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Assessment of Awareness of Bio-medical Waste Management among Health Care Personnel in Omdurman Teaching Hospital in March 2020

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ABSTRACT

Introduction: *Biomedical waste issue is very important as any health issues because the impact of this problem affect not only health workers but also general community and because of the seriousness of the problem, health care workers as the first line of defense must have a proper knowledge about this issue and their awareness about how to deal with it should be assessed. This research was conducted to assess biomedical waste management among health care personnel in Omdurman teaching hospital.*

Objective: *The objective of the study was to know the awareness and existing knowledge about biomedical waste management among health care personnel in Omdurman teaching hospital, Khartoum, Sudan.*

Methodology: *The methodology was cross-sectional descriptive based on case study. Data was collected from 244 participants (doctors, nurses, laboratory technicians and waste handlers) by use of self-administered questionnaire and interview-based questionnaire.*

Results: *The results showed that there is average knowledge and awareness regarding Biomedical waste management and colour coding system. Of the participants 10.7% received training about biomedical waste management.*

Conclusion: *In conclusion, health care personnel had average knowledge about biomedical waste management with lack of workshop about it, the practice of discarding sharp waste and usage of personal protective equipment is good but with little lower percentage within laboratory technicians. Needle stick injuries were very high among almost half of the participants and their response toward it was very poor.*

Keywords: Needle stick, Biomedical waste management, Saws, Broken glass

INTRODUCTION

The term health-care waste includes all the waste generated within health-care facilities, research centers and laboratories related to medical procedures. In addition, it includes the same types of waste originating from minor and scattered sources, including waste produced in the course of health care undertaken in the home (e.g. home dialysis, self-administration of insulin, recuperative care). Between 75% and 90% of the waste produced by health-care providers is comparable to domestic waste and usually called “non-hazardous” or “general health-care waste”. It comes mostly from the administrative, kitchen and housekeeping functions at health-care facilities and may also include packaging waste and waste generated during maintenance of health-care buildings. The remaining 10%-25%

of health-care waste is regarded as "hazardous" and may pose a variety of environmental and health risks.

MATERIALS AND METHODS

Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpels and other blades, knives, infusion sets, saws, broken glass and pipettes. Whether or not they are infected, such items are usually considered highly hazardous health-care waste and should be treated as if they were potentially infected.

Infectious waste: Infectious waste is material suspected to contain pathogens (bacteria, viruses, parasites or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts.

This category includes:

- Waste contaminated with blood or other body fluids.
- Cultures and stocks of infectious agents from laboratory work.
- Waste from infected patients in isolation wards.

Waste contaminated with blood or other body fluids include free-flowing blood, blood components and other body fluids; dressings, bandages, swabs, gloves, masks, gowns, drapes and other material contaminated with blood or other body fluids and waste that has been in contact with the blood of patients undergoing hemodialysis (e.g. dialysis equipment such as tubing and filters, disposable towels, gowns, aprons, gloves and laboratory coats).

Laboratory cultures and stocks are highly infectious waste. Waste from autopsies, animal bodies and other waste items that have been inoculated, infected or in contact with highly infectious agents are highly infectious waste. Discarded instruments or materials that have been in contact with persons or animals infected with highly infectious agents are also to be considered infectious waste [1].

Waste from infected patients in isolation wards includes excreta, dressings from infected or surgical wounds and clothes heavily soiled with human blood or other body fluids. Waste from non-infective patients and that is not contaminated with blood or body fluids may be considered non-infectious. In low-resource settings, the infection-control or medical personnel should determine whether waste from non-isolation ward patients should be classified as infectious waste [2]. They should apply the principles of the chain of infection to assess the risk of disease transmission from local practices used in the collection, handling, transport, treatment and disposal of waste.

Pathological waste: Pathological waste could be considered a subcategory of infectious waste, but is often classified separately-especially when special methods of handling, treatment and disposal are used. Pathological waste consists of tissues, organs, body parts, blood, body fluids and other waste from surgery and autopsies on patients with infectious diseases [3]. It also includes human fetuses and infected animal carcasses. Recognizable human or animal body parts are sometimes called anatomical waste. Pathological waste may include healthy body parts that have been removed during a medical procedure or produced during medical research.

Pharmaceutical waste, including genotoxic waste: Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, prescribed and proprietary drugs, vaccines and sera that are no longer required and, due to their chemical or biological nature, need to be disposed of carefully [4]. The category also includes discarded items heavily contaminated during the handling of pharmaceuticals, such as bottles, vials and boxes containing pharmaceutical residues, gloves, masks and connecting tubing. Genotoxic waste is highly hazardous and may have mutagenic (capable of inducing a genetic mutation), teratogenic (capable of causing defects in an embryo or fetus) or carcinogenic (cancer-causing) properties. The disposal of genotoxic waste raises serious safety problems, both inside hospitals and after disposal and should be given special attention. Genotoxic waste may include certain cytostatic drugs (see below), vomit, urine or faeces from patients treated with cytostatic drugs, chemicals and radioactive material. Technically, genotoxic means toxic to the Deoxyribonucleic Acid (DNA);

cytotoxic means toxic to the cell; cytostatic means suppressing the growth and multiplication of the cell; antineoplastic means inhibiting the development of abnormal tissue growth and chemotherapeutic means the use of chemicals for treatment, including cancer therapy [5]. Cytotoxic (chemotherapeutic or antineoplastic) drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells and are used in chemotherapy of cancer. They play an important role in the therapy of various neoplastic conditions, but are also finding wider application as immunosuppressive agents in organ transplantation and in treating various diseases with an immunological basis [6]. Cytotoxic drugs are most often used in specialized departments, such as oncology and radiotherapy units, whose main role is cancer treatment. Their use in other hospital departments and outside the hospital in clinics and elsewhere is also increasing.

