

3

Health impacts of health-care waste

3.1 Hazards of health-care waste

Health-care waste includes a large component of general waste and a smaller proportion of hazardous waste. This chapter addresses the potential hazards of exposure to hazardous (or risk) health-care waste.

3.1.1 *Types of hazards*

Exposure to hazardous health-care waste can result in disease or injury. The hazardous nature of health-care waste 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.

3.1.2 *Persons at risk*

All individuals exposed to hazardous health-care waste are potentially at risk, including those within health-care establishments that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. The main groups at risk are the following:

- medical doctors, nurses, health-care auxiliaries, and hospital maintenance personnel;
- patients in health-care establishments or receiving home care;
- visitors to health-care establishments;
- workers in support services allied to health-care establishments, such as laundries, waste handling, and transportation;
- workers in waste disposal facilities (such as landfills or incinerators), including scavengers.

The hazards associated with scattered, small sources of health-care waste should not be overlooked; waste from these sources includes that generated by home-based health care, such as dialysis, and that generated by illicit drug use (usually intravenous).

3.1.3 *Hazards from infectious waste and sharps*

Infectious waste may contain any of a great variety of pathogenic microorganisms. Pathogens in infectious waste may enter the human body by a number of routes:

- through a puncture, abrasion, or cut in the skin;
- through the mucous membranes;
- by inhalation;
- by ingestion.

Examples of infections that can be caused by exposure to health-care waste are listed in Table 3.1, together with the body fluids that are the usual vehicles of transmission.

There is particular concern about infection with human immunodeficiency virus (HIV) and hepatitis viruses B and C, for which there is strong evidence of transmission via health-care waste. These viruses are generally transmitted through injuries from syringe needles contaminated by human blood.

The existence in health-care establishments of bacteria resistant to antibiotics and chemical disinfectants may also contribute to the hazards created by poorly managed health-care waste. It has been demonstrated, for example, that plasmids from laboratory strains contained in health-care waste were transferred to indigenous bacteria via the waste disposal system. 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.

Sharps may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens. Because of this double risk—of injury and disease transmission—sharps are considered as a

Table 3.1 *Examples of infections caused by exposure to health-care wastes, causative organisms, and transmission vehicles*

Type of infection	Examples of causative organisms	Transmission vehicles
Gastroenteric infections	Enterobacteria, e.g. <i>Salmonella</i> , <i>Shigella</i> spp.; <i>Vibrio cholerae</i> ; helminths	Faeces and/or vomit
Respiratory infections	<i>Mycobacterium tuberculosis</i> ; measles virus; <i>Streptococcus pneumoniae</i>	Inhaled secretions; saliva
Ocular infection	Herpesvirus	Eye secretions
Genital infections	<i>Neisseria gonorrhoeae</i> ; herpesvirus	Genital secretions
Skin infections	<i>Streptococcus</i> spp.	Pus
Anthrax	<i>Bacillus anthracis</i>	Skin secretions
Meningitis	<i>Neisseria meningitidis</i>	Cerebrospinal fluid
Acquired immunodeficiency syndrome (AIDS)	Human immunodeficiency virus (HIV)	Blood, sexual secretions
Haemorrhagic fevers	Junin, Lassa, Ebola, and Marburg viruses	All bloody products and secretions
Septicaemia	<i>Staphylococcus</i> spp.	Blood
Bacteraemia	Coagulase-negative <i>Staphylococcus</i> spp.; <i>Staphylococcus aureus</i> ; <i>Enterobacter</i> , <i>Enterococcus</i> , <i>Klebsiella</i> , and <i>Streptococcus</i> spp.	
Candidaemia	<i>Candida albicans</i>	Blood
Viral hepatitis A	Hepatitis A virus	Faeces
Viral hepatitis B and C	Hepatitis B and C viruses	Blood and body fluids

very hazardous waste class. The principal concerns are infections that may be transmitted by subcutaneous introduction of the causative agent, 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 patients' blood.

3.1.4 Hazards from chemical and pharmaceutical waste

Many of the chemicals and pharmaceuticals used in health-care establishments are hazardous (e.g. toxic, genotoxic, corrosive, flammable, reactive, explosive, shock-sensitive). These substances are commonly present in small quantities in health-care waste; 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 membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances). The most common injuries are burns.

Disinfectants are particularly important members of this group: they are used in large quantities and are often corrosive. It should also be noted that reactive chemicals may form highly toxic secondary compounds.

