An-Najah National University
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An Environmental Health Study of Medical Waste in Nablus Hospitals

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Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Environmental Science, Faculty of Graduate Studies, at An-Najah National University, Nablus, Palestine

February 2001

Defense Committee Decision

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TO

MY PARENTS

MY WIFE

BOTHERS, AND

SISTERS,

WITH LOVE AND

RESPESCT.

Acknowledgments

I would like to express my special, sincere thanks and gratitude to my supervisor Professor Mohammed S. Ali-Shtayeh and my co-supervisor Dr. Issam A. Al-Khatib, for their supervision, encouragement, guidance, and help throughout this study.

I am also grateful to my friend Mohammed S. Al-Hmidi for his strong support, and encouragement by providing me with helpful material for this study.

I am also grateful to my friend Imad Al-Atrash for his support.

I am also grateful to my friend Murad Abo Al-Hija for his assistance in statistical analysis.

Also special thanks are due to laboratory technicians Abeer sweeseh, Ayman Kurd, and Ja'far Weld-Ali for their assistance during the laboratory analysis.

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Abstract

Field investigations of four hospitals medical wastes in Nablus City were carried out in 1998 and 1999.

The management of medical waste in Palestine was not given the proper attention. Still there are lacks of legislation and defined policy regarding this issue. The entire medical waste generated is dumped within general waste.

Medical waste generated at four hospitals (Rafidia, Al-Watani, Al-Ittehad, and Al-Injili) in the city of Nablus, were weighted twice over 11 days during March-June 1999, and during November –December 1999, and generation rates, volume and density of medical waste were calculated.

Hepatitis B serology tests were also carried out in 62 waste care workers from the study hospitals during December 1999.

This study shows the average daily quantities and generation rates of four general, governmental and none-governmental, hospitals were mentioned. Also the social and health conditions of the waste care workers in these hospitals were mentioned too.

Generation rates (kg/bed/day) were 0.67 in Rafidaia, 0.83 in Al-Watani, 0.76 in Al-Ittihad, and 0.69 in Al-Injili hospitals. While

the generation rates (kg/in-patient day) were 0.96 in Rafidia, 1.34 in Al-Watani, 1.18 in Al-Ittihad, and 1.37 in Al-Injili hospitals.

Results of serological tests for Hepatitis B virus, for 61 waste care workers (20 in Rafidia, 12 in Al-Watani, 11 in Al-Injili, and 19 in Al-Ittehad hospitals), were negative, while the results were positive for one case (one worker from Rafidia hospital), so that the prevalence of Hepatitis B for waste care workers was 1.6%.

CHAPTER ONE

GENERAL INTRODUCTION

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CHAPTER ONE
INTRODUCTION

1.1 DEFINITION OF MEDICAL WASTE

Several definitions have been suggested for medical waste. However, medical waste generated at hospitals can be defined according to the World Health Organization (WHO, 1999) as waste includes all the waste generated by health- care establishments (hospitals, medical centers, clinics, research facilities, medical laboratories, pharmaceutical research and production, in addition to waste originating from sources such as that produced in the course of health care undertaken at home, e.g. dialysis and insulin injections).

The USA Environmental Protection Agency (EPA) (1986) defined infectious waste as: waste capable of producing an infectious disease. This definition requires consideration of certain factors including presence of pathogen, dose, portal of entry, and resistance of host. Other definitions for medical waste can be seen in Appendix A.

1.2 CATEGORIES OF MEDICAL WASTE

Medical waste is generated at different parts of hospitals. These include patients departments (e.g., surgery, burn unit,

maternity), support services (e.g., lab, X- ray unit, blood bank, pharmacy), administration, and nurses and doctors residence. Several classifications have been suggested, however, medical waste generated at hospitals can be classified according to *The Health and Safety Commission, HSC, (1992) as follows:*

Group A waste	a) All human tissues, including blood, animal carcasses and tissues from veterinary centers, hospitals and laboratories, and all related swabs and dressings. b) Waste materials where the assessment indicates a risk arising from there sources (example infectious diseases cases) c) Solid surgical dressings, swabs and other solid waste from treatment areas.
Group B waste	Discarded syringe needles, cartridges, broken glass and other contaminated disposable sharp instruments or items.
Group C waste	Microbiological cultures and potentially affected waste from pathology and other clinical or research laboratories.
Group D waste	Certain pharmaceutical products and chemical wastes.
Group E waste	Items used to dispose off: urine, faeces and other bodily secretions or excretions assessed as not falling within Group A (e.g., used disposable bedpans, incontinence pads, stoma bags and urine containers).

Hospitals and other health facilities generate two categories of solid waste, general and medical waste, from each department.

General waste components are garbage, paper, plastic, food, textiles, glass, ...etc.

Medical waste generated at hospitals can also be classified as follows according to WHO (1999):

1- **Infectious waste**: suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. It includes culture and stocks of infectious agents from laboratory, waste from surgery and autopsies on patients with infectious diseases (e.g., tissues, materials, and equipment's), waste from infected patients in isolation wards and waste that has been in contact with infected patients undergoing heamodialysis, and others.