Cytostatic drugs can be categorized as follows:

- **Alkylating agents:** Cause alkylation of DNA nucleotides, which leads to cross- linking and miscoding of the genetic stock;
- **Antimetabolites:** Inhibit the biosynthesis of nucleic acids in the cell;
- **Mitotic inhibitors:** Prevent cell replication.
- Cytotoxic wastes are generated from several sources and can include the following:
- Contaminated materials from drug preparation and administration, such as syringes, needles, gauzes, vials, packaging;
- Outdated drugs, excess (leftover) solutions, drugs returned from the wards;
- Urine, faeces and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.
- In specialized oncological hospitals, genotoxic waste (containing cytostatic or radioactive substances) may constitute as much as 1% of the total health-care wastes.

Chemical waste

Chemical waste consists of discarded solid, liquid and gaseous chemicals; for example, from diagnostic and experimental work and from cleaning and disinfecting procedures. Chemical waste from health care is considered to be hazardous if it has at least one of the following properties:

- Toxic (harmful).
- Corrosive (e.g. acids of pH<2 and bases of pH>12).
- Flammable.
- Reactive (explosive, water reactive, shock sensitive).
- Oxidizing.

Non-hazardous chemical waste consists of chemicals with none of the above properties; for example, sugars, amino acids and certain organic and inorganic salts, which are widely used in transfusion liquids [7].The most common types of hazardous chemicals used in health-care centres and hospitals and the most likely to be found in waste, are described in the following paragraphs. Formaldehyde is a significant source of chemical waste in hospitals. It is used to clean and disinfect equipment (e.g. haemodialysis or surgical equipment); to preserve specimens; to disinfect liquid infectious waste and in pathology, autopsy, dialysis, embalming and nursing units. Photographic fixing and developing solutions are used in X-ray departments where photographic film continues to be used. The

fixer usually contains 5%-10% hydroquinone, 15% potassium hydroxide and less than 1% silver. The developer contains approximately 45% glutaraldehyde. Acetic acid is used in both "stop" baths and fixer solutions.

Wastes containing solvents are generated in various departments of a hospital, including pathology and histology laboratories and engineering departments. Solvents include halogenated and non-halogenated compounds. Waste organic chemicals generated in health-care facilities include disinfecting and cleaning solutions, vacuum-pump and engine oils, insecticides and rodenticides [8]. Waste inorganic chemicals consist mainly of acids and alkalis, oxidants and reducing agents. Wastes from materials with high heavy-metal contents represent a subcategory of hazardous chemical waste and are usually highly toxic. Mercury is an example of a highly toxic yet common substance in health-care facilities [9]. Mercury wastes are typically generated by spillage from broken clinical equipment, but their volume is decreasing in many countries with the substitution of mercury-free instruments (e.g. digital thermometers, aneroid blood-pressure gauges). Whenever possible, spilt drops of mercury should be recovered. Residues from dentistry also have high mercury contents. Cadmium waste comes mainly from discarded batteries. Reinforced wood panels containing lead are still used in radiation proofing in X-ray and diagnostic departments. Many types of gas are used in health care and are often stored in portable pressurized cylinders, cartridges and aerosol cans [10]. Many of these are reusable, once empty or of no further use (although they may still contain residues). However, certain types-notably aerosol cans are single-use containers that require disposal. Whether inert or potentially harmful, gases in pressurized containers should always be handled with care; containers may explode if incinerated or accidentally punctured (Table 1).

Table 1 Chemical waste from health-care activities

Chemical waste	Examples
Halogenated solvents	Chloroform, methylene chloride, perchloroethylene, refrigerants, trichloroethylene
Non-halogenated solvents	Acetone, acetonitrile, ethanol, ethyl acetate, formaldehyde, isopropanol, methanol, toluene, xylenes
Halogenated disinfectants	Calcium hypochlorite, chlorine dioxide, iodine solutions, iodophors, sodium dichloroisocyanurate, sodium hypochlorite (bleach)
Aldehydes	Formaldehyde, glutaraldehydes, ortho-phthalaldehyde
Alcohols	Ethanol, isopropanol, phenols
Other disinfectants	Hydrogen peroxide, peroxyacetic acid, quarternary amines
Metals	Arsenic, cadmium, chromium, lead, mercury, silver
Acids	Acetic, chromic, hydrochloric, nitric, sulfuric
Bases	Ammonium hydroxide, potassium hydroxide, sodium hydroxide
Oxidizers	Bleach, hydrogen peroxide, potassium dichromate, potassium permanganate

Reducers	Sodium bisulfite, sodium sulfite
Miscellaneous	Anaesthetic gases, asbestos, ethylene oxide, herbicides, paints, pesticides, waste oils

Radioactive waste

Radioactive wastes are materials contaminated with radionuclides. They are produced as a result of procedures such as *in vitro* analysis of body tissue and fluid, *in vivo* organ imaging and tumor localization and various investigative and therapeutic practices [11].

Radionuclides used in health care are in either unsealed (or open) sources or sealed sources. Unsealed sources are usually liquids that are applied directly, while sealed sources are radioactive substances contained in parts of equipment or encapsulated in unbreakable or impervious objects, such as pins, "seeds" or needles.