Obsolete pesticides, stored in leaking drums or torn bags, can directly or indirectly affect the health of anyone who comes into contact with them. During heavy rains, leaked pesticides can seep into the ground and contaminate the groundwater. Poisoning can occur through direct contact with the product, inhalation of vapours, drinking of contaminated water, or eating of contaminated food. Other hazards may include the possibility of fire and contamination as a result of inadequate disposal such as burning or burying.

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, and derivatives, and disinfectants and antiseptics.

3.1.5 Hazards from genotoxic waste

The severity of the hazards for health-care workers responsible for the handling or disposal of genotoxic waste is governed by a combination of the substance toxicity itself and the extent and duration of exposure. Exposure to genotoxic substances in health care 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 waste, and ingestion as a result of bad practice, such as mouth pipetting. Exposure may also occur through contact with the bodily fluids and secretions of patients undergoing chemotherapy.

The cytotoxicity of many antineoplastic drugs is cell-cycle-specific, targeted on specific intracellular processes such as DNA synthesis and

mitosis. Other antineoplastics, such as alkylating agents, are not phase-specific, but cytotoxic at any point in the cell cycle. Experimental studies have shown that many antineoplastic drugs are carcinogenic and mutagenic; secondary neoplasia (occurring after the original cancer has been eradicated) is known to be associated with some forms of chemotherapy.

Many cytotoxic drugs are extremely irritant and have harmful local effects after direct contact with skin or eyes (Box 3.1). They may also cause dizziness, nausea, headache, or dermatitis. Additional information on health hazards from cytotoxic drugs may be obtained on request from the International Agency for Research on Cancer (IARC).¹

Special care in handling genotoxic waste is absolutely essential; any discharge of such waste into the environment could have disastrous ecological consequences.

Radioactive waste is dealt with separately, in section 3.1.6.

3.1.6 *Hazards from radioactive waste*

The type of disease caused by radioactive waste is determined by the type and extent of exposure. It can range from headache, dizziness, and vomiting to much more serious problems. Because radioactive waste, like certain pharmaceutical waste, is genotoxic, it may also affect genetic material. Handling of highly active sources, e.g. certain sealed sources from diagnostic instruments, may cause much more severe injuries (such

Box 3.1 Cytotoxic drugs hazardous to eyes and skin

Alkylating agents

Vesicant¹ drugs: aclarubicin, chlormethine, cisplatin, mitomycin

Irritant drugs: carmustine, cyclophosphamide, dacarbazine, ifosfamide, melphalan, streptozocin, thiotepa

Intercalating agents

Vesicant drugs: amsacrine, dactinomycin, daunorubicin, doxorubicin, epirubicin, pirarubicin, zorubicin

Irritant drugs: mitoxantrone

Vinca alkaloids and derivatives

Vesicant drugs: vinblastine, vincristine, vindesine, vinorelbine

Epipodophyllotoxins

Irritant drugs: teniposide

¹Blistering.

¹ International Agency for Research on Cancer, Unit of Gene–Environment Interactions, 150 Cours Albert-Thomas, 69372 Lyon Cedex 08, France.

as destruction of tissue, necessitating amputation of body parts) and should therefore be undertaken with the utmost care.

The hazards of low-activity waste may arise from contamination of external surfaces of containers or improper mode or duration of waste storage. Health-care workers or waste-handling or cleaning personnel exposed to this radioactivity are at risk.

3.1.7 Public sensitivity

Quite apart from fear of health hazards, the general public is very sensitive about the visual impact of *anatomical waste*, that is recognisable human body parts, including fetuses. In no circumstances is it acceptable to dispose of anatomical waste inappropriately, such as on a landfill.

In some cultures, especially in Asia, religious beliefs require that human body parts be returned to a patient's family, in tiny "coffins," to be buried in cemeteries. The Muslim culture, too, generally requires that body parts are buried in cemeteries.

3.2 Public health impact of health-care waste

3.2.1 Impacts of infectious waste and sharps

For serious virus infections such as HIV/AIDS and hepatitis B and C, health-care workers—particularly nurses—are at greatest risk of infection through injuries from contaminated sharps (largely hypodermic needles). Other hospital workers and waste-management operators outside health-care establishments are also at significant risk, as are individuals who scavenge on waste disposal sites (although these risks are not well documented). The risk of this type of infection among patients and the public is much lower. Certain infections, however, spread through other media or caused by more resilient agents, may pose a significant risk to the general public and to hospital patients. For instance, uncontrolled discharges of sewage from field hospitals treating cholera patients have been strongly implicated in cholera epidemics in some Latin American countries.

Individual cases of accidents and subsequent infections caused by health-care waste are well documented (see Box 3.2 for example). The overall situation, however, remains difficult to assess, especially in developing countries. It is suspected that many cases of infection with a wide variety of pathogens have resulted from exposure to improperly managed health-care wastes in developing countries.