2- **Pathological waste**: consists of tissues, organs, body parts, human fetuses, animal carcasses, blood, and body fluids.

3- **Sharps:** are highly hazardous items that could cause cuts or puncture wounds (e.g. needles, hypodermic needles, scalps, and surgical blades) (Andre, 1995).

4- **Pharmaceutical waste:** includes items such as expired, unused, spilt, and contaminated pharmaceutical products,

drugs, vaccines, and sera that no longer required and need to be disposed off appropriately.

5-**Genotoxic waste:** is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties (e.g., cytotxic drugs, vomit, urine, or feces from patients treated with cytotoxic drugs and chemicals).

6-**Chemical waste:** consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work from cleaning, housekeeping, and disinfecting procedures.

7-**Wastes with high content of heavy metals:** hazardous chemical waste that is usually highly toxic, such as mercury and cadmium.

8-**Pressurized containers:** include cylinders, cartridges, and aerosol cans.

9-**Radioactive waste:** includes solid, liquid, and gaseous materials contaminated with radionuclides. It is produced as a result of procedures such as *in-vitro* analyses of body tissue and fluid, *in-vivo* organ imaging and tumor localization, and various investigative and therapeutic practices.

Several other classifications have been suggested (Appendix A).

1.3 GENERATION OF MEDICAL WASTE

Generation rates of hospital medical waste differ not only from country to country but also within a country (WHO, 1999). Medical waste generation depends on numerous factors such as established waste management methods, type of health-care establishment, hospital specialization, proportion of reusable items employed in health care, and proportion of patients treated on a day-care basis. In middle-and low- income countries, health-care waste generation is usually lower than in high-income countries (WHO, 1999).

Generation rates may be expressed in several ways, these include quantity generated (weight or volume) per patient per day (kg/pat/day); quantity generated (weight or volume) per bed per day (kg/bed/day); quantity generated (weight or volume) per gross patients which is the summation of total patients, out patients, and employees (kg/person gross population/day); quantity generated (weight or volume) per equivalent population (Qusus, 1988).

Percentages of wastes generated at other departments in the hospitals depend greatly on the way they are presented in the literature, as well as on the number of the departments and facilities available at the hospital in general. The range of

laboratories waste is between 2-6%, operating theaters and intensive care unit (ICU) is about 10%, surgery wastes range between 4.5- 6.5%, maternity from about 3- 4% and X-ray unit about 3% of the total load (Qusus, 1988). Countries that have not performed their own surveys of health-care waste may find the following estimates for average distribution of medical wastes useful for preliminary planning of medical waste management: 80% are general domestic waste, 15% are pathological and infectious waste, 1% sharps, 3% chemical and pharmaceutical waste, and less than 1% special waste which includes radioactive, cytotoxic, pressurized containers, broken thermometers, and used batteries (WHO, 1999).

1.4 FACTORS AFFECTING GENERATION RATES AT HOSPITALS

Several factors have been reported to affect waste generation rates at hospitals (Qusus, 1988), these include:

1- Classification of the hospital (range and type of care). Types of hospitals include general or specialized hospitals (both may be governmental, teaching, military or private). The range and type of care received (e.g., heavy care units such as ICU, operating theaters produce about two folds that produced by light care units

such as pediatric unit) reflect the effect of type of hospital on waste production. The effect of type of hospital on generation rates is shown in Table 1.1.

Table 1.1: Generation rates (kg/bed/day) by type of hospitals in Norway, Spain and United Kingdom. *

Type of hospital	Norway	Spain	United Kingdom
Teaching	3.9	4.4	3.3
General	-	2.8	2.5
Maternity	-	3.4	3
Mental	-	1.6	0.5

* After: WHO, (1985).

2- Capacity of the hospital. Quantity of solid wastes generated in a hospital depends on number of patients. As the capacity of the hospital increases, the number of staff members who provide service has to be increased. In addition, number of outpatients and visitors increases are associated with increase in generation rate of hospital waste (WHO, 1985).

1.5 HANDLING OF HOSPITAL WASTE

The term handling means the link between the steps of segregation, collection, packaging, initial storage, internal transport, on-site storage, internal storage, off-site storage, and external transport of waste. Handling is the most important process

to hygienically and economically minimize the risks of medical waste for both health and environment (Qusus, 1988).

The removal of hospital waste from point of segregation to the point of final disposal is achieved in the steps of handling as segregation, collection, storage, and transport.

Transportation of medical waste from the hospital to the final disposal place by separate vehicle, away of general waste in a proper packing will exclude rodents and insects and prevent spilling during handling and transportation (WHO, 1999).