Radioactive health-care waste often contains radionuclides with short half-lives (i.e. half of the radionuclide content decays in hours or a few days); consequently, the waste loses its radioactivity relatively quickly [12]. However, certain specialized therapeutic procedures use radionuclides with longer half-lives; these are usually in the form of small objects placed on or in the body and may be reused on other patients after sterilization. Waste in the form of sealed sources may have a relatively high radioactivity, but is only generated in low volumes from larger medical and research laboratories. Sealed sources are generally returned to the supplier and should not enter the waste stream.

The waste produced by health-care and research activities involving radionuclides and related equipment maintenance and storage can be classified as follows:

- Sealed sources;
- Spent radionuclide generators;
- Low-level solid waste (e.g. absorbent paper, swabs, glassware, syringes, vials);
- Residues from shipments of radioactive material and unwanted solutions of radionuclides intended for diagnostic or therapeutic use;
- Liquid immiscible with water, such as liquid scintillation counting;
- Residues used in radioimmunoassay and contaminated pump oil;
- Waste from spills and from decontamination of radioactive spills;
- Excreta from patients treated or tested with unsealed radionuclides;
- Low-level liquid waste (e.g. from washing apparatus);
- Gases and exhausts from stores and fume cupboards.

Non-hazardous general waste

Non-hazardous or general waste is waste that has not been in contact with infectious agents, hazardous chemicals or radioactive substances and does not pose a sharps hazard. A significant proportion (about 85%) of all waste from health-care facilities is non-hazardous waste and is usually similar in characteristics to municipal solid waste. More than half of all non-hazardous waste from hospitals is paper, cardboard and plastics, while the rest comprises discarded food, metal, glass, textiles, plastics and wood.

In many places, community or regulatory requirements encourage materials recycling. In the past, all or most non-hazardous and municipal waste was discarded in dumps or landfills or burnt in municipal incinerators. Greater awareness of the environmental impacts of waste and the recognition that most of the non-hazardous waste from health-care facilities is potentially recyclable or compostable have changed the approaches to managing general waste (Table 2).

Table 2 Categories of wastes and their descriptions and examples

Waste categories hazardous health-care waste	Descriptions and examples
Sharp waste	Used or unused sharps (e.g. hypodermic, intravenous or other needles; auto-disable syringes; syringes with attached needles; infusion sets; scalpels; pipettes; knives; blades; broken glass)
Infectious waste	Waste suspected to contain pathogens and that poses a risk of disease transmission (see section 2.1.2) (e.g. waste contaminated with blood and other body fluids; laboratory cultures and microbiological stocks; waste
	Including excreta and other materials that have been in contact with patients infected with highly infectious diseases in isolation wards)
Pathological waste	Human tissues, organs or fluids; body parts; fetuses; unused blood products
Pharmaceutical waste, cytotoxic waste	Pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals cytotoxic waste containing substances with genotoxic properties (e.g. waste containing cytostatic Drugs-often used in cancer therapy; genotoxic chemicals)
Chemical waste	Waste containing chemical substances (e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents; waste with high content of heavy metals, e.g. batteries; broken thermometers and blood-pressure gauges)
Radioactive waste	Waste containing radioactive substances (e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources)
Non-hazardous or general health care waste	Waste that does not pose any particular biological, chemical, radioactive or physical hazard

Sources of health-care waste: Different types of health-care facilities can be viewed as major or minor sources of health-care waste, according to the quantities produced (Table 3).

Table 3 Major sources of health-care waste

1.	Hospitals
2.	University hospital
3.	General hospital
4.	District hospital
5.	Other health-care facilities
6.	Emergency medical care services
7.	Health-care centers and dispensaries
8.	Obstetric and maternity clinics
9.	Outpatient clinics
10.	Dialysis centers
11.	Long-term health-care establishments and
12.	Transfusion centers
13.	Military medical services
14.	Prison hospitals or clinics
15.	Related laboratories and research centers
16.	Medical and biomedical laboratories
17.	Biotechnology laboratories and institutions
18.	Medical research centers
19.	Mortuary and autopsy centers
20.	Animal research and testing
21.	Blood banks and blood collection services
22.	Nursing homes for the elderly

Minor and scattered sources produce some health-care waste, but their quantities and composition will vary. These sources typically have some common features: They rarely produce radioactive or cytostatic waste. Human body parts are not normally produced. Sharps consist mainly of hypodermic needles (Table 4).

Table 4 Minor sources of health-care waste

S.No.	**Minor sources of health-care waste**
1.	Small health-care establishments
2.	First-aid posts and sick bays
3.	Physicians' offices
4.	Dental clinics
5.	Acupuncturists
6.	Chiropractors
7	Specialized health-care establishments and institutions with low waste generation
8.	Convalescent nursing homes
9.	Psychiatric hospitals
10.	Disabled persons' institutions
11.	Activities involving intravenous or subcutaneous
12.	Cosmetic ear-piercing and tattoo parlours
13.	Illicit drug users and needle exchanges

14.	Funeral services
15.	Ambulance services
16.	Home treatment

Types of hazards

The hazardous nature of health-care waste is due to one or more of the following characteristics:

- A genotoxic or cytotoxic chemical composition.
- Presence of toxic or hazardous chemicals or biologically aggressive pharmaceuticals.
- Presence of radioactivity.
- Presence of used sharps.

