comply with national regulations governing the transport of hazardous wastes and with international agreements if wastes are shipped abroad for treatment.

Preparation for transportation: Before the transportation of wastes, dispatch documents should be completed, and all arrangements should be made between consignor, carrier, and consignee. In case of exportation, the consignee should have confirmed with the relevant competent authorities that the wastes can be legally exported and that no delays will incur in the delivery of the consignment to its destination.

Transportation of vehicles or containers: Waste bags may be placed directly into the transportation vehicle, but it is safer to place them in further containers, e.g. cardboard boxes or wheeled, rigid, lidded plastic or galvanized bins. This has the advantage of reducing the handling of filled waste bags, but results in higher disposal costs. These secondary containers should be placed close to the waste source. Any vehicle used for transporting healthcare wastes should fulfill the following design criteria:

- The body of the vehicle should be of a suitable size commensurate with the design of the vehicle, with an internal body height of 2.2 metres.
- There should be bulkhead between the driver's cabin and vehicle body, which is designed to retain the load if the vehicle is involved in a collision.
- There should be suitable systems for securing the load during transport.
- Empty plastic bags, suitable protective clothing, cleaning equipment, tools, and disinfectant, together with special kits for dealing with liquid spills, should be carried in a separate compartment in the vehicle.
- The internal finish of the vehicle should allow it to be steam-cleaned, and the internal angles should be rounded.
- The vehicle should be marked with the name and address of the waste carrier.
- The international hazard sign should be displayed on the vehicle or container, as well as an emergency telephone number.

The vehicles or containers used for the transportation of healthcare wastes should not be used for the transportation of any other materials. They should be kept locked at all times, except when loading and unloading. Articulated trailers (temperature controlled if required) are particularly suitable, as they can easily be left at the site of waste production. Other systems, such as specially-designed large containers or skips, may be used; however, open-topped skips or containers should never be used for transporting healthcare wastes.

Routing: The quickest possible route, which should be planned before the journey begins, should transport healthcare wastes; after departure from the waste-production point, every effort should be made to avoid further handling. If handling can not be avoided, it should be pre-arranged and should take place in adequately-designed and authorized premises. Handling requirements can be specified in the contract established between the waste producer and the carrier.

Treatment and disposal technologies for healthcare wastes

The final choice of treatment system should be made carefully, on the basis of various factors, many of which depend on local conditions as follows:

- Disinfection efficiency
- Health and environmental considerations
- Volume and mass reduction

- Occupational health and safety considerations
- Quantity of wastes for treatment and disposal/capacity of the system
- Types of wastes for treatment and disposal
- Infrastructure requirements
- Locally-available treatment options and technologies
- Options available for final disposal
- Training requirements for operation of method
- Operation and maintenance considerations
- Available space
- Location and surroundings of the treatment site and disposal facility
- Public acceptability
- Regulatory requirements

Certain treatment options may effectively reduce the infectious hazards of healthcare wastes and prevent scavenging.

Some used treatment technologies

Commonly-used technologies are: Land filling, burning, incineration, autoclaving, and chemical treatment.

Some emerging technologies are: Microwave disinfections, plasma touch technique, detoxification technique, and advanced wet oxidation.

Collection and disposal of wastewater

Characteristics and hazards of wastewater generated by healthcare establishments: Wastewater generated by healthcare establishments is of similar quality to urban water, but may also contain various potentially hazardous components, such as microbiological pathogens, hazardous chemicals, pharmaceuticals, and radioactive isotopes.

Management of wastewater

The basic principle underlying effective wastewater management is a strict limit on the discharge of hazardous liquids to sewers. In countries that do not experience epidemics of enteric diseases and that are not endemic for intestinal helminthiasis, it is accepted to discharge the sewage of healthcare establishments to municipal sewers without pretreatment, provided that the following requirements are met (54):

1. The municipal sewers are connected to efficiently-operated sewage-treatment plants that ensure at least 95% removal of bacteria.
2. The sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminth egg per litre in the digested sludge.

3. The waste-management system of a healthcare establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, pharmaceuticals, radionucleotides, cytotoxic drugs, and antibiotics in the discharged sewage.
4. Excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated.