1.5.1 Medical waste segregation and packaging

Segregation of medical waste is the key for the minimization and effective management of medical waste (WHO, 1999). Infectious waste should be segregated at the point of origin and, as soon as possible, packed and labeled by suitable codes (Blackman, 1996). The most appropriate way of identifying medical waste categories is by sorting the waste into colour-coded plastic bags or containers (Table 1.2).

Table1.2 Recommended colour-coding for medical waste.*

Type of medical waste	Colour of container and markings	Type of container
Highly infectious waste	Yellow, marked' "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag or container of being autoclaved
Other infectious waste, pathological and anatomical waste	Yellow label	Leak-proof plastic bag or container
Sharps	Yellow label marked' SHARPS'	Puncture proof container
Chemical and pharmaceutical waste.	Brown label	Plastic bag or container
General hospital waste	Black label	Plastic bag

* After: WHO (1999).

In addition to colour coding, the following practices are recommended (WHO, 1999):

1- Sharps should be collected together in sharp boxes difficult to open or break, and puncture proof.

2- Bags and containers for infectious waste should be marked with the international infectious substance symbol.

3- Highly infectious waste should be sterilized immediately by autoclaving.

4- Cytotoxic waste should be collected in strong, leak-proof containers labeled clearly "Cytotoxic Waste".

5- Chemical waste should be packed in chemical resistance containers and sent to special management facility.

6- An aerosol container should not be incinerated.

1.5.2 Collection of medical waste

Housekeeping or medical waste care staff normally collects medical waste. Packaging done and the medical waste placed in covered carts for transport to chutes or to elevator for subsequent transport to the outside storage containers. Medical waste is usually collected daily. The collection inside the hospital should be differentiated at the source to recognize the danger of the waste and to avoid any possible contamination (Qusus, 1988).

When collecting medical waste, waste bags are tightly closed when they are about three-quarters full. Tightening the neck can close gauge bags, but heavier-gauge bags probably require a plastic sealing tag. Stapling should not be used to close bags. Sealed sharps containers should be placed in a labeled, yellow infectious health-care waste bag before removal from the hospital ward. Medical waste should not be allowed to accumulate at the point of production (WHO, 1999).

1.5.3 Storage of medical waste

Storage of medical waste is believed to be the key of whole management process. Storage facilities inside the hospitals are usually placed in separate areas. Storage temperature and duration are important considerations. The EPA (1986)

recommends that the location of storage area should be close to the treatment site to minimize the storage time, and positing of universal biological hazard symbol on storage area door or waste containers or freezers or refrigerators. The WHO (1999) recommended that the duration of medical waste storage in temperate should be 72 hours in winter and 48 hours in summer, while in the warm climate 48 hours during the cool season and 24 hours during the hot season. Medical waste storage site should also be accessible to collection vehicles, and protected from animals and scavengers (Atyani, 1996).

1.5.4 On-site transport:

Medical waste should be transported within the hospital by means of wheeled trolleys, containers, or carts that are not used for any other purposes. These are prefer to be easy to load and unload, and easy to clean.

1.5.5 Off-site transport:

Packaging and labeling of medical waste should comply with national regulations governing the transport of medical waste (WHO, 1999). Special, totally enclosed vehicles should be used for the off-site transport of medical waste. The vehicle has a bulkhead between the driver's cabin and the vehicle body to prevent any risk

of contamination to the driver. The off-site transport vehicle should be leak-proof and easy to clean and labeled with the type of waste being carried, and it should be cleaned at the end of the working day and disinfected in case of spillage. The driver of the vehicle shold be accompanied with a written document indicating: the classification of the waste, the waste principal hazardous component, any special precautions to be taken while handling, emergency procedures in the event of spillage, and the name of the authority to contact in emergency.

1.6 TREATMENT AND DISPOSAL OF MEDICAL WASTE

The term treatment refers to processes that modify the waste in some way before it is taken to its final resting-place (WHO, 1999). It may be required to disinfect or sterilize the waste, reduce its bulk volume, and to make recyclable unusable items.

The EPA (1986) defines treatment as any method, technique, or process designed to change the biological character to composition of waste. The EPA recommended techniques for the treatment of infectious waste (Blackman, 1996), are presented in Table1.3.

Table 1.3 Recommended techniques for treatment of infectious waste. *

Category of infectious waste	Recommended treatment technique
Isolation wastes	- Steam sterilization - Incineration
Cultures and stocks of infectious agents associated biologicals.	- Steam sterilization - Incineration - Thermal inactivation - Chemical disinfection
Human blood and blood products	- Steam sterilization - Incineration - Chemical disinfection - Discharge of sanitary sewer
Pathological wastes	- Steam sterilization - Incineration
Contaminated animal carcasses, body parts	- Steam sterilization - Incineration

* After: Blackman (1996).

Certain wastes require special treatment before final disposal and several treatment methods are used. These include:

Steam sterilization /autoclaving: is widely used for decontamination of microbiological and high-risk infectious waste (autoclaved at source) and other laboratory waste prior to disposal (Blackman, 1996).

Gas sterilization: involves exposing of the waste to toxic fumes.