Persons at risk

All individuals coming into close proximity with hazardous health-care waste are potentially at risk from exposure to a hazard, including those working within health-care facilities who generate hazardous waste and those who either handle such waste or are exposed to it as a consequence of careless actions.

The main groups of people at risk are:

- Medical doctors, nurses, health-care auxiliaries and hospital maintenance personnel.
- Patients in health-care facilities or receiving home care.
- Visitors to health-care facilities.
- Workers in support services, such as cleaners, people who work in laundries, porters.
- Safe management of wastes from health-care activities.
- Workers transporting waste to a treatment or disposal facility.
- Workers in waste-management facilities (such as landfills or treatment plants), as well as informal recyclers (scavengers).

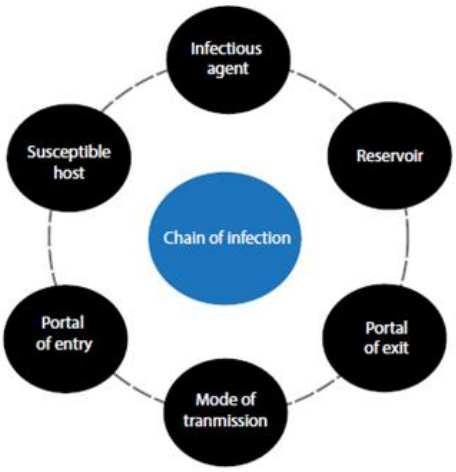
Hazards from infectious waste and sharps

Infectious waste should always be assumed to potentially contain a variety of pathogenic microorganisms. This is because the presence or absence of pathogens cannot be determined at the time a waste item is produced and discarded into a container. Through a puncture, abrasion or cut in the skin

- Through mucous membranes.
- By inhalation.
- By ingestion.

Pathogens in infectious waste that is not well managed may enter the human body through several routes (Figure 1).

Figure 1 Chain of infection



The transmission of infection and its control is illustrated by a "chain of infection" diagram, good health-care waste management can be viewed as an infection-control procedure. It is also important to note that breaking any link in the chain will prevent infection, although control measures for health-care waste are most often directed at the "mode of transmission" stage in the chain of infection (Table 5).

Table 5 Potential 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. *Salmonella*, *Shigella* spp., *Vibrio cholerae*, Clostridium difficile, helminths	Faeces and/or vomit
Respiratory infections	Mycobacterium tuberculosis, measles virus, Streptococcus Pneumoniae, Severe Acute Respiratory Syndrome (SARS)	Inhaled secretions, saliva
Ocular infection	Herpesvirus	Eye secretions
Genital infections	Neisseria gonorrhoeae, herpesvirus	Genital secretions
Skin infections	*Streptococcus spp.*	Pus
Anthrax	*Bacillus anthracis*	Skin secretions
Meningitis	*Neisseria meningitidis*	Cerebrospinal fluid
Acquired immunodeficiency syndrome (AIDS)	Human Immunodeficiency Virus (HIV)	Blood, sexual secretions, body fluids
Haemorrhagic fevers	Junin, Lassa, Ebola and Marburg viruses	All bloody products and secretions
Septicaemia	*Staphylococcus spp.*	Blood
Bacteraemia	Coagulase-negative *Staphylococcus spp*. (including methicillian-resistant S. aureus), *Enterobacter*, *Enterococcus*, *Klebsiella* and *Streptococcus spp*.	Nasal secretion, skin contact
Candidaemia	*Candida albicans*	Blood
Viral hepatitis A	Hepatitis A virus	Faeces

Viral hepatitis B and C	Hepatitis B and C viruses	Blood and body fluids
Avian influenza	H5N1 virus	Blood, faeces

Hazards from chemical and pharmaceutical waste

Many of the chemicals and pharmaceuticals used in health care are hazardous. They are commonly present in small quantities in health-care waste, whereas larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are sent for disposal. Chemical wastes may cause intoxication, either by acute or chronic exposure or physical injuries the most common being chemical 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 occur by contact with flammable, corrosive or reactive chemicals (e.g. formaldehyde and other volatile substances).

Laboratory staff is regularly exposed to dozens of chemicals during the course of their work, especially in specialist and research hospitals (Table 6).

Table 6 WHO-recommended segregation scheme

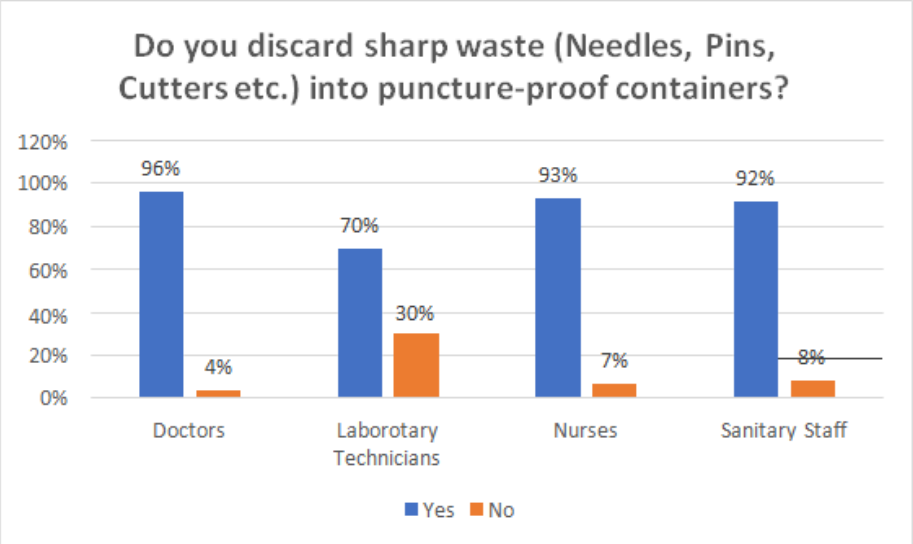
Type of waste	Colour of container and markings	Type of container
Highly infectious waste	Yellow, marked "Highly Infectious", with biohazard symbol	Strong, leak-proof plastic bag or container capable of being autoclaved
Other infectious waste, pathological and anatomical waste	Yellow with biohazard symbol	Leak-proof plastic bag or container
Sharps	Yellow, marked "Sharps", with biohazard symbol	Puncture-proof container
Chemical and pharmaceutical waste	Brown, labelled with appropriate hazard symbol	Plastic bag or rigid container
Radioactive waste	Labelled with radiation symbol	Lead box
General health-care waste	Black	Plastic bag