If these requirements can not be met, the wastewater should be managed and treated in the following way:

On-site treatment or pretreatment of wastewater: Many hospitals, in particular those that are not connected to any municipal treatment plant, have their own sewage-treatment plants (55).

Treatment of wastewater

Efficient on-site treatment of hospital sewage should include the following operations (55):

1. Primary treatment.
2. Secondary biological purification: Most helminths will settle in the sludge resulting from secondary purification, together with 90-95% of bacteria and a significant percentage of viruses; the secondary effluent will, thus, be almost free of helminths, but will still include infective concentrations of bacteria and viruses.
3. Tertiary treatment: The secondary effluent will probably contain at least 20 mg/L of suspended organic matter, which is too high for efficient chlorine disinfections. It should, therefore, be subjected to a tertiary treatment, such as lagooning; if no space is available for creating a lagoon, rapid sand filtration may be substituted to produce a tertiary effluent with a much-reduced content of suspended organic matter (<10 mg/L).
4. Chlorine disinfections: To achieve pathogen concentrations comparable to those found in natural water, the tertiary effluent will be done with chlorine dioxide, sodium hypochlorite, or chlorine gas. Another option is ultraviolet light disinfections.

Treatment of sludge

The sludge from the sewage-treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens. Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious healthcare wastes. On-site treatment of hospital sewage will produce a sludge that contains high concentrations of helminths and other pathogens.

Review of Healthcare Waste-management Activities in Bangladesh

GoB Activities

Directorate General of Health Services

A study, conducted by the Directorate General of Health Services (DGHS) in 2000, reported that the supervisory persons agreed that they have the responsibility toward waste management, but there was no provision of quantifying and record-keeping of wastes in the hospital (56). The supervisors were silent about the health and safety of the staff, and the majority of them believed that waste management was the responsibility of the hospital director. The waste generators were mostly government staff with positive attitude toward waste management, but they did not identify and segregate the wastes at the point of generation.

There was a lack of awareness and knowledge among the staff about the consequences of the wastes and environmental impact. Recycling of waste materials started from the point of generation, and a number of hospital staff were familiar with recycling. Seriocomic conditions of most waste handlers were low. Their level of education and knowledge was also very low, but they showed positive attitude toward waste management. They were handling the wastes in an improper way without necessary protective equipment. The wastes were dumped either into the dustbin or in outside hospital premises or dumped on the ground within the hospital premises.

National Institute of Preventive and Social Medicine

The National Institute of Preventive and Social Medicine (NIPSOM) conducted a study at the Mymensingh Medical College Hospital and Thana Health Complexes, in 1992, to compare the existing systems of disposal of hospital wastes (57). The institute conducted another study at the Dhaka Medical College Hospital in 1995 to assess the generation of hospital wastes and its management system (58). These studies reported that the existing waste-disposal systems were not satisfactory in all the places. The major factor responsible for this was improper supervision by the authority concerned. There was also a lack of awareness on the consequences of unhygienic disposal of the hospital waste and absence of training facilities for the concerned staff. Besides, there was a shortage of supply of equipment and materials required for the disposal of hospital wastes.

Bangladesh University of Engineering and Technology

The Bangladesh University of Engineering and Technology (BUET) conducted a study in some hospitals in Dhaka city in 1999 (59). The total study was limited to the generation of solid wastes per bed per day. It has been found that an average rate of solid waste generation was 1.00 kg/bed. day. The university conducted another study in different hospitals in Dhaka city in 1997 (60) to assess the existing waste management and also to assess different technological options for improvement of the present situation. It has been found that the rate of waste generation was about 1.16 kg/bed. day, and the hazardous waste was 0.169 kg/bed. day. The contribution of infectious,

sharps, and pathological wastes was about 10.5%, 3.5%, and 1.5% respectively compared to solid waste of 3,000 tons/day in Dhaka city. It has also been reported that careful sorting, handling, and storage of wastes inside the hospital is the key factor to maintain the hospital hygiene. No law and regulations exist, and there is no penal action against improper disposal of hazardous wastes. It has been mentioned that considering various factors and cost-benefit analysis, incinerator is the best treatment options for the management of hospital wastes in Dhaka city (59).