Box 3.2 Reported case of infection caused by contact with health-care waste

A hospital housekeeper in the USA developed staphylococcal bacteraemia and endocarditis after a needle injury.

The annual rates of injuries from sharps in medical waste for health-care and sanitary service personnel, within and outside hospitals, were estimated by the US Agency for Toxic Substances and Diseases Register (ATSDR) in their report to Congress on medical waste (Table 3.2). Many injuries are caused by recapping of 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.

Box 3.3 summarizes data on occupational transmission of HIV, and Table 3.3 shows the estimated risk of infection with HIV or viral hepatitis after hypodermic needle puncture based on data from France, Japan, and USA. Outside health-care establishments, the risk to the general public of HIV infection by this means is negligible: it has been estimated that no more than 1–4 HIV infections are caused annually by health-care waste in the USA, compared with an overall total of about 68 000 infections for the whole country during 1995. The risk of viral hepatitis B and C infection from contact with health-care waste may be more significant, as this virus is viable for longer than HIV.

A report by the US Environmental Protection Agency to Congress on medical waste estimated the annual numbers of viral hepatitis B (HBV) infections resulting from injuries from sharps among medical personnel and waste-management workers (Table 3.2). The annual number of HBV infections in the USA resulting from exposure to health-care waste is between 162 and 321, out of an overall yearly total of 300 000 cases.

Box 3.3 Occupational transmission of HIV in France and USA

France

In 1992, eight cases of HIV infection were recognized as occupational infections. Two of these cases, involving transmission through wounds, occurred in waste-handlers.

USA

In June 1994, 39 cases of HIV infection were recognized by the Centers for Disease Control and Prevention as occupational infections, with the following pathways of transmission:

- 32 from hypodermic needle injuries
- 1 from blade injury
- 1 from glass injury (broken glass from a tube containing infected blood)
- 1 from contact with non-sharp infectious item
- 4 from exposure of skin or mucous membranes to infected blood.

By June 1996, the cumulative recognized cases of occupational HIV infection had risen to 51. All cases were nurses, medical doctors, or laboratory assistants.

Table 3.2 *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

Table 3.3 *Risk of infection after hypodermic needle puncture*

Infection	Risk of infection
HIV	0.3%
Viral hepatitis B	3%
Viral hepatitis C ^a	3–5%

^aData from Japan.

There were insufficient data on other infections linked to health-care waste to allow any conclusions to be reached. On the basis of the figures for HBV, however, it is recommended that all personnel handling health-care waste should be immunized against the disease. Unfortunately, no vaccine is yet available against viral hepatitis C.

If these data are to be extrapolated to developing countries, it should be borne in mind that supervision and training of personnel exposed to waste in those countries may be less rigorous, with the result that more people are likely to be exposed to health-care wastes, both within and outside health-care establishments.

In any health-care establishment, nurses and housekeeping personnel are the main groups at risk of injuries; annual injury rates are 10–20 per 1000 workers. Highest rates of occupational injury among all workers who may be exposed to health-care waste are reported by cleaning personnel and waste handlers; the annual rate in the USA is 180 per 1000. Although most work-related injuries among health-care workers and refuse collectors are sprains and strains caused by overexertion, a significant percentage are cuts and punctures from discarded sharps.

3.2.2 *Impacts of chemical and pharmaceutical waste*

While there is no scientifically documented incidence of widespread illnesses among the general public due to chemical or pharmaceutical

waste from hospitals, many examples may be found of extensive intoxication caused by industrial chemical waste. Moreover, many cases of injury or intoxication result from the improper handling of chemicals or pharmaceuticals in health-care establishments. Pharmacists, anaesthetists, and nursing, auxiliary, and maintenance personnel may be at risk of respiratory or dermal diseases caused by exposure to such substances as vapours, aerosols, and liquids. To minimize this type of occupational risk, less hazardous chemicals should be substituted whenever possible and protective equipment should be provided to all 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.

3.2.3 Impacts of genotoxic waste

To date there are few data on the long-term health impacts of genotoxic health-care waste. This is partly because of the difficulty of assessing human exposure to this type of compound. A study undertaken in Finland, for example, found a significant correlation between fetal loss and occupational exposure to antineoplastic drugs during the first three months of pregnancy, but similar studies in France and the USA failed to confirm this result.