The hazardous properties most relevant to wastes from health care are as follows

Toxic: Most chemicals are toxic at some level of exposure. Fumes, dusts and vapours from toxic materials can be especially harmful because they can be inhaled and pass quickly from the lungs into the blood, permitting rapid circulation throughout the body.

Corrosive: Strong acids and alkali bases can corrode completely through other substances, including clothing. If splashed on the skin or eyes, they can cause serious chemical burns and permanent injury. Some of these also break down into poisonous gases, which further increase their hazardousness (Figure 2).

Figure 2 The practices for different strata towards biomedical waste regarding discard of sharp waste



Explosive: Some materials can explode when exposed to heat or flame, notably flammable liquids when ignited in confined spaces and the uncontrolled release of compressed gases.

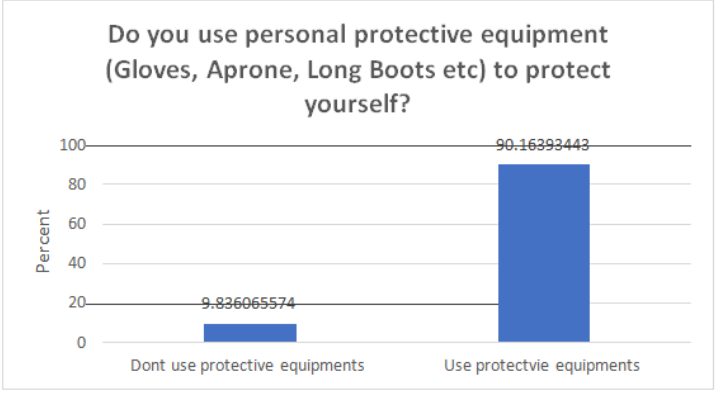
Flammable: Compounds with this property catch fire easily, burn rapidly, spread quickly and give off intense heat. Many materials used and stored in medical areas, laboratories and maintenance workshops are flammable, including solvents, fuels and lubricants.

Chemically reactive: These materials should be used with extreme caution and stored in special containers. Some can burn when exposed to air or water, some when mixed with other substances. It is important to note that reactive materials do not have to be near heat or flames to burn. They may burn spontaneously in the presence of air and also give off vapours that may be harmful if inhaled.

Hazards from genotoxic waste

Special care in handling genotoxic waste is essential. 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, ingestion as a result of bad practice, such as mouth pipetting or from waste items. Exposure may also occur through contact with body fluids and secretions of patients undergoing chemotherapy (Figure 3).

Figure 3 The practices of health care workers towards biomedical waste



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 are 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 extreme irritants and have harmful local effects after direct contact with skin or eyes. Cytotoxic drugs 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).

Any discharge of genotoxic waste into the environment could have disastrous ecological consequences.

Hazards from health-care waste-treatment methods

In addition to the specific hazards posed by different types of health-care waste, there are occupational hazards associated with waste-treatment processes. Some are similar to those common in industries using machinery:

- Flue gases from waste incinerators may have an impact on people living and working close to a treatment site. The health risk is most serious where an incinerator is improperly operated or poorly maintained. If poorly controlled, emissions from waste incinerators may cause health concern from particulates (associated with increased cardiovascular and respiratory mortality and morbidity); volatile metals, such as mercury and cadmium (associated with damage to the immune system, neurological system, lungs and kidneys) and dioxins, furans and polycyclic aromatic hydrocarbons (which are known carcinogens but may also cause other serious health effects).

- Ash from the incineration of hazardous health-care waste may continue to pose a risk. Burnt-out needles and glass may have been disinfected but can still cause physical injury. Furthermore, incinerator ash may contain elevated concentrations of heavy metals and other toxic items and the ash provides ideal conditions for the synthesis of dioxins and furans, because it is often exposed for a long time to a temperature range of 200°C-450°C.

- Autoclave and steam disinfection treatment methods can also pose potential hazards that need to be managed. In particular, good maintenance and operation should be undertaken to avoid physical injuries from high operating temperatures and steam generation. Post-waste treatment water contains organic and inorganic contaminants. The concentrations should be monitored to ensure that discharges to sewerage systems are within regulated limits.

- Health-care waste treatment mechanical equipment, such as shredding devices and waste compactors, can cause physical injury when improperly operated or inadequately maintained.