Chemical disinfection: is carried out by soaking medical wastes in a liquid chemical disinfectant to kill the infectious agents (EPA, 1996).

Mechanical treatment and grinding (crushing) is used to convert medical wastes into a more homogenous form that can be easily handled.

Thermal inactivation involves heating a waste to destroy infectious agents in only large volumes of liquid wastes.

Irradiation involves using ionizing radiation from a source such as cobalt 60 to destroy infectious agents.

Incineration: WHO (1999) reported that treatment of medical waste by using incinerators, is the method of choice for the most hazardous health-care wastes and is still widely used. Incineration is a good effective method for combustible chemical waste, cytotoxic and genotoxic drugs, human tissue and limbs, placenta, dialysis waste, sharps, solid surgical dressings, and swabs.

Incineration is a high-temperature dry oxidation process usually selected to treat medical waste that cannot be recycled, reduced, or disposed off in a landfill site. Some medical waste types cannot be incinerated as pressurized containers (to avoid explosion), radioactive chemical waste, silver salts or radiographic waste, and waste with high mercury or cadmium content (broken thermometers, used batteries) (WHO, 1999).

Landfiling is recommended only for post-incinerated or sterilized medical waste (WHO, 1994). Landfiling is effective for ashes from

incinerators, general waste, pressurized cylinders, solid surgical dressings, animal carcasses, used empty disposal bed-pan lins, and urine containers.

Recycling and recovery is recommended for recyclable hazardous and none-hazardous chemical waste, and noxious waste (Coad, 1999). Different types of chemicals that can be recycled and their recycling methods are listed in Table 1.4.

Table 1.4 Recycling and recovery methods used for chemical waste. *

Chemical waste	Recycling and recovery method
- Unused hazardous chemicals - Unused medicine	- Given or sold to other health providers - Returned to the pharmacy
- Solvents (xyline, acetone)	- Recovered by distillation
- Flammable organic solvents	- Reuse as fuel
- Chromic acid	- Recycled for recovery of chromium
- Mercury	- Collected for recovery of silver
- Developing solutions	- Recycled for the recovery of metals
- Discarded Batteries	- Sold for recovery of metals
- Waste oil	- Used as supplementary fuel

* After: Atyani (1996)

Different centers and associations recommended different methods of medical waste treatment (Table 1.5).

Table 1.5 Summary of treatment and disposal methods, by type of medical hospital waste.*

Type of solid waste	CDC	JCAH	EPA
Microbiological	S, I	S, I	S
Blood and blood products	S, I, Sew	SL, Sew	S , I
Communicable disease isolation	S, I	SL, Sew	S, I
Pathological (tissues, organs)	I	I	I, SW, CB
Item containing secretions and excretions	N	SL, Sew	-
Contaminated lab wastes	-	S, I	S, I
Surgical , Dialysis units	-	-	S, I
Sharps , syringes	G, I, S	N	S

S: Steam sterilization
I: Incineration
Sew: Sewage after grinding
CB: Cremation or burial by mortician
SW: Steam sterilization with incineration or grinding
CDC: Center of Disease Control in USA
JCAH: Joint Commission on Accreditation of Hospitals in USA
EPA: Environmental Protection Agency in USA
SL : Sanitary landfill
N : Not indicated
G: With general hospital waste
* After: Qusus (1988)

Disposal of hospital waste: this includes disposal of solid waste (dumping landfill) and disposal of wastewater (WHO, 1999). Recycling and recovery are considered as one option for treatment of hospital wastes.

1.7 COLLECTION AND DISPOSAL OF WASTEWATER

Wastewater from medical waste may contain various potentially hazardous components such as microbiological pathogens, hazardous chemicals, pharmaceuticals, and radioactive isotopes. Efficient on-site treatment of hospital sewage usually include the following operations (WHO, 1999):

Primary treatment: This includes handling steps such as on-site segregation, collection, packaging, in-sight storage, transport and off-site storage.

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. At the end of this operation the sludge still include infective concentration of bacteria and viruses.

Tertiary treatment: the secondary effluent will probably contain at least 20 mg/liter suspended organic matter, which is too high for efficient chlorine disinfection. It should therefore be subjected to tertiary treatment, such as lagooning; if no space is available for creating a lagoon, rapid sand filtration may be substituted for produce a tertiary effluent with a much reduced content of suspended organic matter (< 10 mg / liter).

Chorine disinfection: the tertiary effluent is subjected to chlorine dioxide or sodium hypochloride or chlorine gas.