NGO Activities

Bangladesh Rural Advancement Committee

The Bangladesh Rural Advancement Committee (BRAC) conducted a study, in 1998, in different government and non-government hospitals, clinics, and diagnostic laboratories in Dhaka city (7). On-site observations and in-depth interviews of the concerned staff using pre-designed questionnaires revealed that a variety of methods, such as burning, burial, selling, dumping, reuse and removal by municipal bins, were used by the healthcare facilities to dispose of their wastes. Most hospitals, clinics, and laboratories do not have any waste-management system in place. All wastes are collected together and are dumped in a common place, such as roadside, hospital surroundings, and dustbin of the Dhaka City Corporation. It was found that used saline bags, x-ray water, syringes, vials slides, empty packets, and bottles were collected and sold. Hospital authorities and cleaners collect the healthcare wastes and sell it to whole-sellers. Some hospitals and laboratories autoclaved and use less-harmful chemicals for fixing of slides. However, they still dispose of their wastes in municipal bins like other hospitals and laboratories. Some clinics and laboratories clean and re-use syringes and instruments by disinfectants, such as dettol and detergents. These agents are less harmful than phenol that most hospitals use for disinfection. Some mentioned that they reused gloves, masks, slides and test tubes, etc. without proper disinfection. In all laboratories and clinics, liquid wastes are disposed of via the municipal sewerage system. Private clinics and laboratories had terrible edict in handling their samples and wastes. It was apparent that there was insufficient awareness of the magnitude of the medical waste issue at all levels. Most people were not either aware or clear about the composition of medical wastes. There had been no formal/informal training of staff on how to dispose of healthcare wastes. Medical officers were generally aware that medical wastes could pose a problem, but most thought they were handling the situation sufficiently. Some of them (38.1%) mentioned that they had not received any training on how to handle medical wastes. Few of them mentioned that they had academic training on nursing or public health, but not specifically on medical waste issues. Nurses, laboratory technicians, and cleaners had no training on handling procedures and disposal methods.

Environment and Development Associates (Prodipan)

The Environment and Development Associates (Prodipan) conducted a study, in 2000, in different clinics and hospitals of Khulna city aiming at formulating and demonstrating replicable models for hospital waste management (61). Results of the study showed that the method of waste disposal was improper and inadequate in most clinics and hospitals. The current practice of waste disposal was to dump all types of wastes in the

nearest Khulna City Corporation (KCC) bins or adjacent low-lying areas. Hazardous wastes are openly burnt in some hospitals without any air emission and temperature control. Wastes are collected by the municipal waste-collection service, and are transported for final disposal with municipal wastes. Most wastes were disposed of in municipal waste dumps along with municipal solid wastes. The knowledge of the hospital staff on the dangerous consequences of improper handling and disposal of hazardous wastes was very low. Most hospital staff had only a basic understanding of healthcare, and did not perceive handling or disposal of medical wastes as a hazard at all. The hospital staff, professionals, and the general people were not aware of the hazards of hospital wastes. Wastes were not segregated at any hospitals. The medical staff were not either informed on the need for segregation or apathetic to the consequences of not segregating various types of wastes. As a result, mixing of wastes led to contamination of potentially-recyclable components of general wastes and high risk of occupational exposure of workers. There was no trained staff in any hospital in Khulna city for waste handling and disposal. Most management people were not concerned with the disposal system, and they believe that placing of wastes in the municipal bins or discharging it into the drains is enough. There was no environmental awareness programme in any hospital in the city.

Bangladesh Centre for Advanced Studies

The Bangladesh Centre for Advanced Studies (BCAS) conducted a study, in 1998, in clinics and hospitals in Dhaka city, Saver, and Narayanganj. It was observed that most hospitals in Dhaka city were situated in the residential area (15). The average distance of these hospitals from the nearest municipal dustbin was within 100 feet. The waste generated inside the hospitals was collected without any separation and by untrained, unprotected and unaware cleaners. None of those hospitals practised proper separation or disposal. Many hospitals sold the empty saline bags, bottles, syringes, and other materials for recycling purposes. A training workshop was organized for the health professionals, health workers, and staff to raise awareness and to educate them about the hazards of medical wastes. After the training, an immediate change in waste management, such as separation of wastes at the point of generation (disposing wastes in properly-sealed coloured bags, safe disposal of infected sharps) was observed. Unfortunately, the change was not sustained for a longer period. The reasons could be lack of facilities to carry the wastes, lack of proper guidelines, lack of practical laws for safe disposal of clinical wastes as well as its proper implementation, and lack of a treatment facility for medical wastes. Consensus among the private clinics owners and the policy-makers of the government and non-government organizations is also lacking which is crucial for healthy environment in the healthcare establishments.