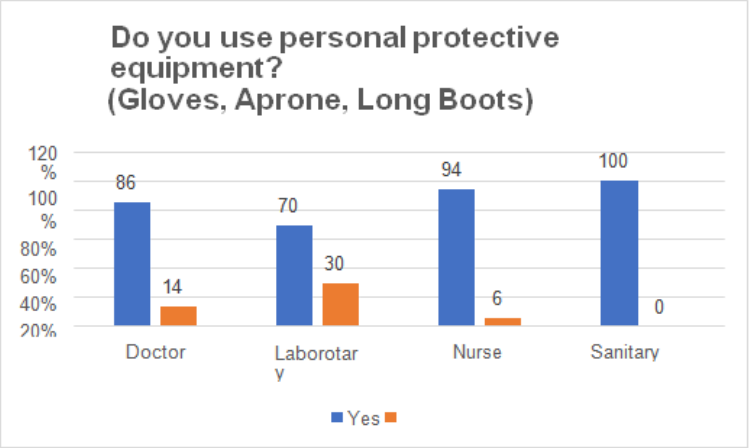
- Burial of health-care waste in landfill sites may pose hazards to workers and public. The risks are often difficult to quantify and the most likely injury comes from direct physical contact with waste items. Chemical contaminants or pathogens in landfill leachate may be released into surface streams or groundwater. On poorly controlled land-disposal sites, the presence of fires and subsurface burning waste poses the further hazard of airborne smoke. The smoke may contain heavy metals and other chemical contaminants that over time may affect the health of site workers and the general public.

Segregation, storage and transport of health-care waste

Segregation systems: The correct segregation of health-care waste is the responsibility of the person who produces each waste item, whatever their position in the organization. The health-care facility management is responsible for making sure there is a suitable segregation, transport and storage system and that all staff adhere to the correct procedures. Segregation should be carried out by the producer of the waste as close as possible to its place of generation, which means segregation should take place in a medical area, at a bedside, in an operating theatre or laboratory by nurses, physicians and technicians. If classification of a waste item is uncertain, as a precaution it

should be placed into a container used for hazardous health-care waste. The simplest waste-segregation system is to separate all hazardous waste from the larger quantity of non-hazardous general waste. However, to provide a minimum level of safety to staff and patients, the hazardous waste portion is commonly separated into two parts: used sharps and potentially infectious items. In the latter, the largest components are typically tubing, bandages, disposable medical items, swabs and tissues. Consequently, the segregation of general, non-hazardous waste, potentially infectious waste and used sharps into separate containers is often referred to as the "three-bin system". Further types of containers can be used for other categories of wastes, such as chemical and pharmaceutical wastes or to separate out pathological waste, where it is to be handled and disposed of in different ways from the other portions of the waste flow (Figure 4).

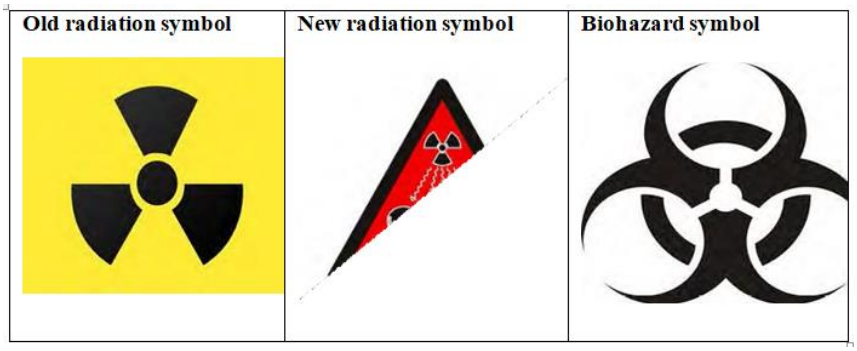
Figure 4 Practices for different strata towards biomedical waste regarding use of personal protective equipment to protect themselves at Omdurman Teaching Hospital, March 2020. Chi-Square test was 0.006 which is statically significant (n=244)



Waste containers, color codes and labels

Ideally, the same system of segregation should be in force throughout a country and many countries have national legislation that prescribes the waste segregation categories to be used and a system of color coding for waste containers. Where there is no national legislation, a World Health Organization (WHO) scheme is available. Color coding makes it easier for medical staff and hospital workers to put waste items into the correct container and to maintain segregation of the wastes during transport, storage, treatment and disposal. Color coding also provides a visual indication of the potential risk posed by the waste in that container. Labelling of waste containers is used to identify the source, record the type and quantities of waste produced in each area and allow problems with waste segregation to be traced back to a medical area. A simple approach is to attach a label to each filled container with the details of the medical area, date and time of closure of the container and the name of the person filling out the label. Using an international hazard symbol on each waste container is also recommended. Since sharps can cause injuries that leave people vulnerable to infection, both contaminated and uncontaminated sharps should be collected in a puncture-proof and impermeable container that is difficult to break open after closure. Performance specifications for these containers are given in WHO. Sharps containers may be disposable or designed for disinfection and reuse. Disposables are boxes made of plasticized cardboard or plastic; reusable designs are plastic or metal. Low-cost options include the reuse of plastic bottles or metal cans. If this is to be done, the original labels should be removed or obscured and the containers should be clearly relabeled as "Sharps containers" (Figure 5).