1.8 HEALTH IMPACTS OF MEDICAL WASTE

Exposure to medical waste can result in disease or injury. According to WHO (1999), all individuals especially the health care staff (e.g., doctors, nurses, laboratory technicians, and waste

handlers), exposed to medical waste, are potentially at risk. Waste care workers handling waste containing blood-soaked objects from patient in different units in the hospitals must be protected from the transmission of Hepatitis B (WHO, 1985). Maintenance staff, personnel who are involved in the final disposal or incineration, pharmacy personnel, personnel working in or visiting laboratories and rooms in clinics, and public who live near disposal places should be protected too. Hospital staff were reported to frequently have an infection rate of Hepatitis B three to six times higher than normal risk, Qusus (1988). There is strong epidemiological evidence, that the main concern of infectious hospital waste is the transmission of AIDS/HIV virus and, more often, of Hepatitis B virus (HBV) through the injuries caused by syringe needles contaminated by the human blood (WHO, 1994).

According to different authors (Atyani, 1996; WHO 1999; and Qusus, 1988), expected health hazards and risks from medical waste include physical injury (e.g., by sharp objects), direct irritation of the skin (e.g., from soap, detergents), allergic contact dermatitis (e.g., rubber, metallic salts, and plastic resin), chemical burns, transmission of infection (through damaged skin by contaminated sharps) or transmission of pathogens (e.g., HIV, AIDS, hepatitis), skin absorption of cytotoxic drugs, and radiation

hazards (e.g., skin burn, neoplastic changes). Infection can be spread, also, by cockroaches, flies, birds, rats and other animals, infected dressings and infected surgical waste (Coad, 1999).

In addition to hepatitis B infection in hospitals, tuberculosis and salmonellosis infections are frequently encountered in hospitals housekeeping staff (Refa'ee, 1996). Pathogenic bacteria can be and are present in very high concentration in hospitals solid wastes, and the highest coliform counts were found in some hospitals in the West Bank, from ICU, and pediatric wards (Atyani, 1996).

Hepatitis B viral infection is one of the main epidemiological infections in the hospitals which can be transmitted by medical activities during treatment, investigations, vaccination, by using any type of injection (intramuscular, intravenous, or intradermal), or trauma from surgical blades or during blood transfusion. The hepatitis B virus (HBV) is a complex, 42-nm DNA virus that belongs to a new class called hepanda viruses. HBV virus does not grow in tissue culture (Refa'ee, 1996). HBV infection is dangerous and lead to many complications such as cirrhosis of liver and may be death.

Available data regarding the prevalence rate of HBV infection in regional and neighboring countries seems to indicate

that HBV is an endemic disease in the Middle East (Refa'ee, 1996). The following rates were reported: for Jordan (4.4%), Israel (0.5-4%), Saudia Arabia (7.4%), Turkey (5-10%), and southern parts of Palestine (4%) (Refa'ee, 1996). Numbers of cases (patients or carriers) in the West Bank during years 1997, 1998 and 1999 (eight months) can be seen in Table 1.6.

Table 1.6, Number of cases of hepatitis B in the West Bank for the years 1997,1998, and 1999. *

		1997	1998	1999 (1/1 – 31/8)
HBV	Case	116	99	51
	Carrier	1526	1124	1037

* Palestinian Ministry of Health (1997, 1998, 1999)

The long incubation period of HBV (45-160 days) and the sub-clinical infection play a role in difficulty of diagnosis. In addition to that, most of the cases are carriers without any symptoms that those play a big role in transmission of HBV (Refa'ee, 1996).

Mode of transmission of HBV:

1-Transmission through blood transfusion (Jadallah, 1998).

2- Transmission from needle stick and other sharps. Needle stick injury was the most important risk event for HBV transmission to health care workers (Refa'ee, 1996).

3- Sexual transmission. HBV is considered as one of the sexually transmitted diseases (STD's).

4- Maternal transmission, due to mixing of maternal and fetal blood during labor, ingestion of amniotic fluid and breast-feeding.

5- Transmission from environmental surfaces, HBV has been shown to survive in dried blood at room temperature on environmental surfaces for at least one week. Thus contaminated surfaces in hospitals, including laboratories, seem to be a source of HBV infection.

6- Transmission by blood-sucking insects as mosquitoes and bedbugs.

1.9 HOSPITAL MEDICAL WASTE MANAGEMENT IN THE WEST BANK (WB)

Hospital waste management was not given the proper attention in the WB with lack in legislation and defined policy regarding this issue (Atyani, 1998).

The Israeli Civil Administration issued an order Number 653/1975 regarding the control of special materials includes list of

some hazardous chemicals which requires special handling procedures.

In a study on medical waste management in Ramallah Hospital, Atyani (1998) found that handling procedures did not meet the WHO recommendations in terms of segregation, storage, transportation and disposal. All the waste generated from hospitals, she studied, were dumped within general waste. Liquid wastes were discharged in the public sewer network which in turn discharged in Ramallah wastewater treatment plant (Atyani, 1998).

In 1996, municipalities of Jericho and Nablus cities set up two incinerators used for medical waste management (Ministry of Local Governance).

Only in December 1999, the Palestinian Environmental Law was approved and indorsed by The Palestinian Authority. This law deals with medical waste as hazardous waste.