Bangladesh Legal Aid Services Trust

The Bangladesh Legal Aid Services Trust (BLAST) conducted a study, in 1999, in three healthcare establishments, namely Sir Salimullah Medical College Hospital, Holy Family Hospital, and Bangabandhu Sheikh Mujib Medical University, to assess the consequences due to current status of healthcare waste-management systems (62). It has been found that there was no national plan for sound disposal of healthcare wastes. There was no local or national authority to look after waste management. There was also no national law for proper management of healthcare wastes.

ICDDR,B: Centre for Health and Population Research

The former MCH-FP Extension Project (Rural) of ICDDR,B: Centre for Health and Population Research conducted a study, in 1996, on the waste-disposal methods in the rural family-planning programme of Bangladesh (63). Results of the study showed that the used cotton balls, swabs, gauze, needles, syringes, and ampoules were collected in open bowls, paper cartoons and baskets, etc. from the Family Welfare Centres (FWC) and Upazila Health Complex (UHC). The cleaners cleaned the used bowls. In some clinics, there were no bowls, and the used items were dropped on the floor, and were removed by the cleaners in the following morning. Sometimes, these items were disposed of by throwing them outside the FWC or UHC through windows. These contaminated items were also thrown into the drains or backyards. The cleaner handled these wastes either every morning or twice a day depending on the amount of wastes. Sometimes, the wastes accumulated for one week in an open container. There were no instructions on how to store or collect clinical wastes. There were no orders on where and how the wastes should safely be disposed of. No training or information was provided to any staff. There were no instructions regarding the responsibility and supervision of such tasks.

It was also reported that the cotton, swabs, needles, syringes, etc. used for providing injectable contraceptives and for insertions of intrauterine contraceptive devices (IUDs) were collected in a paper carton from the satellite clinics and sterilization camps, and were thrown away at the house where the satellite clinic was held. When the cleaner cleaned the IUD insertion set by tubewell water at the premises of satellite clinic residence, s/he threw the wastes away near the tubewell. Clinic wastes were also disposed of at the sterilization camps in a similar way. There were no instructions or guidelines on safe disposal of clinic wastes at the satellite clinics or sterilization camps. The majority of the field-level staff interviewed was not aware of the hazards of contaminated needles. Very few were aware of the diseases, such as hepatitis B and AIDS, which may spread through the contaminated needles. None of the staff was aware of the need for safe disposal of clinic wastes.

Lessons Learned

The lessons learned from the review are as follows:

1. All the government and private healthcare establishments dispose of all wastes in open dustbins, where the wastes remain for several days before the municipal truck removes them.
2. Some healthcare staff earn income by selling used syringes and other medical wastes.
3. There are no instructions or guidelines for the proper management of healthcare wastes.
4. There is a lack of adequate and effective waste-management facilities and a budgetary allocation for safe disposal of healthcare wastes.
5. There are no instructions regarding the responsibility and supervision of proper management of healthcare wastes.

6. There is also lack of awareness, concerns, and knowledge regarding appropriate handling and disposal methods of healthcare wastes at all levels.
7. There is no consensus among the owners of private clinics and the policy-makers of the government and non-government organizations, although it is crucial for healthy environment in the healthcare establishments.
8. There is also inadequate government policy to guide healthcare providers and to punish offenders.
9. There is no specific clause pertaining directly to the handling, transportation, and disposal of healthcare wastes in the Bangladesh Environmental Protection Act, 1995.

The Future Needs

Based on the review, the requirements of effective management of healthcare wastes in Bangladesh are summarized below:

National level

1. The gap between the policy-makers and the personnel involved in the health-care waste management should be narrowed down.
2. Uniform national healthcare waste-management guidelines should be formulated.
3. Videos, newspaper campaigns, short booklets, and leaflets on healthcare waste management should be prepared, distributed, and disseminated among the public to raise awareness among them about the hazards of healthcare wastes.
4. Recyclable materials should be recycled, such as radioactive and pharmaceutical wastes sent back to the manufacturer and supplier.
5. The existing legislation should be uniformly executed.
6. The healthcare waste-management legislations should be reviewed and remodelled in the context of Bangladesh to match with international standard.