Figure 5 Old and new radiation symbol, biohazard symbol

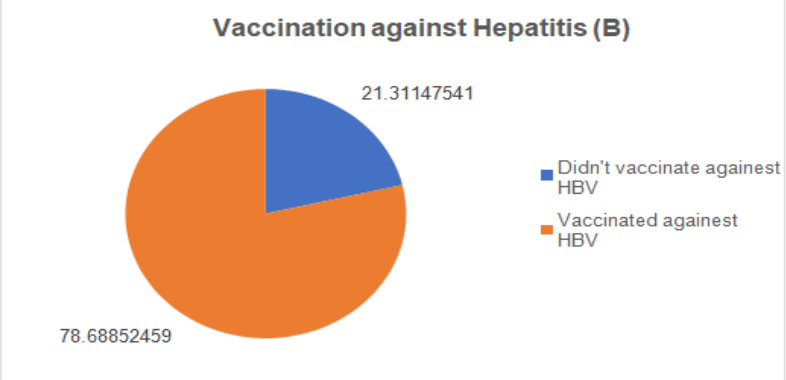


Note: The new radiation symbol was adopted by the United Nations in 2007, but the older symbol is still widely recognized and expected to remain in common use for many years.

Needle stick injuries

It is estimated that there are 35 million Healthcare Workers (HCWs) worldwide representing 12% of the working population. Two million injuries are believed to occur each year among HCWs. Approximately 3 million Health Care Workers (HCWs) experience percutaneous exposure to Blood Borne Viruses (BBVs) each year. This results in an estimated 16,000 hepatitis C, 66,000 hepatitis B and 200 to 5000 Human Immunodeficiency Virus (HIV) infections annually. Percutaneous injuries, caused by needle sticks and other sharps, are a serious concern for all Health Care Workers (HCWs) and pose a significant risk of occupational transmission of blood borne pathogen. Although sharp instruments injuries are preventable, a minor injury can carry the risk of transfer of over twenty pathogens of which the most serious are Hepatitis B Virus (HBV), Hepatitis C Virus (HCV) and Human Immunodeficiency Virus (HIV). Needle stick injuries are defined as wounds that are caused by sharp objects like hypodermic needles, fluid collection needles and IV cannel as which are attributed due to improper handling or manipulation of needles in different activities such as obtaining or transferring sample specimens, recapping activities and failure to dispose needles in puncture proof containers. Those injuries and blood-borne infections can be prevented by applying various strategies such as immunization for hepatitis B virus, post exposure prophylaxis and procedures to prevent percutaneous injuries.It is estimated that worldwide contaminated injection cause 8-16 million hepatitis B virus infection, around 2.4 to 4.5 million hepatitis C virus infection and about 80,000 to 160,000 HIV infections. In 2000-2030, WHO estimate that 16,000 HCV infections attributable to sharps injuries will result in 142 (51-749) early deaths (Figure 6).

Figure 6 The percentage of Vaccination against Hepatitis (B) among participants from Omdurman Teaching Hospital, March 2020 (n=244)



Similarly, the 66,000 HBV infections will lead to 261 (86-923) early deaths and about 736 (129-3578) healthcare workers will die prematurely from 1000 HIV infections.The incidence of NSI is considerably higher than current estimates, due to gross underreporting (often less than 50%). In USA 6,00,000 to 10,00,000 receive NSI from conventional needles and sharps every year, while in UK it is 1,00,000 HCWs/year. In India, authentic data on NSI are scarce. It is known that around 3-6 billion injections are given per year, of which 2/3rd injections are unsafe (62.9%) moreover in a study done at dental school in Sudan there is (69.6%) students reported being exposed to a sharp instrument's injury. Infection by the Human

Immunodeficiency Virus (HIV) and Hepatitis B Virus (HBV) pose great health problems worldwide particularly in the developing countries. The risk of occupational BBI for HCWs in low and middle income countries is high due to crowded hospitals, high patient load per HCW, limited knowledge of risks, inadequate Personal Protective Equipment (PPE), lack of sharps containers, limited knowledge and utilization of Post Exposure Prophylaxis (PEP), low adherence to Universal Precautions (UP), high prevalence of patients with BBI and low hepatitis B vaccination coverage among HCWs. As 2 million cases of HCV and 21 million of HBV infections are due to unsafe therapeutic injections, poor adherence to UP puts both patients and HCWs at risk of BBI. Preventing NSI is an essential part of any blood borne pathogen prevention program in the work place. With regard to prevention, when exposures occur, the risk of infection can be significantly reduced by following protocols for PEP. Guidelines have been issued for the management of HCWs who have had occupational exposure to blood borne pathogens. This includes urgent valuation of the source and exposed person's status along with the timely administration of Hepatitis B Immune Globulin (HBIG), hepatitis B vaccine and/or HIV PEP where applicable. For HCV, testing should be performed to determine if infection develops. The present study addresses the important issue of NSI and aims at determining the occurrence of NSI among different categories of HCWs, the various factors responsible, the circumstances under which these occur and explores the availability and possibilities of measures to prevent these through improvement in knowledge, attitude and practice (Table 7).

Table 7 Frequency of the participants who had training about bio-medical waste management from omdurman teaching Hospital, March 2020 (n=244)

Response	Frequency	Percent
Yes	26	0.107
No	218	0.893
Total	244	1

Previous studies

Based on direct observations and interviews under the title of (Healthcare Waste Management; a case study from Sudan and found that the HCWM was insufficient, all wastes were mixed together, there was inadequate training, a lack of policies, a shortage or improper usage of PPE, high rate of NSIs and low vaccination rate among HCPs.