None of the WB hospitals had a special handling system for medical wastes, the only exception is that Al-Maqased and Augusta Victoria hospitals in Jerusalem where needles kept in sharp boxes. In Ramallah and Al-Injil hospitals, sharps were kept in non-unified separate containers that were utilized after being emptied of their contents. In Qalqilia UNRWA hospital, the waste burnt under semicontrolled conditions (Atyani, 1996).

At the beginning of 1999, sharp box were used widely in governmental hospitals and clinics in the WB (MOH).

In some hospitals (e.g., governmental hospitals), cleaning was the responsibility of private companies and the duties of these workers were defined by the hospital director, and their safety was the employers responsibility who rarely provided or adopted protection measures such as vaccination and the use of gloves (Atyani, 1996). In some hospitals there was no segregation at all, even for special waste such as sharps, infectious and pathological waste. No storage rooms were available for the waste in most hospitals. In most hospitals there were no special carts or special routes to transport hospital waste. In many hospitals, autoclaving was used for the treatment of positive bacterial cultures, blood samples, syringes or any waste produced from testing or treatment. It is rare to take any precautions during the stages of waste handling such as wearing protective gloves or special clothing. All wastes collected from all departments of the WB hospitals end in the domestic municipal waste containers which are usually located inside the hospital yards or in the streets outside the hospitals and the ultimate disposal of those containers is the responsibility of the municipalities to be disposed in the main public landfills (Ishak, 1996).

Atyani (1996) reported that generation rate of solid waste in Ramallah hospital was 3.53 kg/bed/day, and that medical waste constituted 36% of the total solid waste generated. Sharps accounted for 0.7% of the total solid waste generated and 2% of the medical waste. In Khalid hospital, special maternity hospital in Ramallah, generation rate of general hospital solid waste was 2.4 kg/bed/day, with the medical waste constituting about 50% of this waste (Atyani, 1996). She also indicated that similar medical waste treatment practices were applied in all hospitals in the WB. Hospital solid waste quantities in WB districts are shown in Table 1.7.

Table 1.7 Hospital waste generated in WB districts. *

District	Total waste generated Kg/day	Medical waste Kg/day (%)
Nablus	718	259 (36.07%)
Tulkarem, Jenin & Qalquilia	560	202 (36.07%)
Ramallah	432	156 (36.11%)
Hebron	512	184 (28.90%)
Beithlehem	457	165 (36.10%)

* Atyani (1996).

Waste generation rate and component in Ramallah hospital were also found to be comparable to Jordan University Hospital (Qusus, 1988) (Table1.8). Table 1.8 shows percentages of solid waste in different countries.

Table 1.8 Percentages of components of overall solid waste generated in several hospitals in different countries.

Component	Percentage %			
	Jordan University Hospital *	Italy **	University Hospital China ***	India****
- Garbage	- 42. 53	- -	-	- -
- Paper	- 23. 64	- 34	- 16	- 15
- Plastics	- 14. 43	- 46	- 50	- 10
- Textiles	- 7. 37	- -	- 10	- -
- Glass	- 5. 86	- 7.5	- 1	- 4
- Metals	- 2. 65	- 0.4	- 0.5	- 1
- Needles	- 1. 12	- -	- -	- 1.5
- Others	- 2. 4	- 0.1	- 1.5	- -

* Qususe (1988)
** Liberti et al., 1994)
*** Chih-Shan & Fu-Tien (1993)
****WHO, (1999)

1.10 OBJECTIVES

This work was aimed at:

1- Investigating the existing medical waste management practices in four hospitals in Nablus City in terms of handling, treatment and disposal;

2- Determining medical waste generations in these hospitals;

3- Determining possible health risks, especially hepatitis B, that may affect medical waste care workers at these hospitals.

4- Recommending guidelines or proper management of medical waste in the hospitals to minimize the health and environmental risks.

CHAPTER TWO

METHODOLOGY

2.1 DESCRIPTION OF THE STUDY HOSPITALS
2.2 MEDICAL WASTE COLLECTION SYSTEM IN STUDY HOSPITALS
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CHAPTER TWO
METHODOLOGY

The purpose of this study was to evaluate medical waste generation, collection, and disposal systems practiced at four hospitals in Nablus City. In addition, the study was aimed at assessing and evaluating health impacts of medical waste on waste care workers in these hospitals, and obtaining information on physical characteristics of medical waste such as volume and density. To achieve these objectives, the following parameters were studied:

1- Medical waste collection, handling, storage, transport, treatment and disposal systems.

2- Generation rates of medical waste at the four hospitals.

3- Health impacts of medical waste on waste care workers

2.1 DESCRIPTION OF THE STUDY HOSPITALS

Four hospitals in Nablus City were selected in this study to investigate medical waste generation rates and health risks associated with medical waste handling at these hospitals (Table 2.1). These were Rafidia hospital (governmental), Al-Watani (governmental), Al-Ittehad (non- governmental), and Al-Injili hospitals (non-governmental).

Table 2.1 Characteristics of Nablus hospitals.