Numerous published studies have investigated the potential health hazard associated with the handling of antineoplastic drugs, manifested by increased urinary levels of mutagenic compounds in exposed workers and an increased risk of abortion. A recent study has demonstrated that exposure of personnel cleaning hospital urinals exceeded that of nurses and pharmacists; these individuals were less aware of the danger and took fewer precautions. The concentration of cytotoxic drugs in the air inside hospitals has been examined in a number of studies designed to evaluate health risks linked to such exposure (Pyy, 1988; Sessink, 1988).

No scientific publication has yet reported adverse effects on health resulting from mismanagement of genotoxic waste.

3.2.4 Impacts of radioactive waste

Several accidents resulting from improper disposal of nuclear therapeutic materials have been reported, with a large number of persons suffering from the results of exposure.

In Brazil, one case of carcinogenic impact on the general population linked to exposure to radioactive hospital waste has been analysed and fully documented. While moving, a radiotherapy institute left a sealed radiotherapy source in its old premises. An individual who gained access to these premises removed the source and took it home. As a consequence, 249 people were exposed, of whom several either died or suffered severe health problems (IAEA, 1988).

Apart from the Brazil incident, no reliable scientific data are available on the impact of radioactive hospital waste. It may be that many cases of exposure to radioactive health-care waste, and associated health problems, go unreported. The only recorded accidents involving exposure to ionizing radiations in health-care settings have resulted from unsafe operation of X-ray apparatus, improper handling of radiotherapy solutions, or inadequate control of radiotherapy.

3.3 Survival of pathogenic microorganisms in the environment

Pathogenic microorganisms have limited ability to survive in the environment. This ability is specific to each microorganism and is a function of its resistance to environmental conditions such as temperature, humidity, ultraviolet irradiation, availability of organic substrate material, presence of predators, etc.

The hepatitis B virus is very persistent in dry air and can survive for several weeks on a surface; it is also resistant to brief exposure to boiling water. It can survive exposure to some antiseptics and to 70% ethanol and remains viable for up to 10 hours at a temperature of 60°C. The Japanese Association for Research on Medical Waste found that an infective dose of hepatitis B or C virus can survive for up to a week in a blood droplet trapped inside a hypodermic needle.

By contrast, HIV is much less resistant. It survives for no more than 15 minutes when exposed to 70% ethanol and only 3–7 days at ambient temperature. It is inactivated at 56°C.

Bacteria are less resistant than viruses, but much less is known about the survival of prions and agents of degenerative neurological diseases (Creutzfeldt–Jakob disease, kuru, etc.), which seem to be very resistant.

With the exception of waste containing pathogenic cultures or excreta of infected patients, the microbial load of health-care waste is generally not very high. Furthermore, health-care wastes do not seem to provide favourable media for the survival of pathogens, perhaps because they frequently contain antiseptics. Results of a number of studies have shown that the concentration of indicator microorganisms in health-care waste is generally no higher than in domestic waste, and that survival rates are low.

In evaluating the survival or spread of pathogenic microorganisms in the environment, the role of vectors such as rodents and insects should be considered. This applies to management of health-care waste both within and outside health-care establishments. Vectors such as rats, flies, and cockroaches, which feed or breed on organic waste, are well known passive carriers of microbial pathogens; their populations may increase dramatically where there is mismanagement of waste.

3.4 Needs for further research and epidemiological surveys

Very few data are available on the health impacts of exposure to health-care waste, particularly in the case of developing countries. Better assessment of both risks and effects of exposure would permit improvements in the management of health-care waste management and in the planning of adequate protective measures. Unfortunately, the classical application of epidemiology to the problem is difficult because of methodological complications and uncertainties regarding evaluation of both exposure and health outcome. The great diversity of hazardous wastes that can be involved and of circumstances of exposures is a particularly problematic feature of all such evaluations. It prevents not only the development of a unified analytical approach to the assessment of exposure and health outcome but also the generalization of any statistical inferences drawn about a specific waste-exposed population. Neverthe-

less, suspected cases of adverse health effects of health-care waste should be adequately documented, with precise descriptions of exposure, exposed individuals or populations, and outcome.

Within health-care establishments, the surveillance of infection and record-keeping are important tools that can provide indications of inadequate hygiene practices or of contamination of the immediate environment (including that caused by health-care waste). Surveillance allows an outbreak of infection to be recognized and investigated and provides a basis for introducing control measures, for assessing the efficacy of those measures and of the routine preventive measures taken by the establishment, and for reducing the level of avoidable infection. It will also ensure that the control measures have maximum effect and are as cost-effective as possible.

In summary, further research is necessary to increase knowledge of:

- the extent to which health-care waste is contaminated;
- the risk level for contamination of the exposed population by digestive, respiratory, and percutaneous routes;
- growth and survival of pathogens in waste during storage.

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