Tahani Babiker ELya, Babiker Ahmed Babiker conducted a study in port sudan teaching hospital, red sea state from 2014-2015 the data collection based upon experiments, questionnaire and checklists, under the title they found on observation poor practice toward sharp objects disposal All HCFs fail to maintain the segregation along the waste stream due to the absence of specific collection and disposal services for hazardous health care waste, labeling of hazardous waste types was completely absent. No incinerator for medical waste in the hospital and hospital disposed of their waste at the same site as the municipal waste.

RESULTS

Health care waste worker were illiterate, (58%) of them their experienced over 8 years, only (10%) had get a medical examination before employment, 4% of workers were immunized before joining the job and about 27% of workers had an injury during work, most of worker take 8 hours in working. Tayseer Awad Elkareem Basbeer and Alia Taha Ali Taha wrote a paper which is to evaluate the status of biomedical waste disposing in Sudanese hospitals under the title and found that; the field work (management and workers).

- Lack of the continuous control of the waste management process and the complete lack of awareness of the service workers which led to the mixing of the medical wastes with the ordinary wastes.
- The lack of sufficient equipment for protection and safety of the employees.
- The non-use of the red and yellow bags for the medical wastes.
- The non-burning of the plates of the bacterial culture in the incinerator because they are manufactured from glass.
- The number of the containers is very few, in such a manner that it is in commensurate with the size of the discarded wastes.

- The sharp medical wastes were put in the safety bins.
- The bad blood is exterminated through the burning in the incinerators and in some hospitals, it is burned inside the hospital.
- Due to the increase of the price of the safety bin, it was substituted by the use of the drip cartoon or the jericans instead of it.
- The wastes bags are transformed from the departments to the temporary landfill of the hospital by carrying them on hands by the cleaning workers.
- Lack of rooms for the medical wastes with the required designing standards and specifications.

Lack of training or periodical vaccination for the workers. Non-abidance by putting the sharp tools and needles in the safety bin in some times. Musab Omer Ahmed Nour conducted a research in Khartoum North teaching hospital in 2011, under title (Table 8).

Table 8 Percentage of the correct responses, wrong responses and the percentage of those who do not knew the correct answer from the total population under study in Omdurman Teaching Hospital

Question topic	Correct responses	Wrong responses
Definition of BMWs	75.8% (185)	24.2% (59)
Hazards of BMWs	71.7% (175)	28.3% (69)
Knowing about color coding system	82.8% (202)	17.2% (42)
What to dispose in black containers	40.6% (99)	59.4% (145)
What to dispose in yellow containers	40.2% (98)	59.8% (146)
What to dispose in brown containers	10.7% (26)	89.3% (218)
Dispose sharp objects in PPB	93.4% (228)	6.6% (16)
Disposal of expired drugs	30.7% (75)	69.3% (169)
Disposal of cytotoxic agents	41.4% (101)	58.6% (143)
Types of BMWs processing methods	52.9% (129)	47.1% (115)
Use of Protective equipment	90.2% (220)	9.8% (24)
When to put Hazard symbols	81.1% (198)	18.9% (46)
Diseases transmitted by NSIs	41% (100)	59% (144)

The results were it is obvious that Process of health care waste management is generally poor and it is not practice according to WHO's standards in many the stages especially (storage stage, external transport, treatment stage and final disposal of waste). No clear plans to future, no polices to management health care waste, No proper training to health workers in the hospital. Khalid Hamid Gad Elmoula conducted a research in Soba University Hospital and East Nile Hospital 2014, based on questionnaire, observation under title of and the conclusion of the study revealed inadequate and inefficient knowledge of HCWs regarding BWM, adequate practice regarding discard into specific containers and puncture proof containers, both hospitals do not meet the international standers of biosecurity measures at many levels, absence of clear written polices and guidelines, insufficient training programs, high levels of needle stick injuries and insufficient vaccination of HCWs against Hepatitis B and tetanus viruses.

DISCUSSION

The HCPs have average awareness about Biomedical waste management, in which the mean score was found to be 7.85, 7.29, 7.10 and 7.52 out of 13 of the four categories doctors, nurses, Laboratory technicians and sanitary staff respectively, so the doctors show to have better awareness than others which is not statistically significant (p=0.625), but between doctors and nurses was statistically significant (p=0.036). This result contraindicates the results of Hamid K. Which revealed that doctors have less awareness about BMWs management than other groups which was statistically significant (P=0.026).

The practice of discarding Sharp waste in PPCs was better in doctors (96%) than nurses (93%), laboratory technician (70%) and sanitary staff (92%) which is not statistically significant (p=0.08), but this contraindicate the study of Hamid K. Which shows that nurses have better practice (98%) than doctors (88%) Laboratory technicians (50%) and sanitary staff (88%) which was statistically significant (p=0.001). About the usage of personal protective equipment was average but better in sanitary staff (100%) than doctors (86%), Nurses (94%) and laboratory technicians (70%) which is statistically significant (p=0.006). But was so much better is the study of Hamid K. Which shows doctors (97%), Nurses (100%), Laboratory technicians (100%) and sanitary staff (100%) which is not statistically significant (p=0.165).

CONCLUSION

Health care personnel has average but not very good knowledge about biomedical waste management, with an increase in general doctors' knowledge over past years, this knowledge should be increased to improve their medical practice. The practice of discarding sharp waste and usage of personal protective equipment is good but with little lower percentage within laboratory technicians who are mostly deal with patients' samples.

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