Hospital	year	Rafidia hospital	Al-Watani hospital	Al-Ittehead hospital	Al-Injili hospital
Number of beds		145	112	75	48
Annual number of patients	1996	17741	7895	5726	4749
	1997	15681	7838	6036	6069
	1998	15838	9922	5846	6785
Number of employees	1999	328	193	152	103
Departments	Surgery	+	-	+	+
	Pediatrics	-	+	+	+
	Emergency	+	+	+	-
	ICU	+	+	+	+
	Kidney dialysis	-	+	-	-
	ENT	+	-	+	+
	Maternity	+	-	+	+
	Orthopedic	+	-	+	+
	Burn unit	+	-	-	-
Support departments	Pharmacy	+	+	+	+
	Laundry	+	+	+	+
	Physiotherapy	+	+	+	+
	X- ray unit	+	+	+	+
	Laboratory	+	+	+	+
	Maintenance	+	+	+	+
	Kitchen	+	+	+	+

* +, Present; -, not present

Informations about the four hospitals were collected using a questionnaire (Appendix B).

Nablus is the second largest city in the West Bank with a population of 100,281 inhabitants according to Palestinian Central Bureau of Statistics. (PCBS, 1997). In addition, another 151,111 inhabitants reside in other parts of Nablus District. Nablus hospitals also provide medical services to some inhabitants of Jenin, Tulkarem, Qalqilia, and Salfeet districts. Other health facilities that provide medical care also exist (Table 2.2).

Table 2.2 Other health facilities in Nablus (excluding the four hospitals).

GOVERNMENTAL	Four primary health centers including one laboratory
UNRWA	Three primary health centers including one laboratory
NGO's	Three primary health centers including laboratory and X-ray facilities
PRIVATE	- two hospitals, (opened in 1999) - surgical center - four X-ray units - 36 medical and dental laboratories - 83 private clinics - 40 dental clinics - 45 pharmacies

* Ministry of Health, MOH (1998).

2.1.1- Rafidia Hospital: is the main surgical and maternity governmental hospital in the north of the West Bank. It was established in 1975. It accommodates 145 beds and comprises different departments and support services in five floors:

1- Underground: includes kitchen, laundry, sterilization, and maintenance facilities.

2- Basement: includes administration, X-ray, laboratory, outpatient clinic, emergency, pharmacy, finance and physiotherapy.

3- First floor: includes operating rooms, burn unit, urosurgery, ICU, and maternal surgery.

4- Second floor: includes maternity, incubators, and post- delivery.

5- Third floor: includes orthopedic surgery, general surgery, and doctors' residence.

6- Roof of the hospital: includes nurses' residence.

Total number of staff at the hospital is 328 employees.

2.1.2 Al-Watani Hospital: is mainly internal medicine and pediatric governmental hospital. It was established in 1905 and now accommodates 112 beds. It comprises four departments: internal medicine, including oncology and blood disease, pediatric, ICU and emergency in three floors:

1- Basement: outpatient clinic, X-ray, pharmacy, emergency department, and dialysis.

2- First floor: administration, internal medicine department, pediatric and incubators department, doctors and nurses wards, maintenance, and kitchen.

3- Second floor: doctors' and nurses' residences.

The hospital also includes a new separate building (comprising registration, laboratory, and day-care treatment for oncology and blood disease patients departments)

Total number of staff at the hospital is 193 employees.

2.1.3 Al-Ittehad Hospital: is a general non-governmental hospital and was established in 1971. It accommodates 75 beds. It comprises 4 floors.

1- Underground: kitchen, pharmacy, X-ray, laboratory, physiotherapy, emergency, and maintenance.

2-Basement: administration, sterilization, maternity, postnatal, and incubators.

3-First floor: ICU, special ward, and women general ward.

4-Second floor: operation rooms, men general ward.

Total number of staff at the hospital is 152 employees.

2.1.4 Al-Injili Hospital: is a general non-governmental hospital. It was established in 1900. It now accommodates 48 beds. It comprises 6 floors and old separate building:

1-Underground: kitchen, maintenance, and laundry.

2- Basement X-ray, operation rooms, and reception.

3- First floor: ICU, and pharmacy.

4-Second floor: men general ward.

5- Third floor: women general ward.

6-Forth floor: sterilization, maternity, and doctors' residences.

The outpatient clinics, the administration, and laboratory are in independent buildings. The nurses' residence is in near old building.

Total number of staff at the hospital is 103 employees.

2.2 MEDICAL WASTE COLLECTION SYSTEM IN THE STUDIED HOSPITALS

Collection and disposal of medical waste at the four hospitals are carried out by a manually operated system based on one shift work of the waste care workers or jointers. Collection in general starts at the department and ends in a special container outside the hospital building. No special storage rooms for medical waste exist in any of the hospitals. All the medical waste collected from these four hospitals is incinerated and then the ashes hauled to the Nablus Municipality open dump landfill. For all the four hospitals, municipal waste care workers transport the medical waste by a special car equiped with a container, like those in the hospitals to replace the filled container situated inside the hospital building. Medical waste transportation journey starts at Al-Watani hospital at 7.30-8 a.m., then Al-Ittihad hospital, Rafidia and Al-Injili hospitals.