Hospital level

1. Proper and adequate waste-management systems should be introduced and established in all healthcare establishments to protect general health and the environment.
2. There should be standard norms of cleanliness and disposal of wastes with clear-cut job descriptions for the concerned staff.
3. There should be a sufficient supply of equipment for collection, storage, and removal of healthcare wastes.
4. Different categories of healthcare wastes must be segregated at the point of generation. Different colour-coded, strong, water-proof bags should be used for

storing and carrying general and non-sharp hazardous wastes respectively. Sharps should be collected in puncture-proof rigid containers.

5. There should be properly planned storage areas in healthcare establishments, and wastes should not be allowed to accumulate in an inappropriate place for more than 48 hours.
6. There should be special vehicles for the safe transportation of healthcare wastes.
7. Every healthcare establishment should install a large incinerator for safe and proper disposal of healthcare wastes. If not possible immediately, then at least before disposal, the infectious wastes should be treated.
8. Incinerator should be equipped with smoke and emission control facility approved by Ministry of Health and Family Welfare.
9. Healthcare wastes from the government and non-government establishments should be carried to the incinerator plant by the transporting authority on a regular basis. There should be provision for incineration of healthcare wastes on payment basis. After incineration, residues can be transferred to the city corporation dustbins for final disposal.
10. There should be written instructions on healthcare waste management at various places within the healthcare establishments.
11. Administrators, doctors, nurses, and other workers of healthcare establishments must be given adequate training, so that they understand various aspects of healthcare waste management and the consequences of poor practices. Short training manuals should be prepared for various groups of actors involved in waste management.
12. Health education regarding safe disposal of wastes, dangers of healthcare wastes and environmental pollution to patients, visitors, and patients of outpatient department should be given.
13. One healthcare "waste-management committee" should be formed in each healthcare establishment to look after routine cleanliness and proper disposal of healthcare wastes.
14. Mechanisms need to be evolved as to control visitors at hospitals more systematically and purposefully.
15. Remuneration/awards should be given and a certificate should be distributed to personnel of the waste-disposal committee to inspire them for better work in the healthcare establishments.
16. There should be an assigned person with computer facility to keep records on waste quality, quantity-related operating costs, source of origin and method of disposal, etc.

Conclusions

1. There is strong and well-documented evidence that, in industrialized countries, the main impact of improperly-managed healthcare wastes is the transmission of hepatitis B and C and AIDS viruses through injuries by needles and syringes infected with human blood. In developing countries, the risk of hepatitis B and AIDS also exists. In addition, there is suspicion that other illnesses, such as staphylococcal infections, are transmitted through solid healthcare wastes and cholera through sewage from field healthcare facilities.
2. In industrialized countries, the groups most at risk from healthcare wastes are mainly hospital workers, especially nurses and auxiliaries, and outside healthcare establishments to a lesser extent, waste handlers. In developing countries, scavengers and others involved in recycling face a high risk, and even the general public may be at risk because of the activities of these scavengers.
3. All infectious wastes, including sharps, must be disposed of at the earliest possible stage.
4. Careful sorting, handling, and storage of wastes inside healthcare establishments are the key to healthcare hygiene. Normal wastes should be kept separate from hazardous wastes, and each type of hazardous waste should be kept separately in an appropriate container.
5. Chemical and pharmaceutical wastes collected from healthcare establishments should join industrial wastes of similar nature for joint treatment, when available. The same applies to radioactive wastes. Special care must be given to cytotoxic drugs that must never be deposited of in the environment.
6. When no facilities exist for hazardous waste disposal outside healthcare establishments, it is safer to dispose them of inside the premises if enough space is available. In this case open-air burning or in-situ burying may be the least hazardous solutions in developing countries.
7. Dumping of hazardous healthcare wastes in municipal sanitary landfills is acceptable only if scavenging is effectively prevented and access to the landfill by children and scavengers is under control.
8. There is a need to develop cheap but safe containers for hazardous healthcare wastes to be used in developing countries.

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