The journey ends at the site of the incinerator situated in the eastern part of Nablus near the Balata industrial area. This container is made of metal (500kg empty and 2.875 cubic meter in size). At the incinerator facility, which belongs to Nablus Municipality, the workers remove any pressurized items and any chemicals that can be dangerous if burned, and place the

remaining medical waste in the incinerator for burning at 1200 °C. The resulting ash is disposed off at the main solid waste dumping landfill of Nablus Municipality which is situated east of Nablus City near Beit-Forik village.

2.2.1 Medical waste collection system in Rafidia and Alwatani hospitals

A private waste care company is responsible for medical and general waste care. In hospitals, most departments, (except laboratory where they used sometimes cartoon sharp box when available) dispose sharps in plastic cans. Other types of medical waste (e.g., cotton, gauze, pads, disposable towels, placenta, amputating organs, dialyses residues) are disposed off in light easily punctured plastic bags. Culture plates and tubes are autoclaved and then disposed off in plastic sacs. The sacs and bags are stored in plastic containers in the departments. The processes of collection begin at departments where workers at every floor start to collect waste from the plastic containers and place them in light transparent plastic sacs. Waste-care workers collect these bags in the early morning every day and carry them around by hands. They either use lefts or stairs to transport bags

outside the hospital building and place them in special containers that belong to the Municipality of Nablus.

2.2.2 Medical waste collection system in Al-Ittihad and Al-injili hospitals

In these hospitals, the management system of medical waste care depends upon ordinary workers or jointers who are hospital employees. These workers, in addition to handling of medical and ordinary waste, they work also in laundry collection, floor sweeping, bathroom cleaning, and sometimes in serving food to the patients.

The collection system is the same as that in Rafidia and Al-Watani hospitals, except that culture plates were not autoclaved in Al-Injili hospital.

2.3 DETERMINATION OF MEDICAL WASTE GENERATION RATES AT HOSPITALS

Determination of medical waste generation rates at the four hospitals in Nablus was carried out 11 times on week days of Saturday, Tuesday, and Thursday, during March, April, May and June 1999.

Medical waste generated at every hospital was weighed using a portable scale inside the hospital were all the medical waste collected at 7- 9 a.m. on each sampling occasions.

Total medical waste generated from all studied hospitals in Nablus was determined on 11 consecutive days during November, and December 1999.

Total medical waste generated at all medical facilities was weighed using a portable scale for 11 consecutive days at 10.30-11 a.m.

Generation rates were calculated by using three ways (Qusus, 1988):

1- Generation rate kg/bed/day = Average daily generation (kg)/ total number of hospital beds

2- Generation rate kg/in-patients/day = Average daily generation(kg) / number of in- patients

3- Generation rate kg/total patients/day = Average daily generation(kg) / number of total patients

2.4 HEPATITIS B LABORATORY TESTS FOR WASTE CARE WORKERS

2.4.1 Subjects of the study

The subjects of the study placed in (62 waste care workers, 43 were male and 19 were female in the four hospitals) comprised 20 from Rafidai hospital, 19 from Al-Watani hospital, 11 from Al-Injili hospital, and 18 from Al-Ittihad hospital. According to the age, 48 were between 20-40 years and 14 were over 40 years old. 12 of the workers had been working as waste care workers in hospitals for more than three years.

The study was conducted during October 1999. A questionnaire (Appendix B, Questionnaire part D) was prepared and used for the purpose of obtaining specific information regarding subjects of study.

2.4.2 Blood sample collection

Blood samples were obtained from the above mentioned workers using disposable sterile syringes. The blood was left to clot at room temperature, then centrifuged at 3000 rpm for five minutes. Serum was aspirated and four aliquots of each sample were transferred into screw capped tubes and stored at –30 °C.

2.4.3 Procedures

Collected sera were analyzed for HBV markers using "Membrane Test" (ZER HITECH, Israel), which determines hepatitis B surface antigen in serum samples.

Test procedure

- Test cards were removed from pouch and placed on clean level surface, and labeled with patient's name.
- 6 drops (240 μl) of the sample were then placed into the round well of the test card.
- Results were read between not more than 10 and 20 minutes.

- Positive: two pink lines appearing in the window.
- Negative: one pink line appearing in the window.

2.5 STATISTICAL ANALYSIS

Data analysis:

Data on medical waste generation were analyzed using Analysis of Variance, One-way ANOVA test with Duncan test, to detect significant (p=0.05) differences between hospitals, sampling occasions, and number of patients, using SPSS computer program version 8.

Relationship between numbers of in-patients and medical waste generated in kg at the four hospital studies were tested by ANOVA test.

CHAPTER THREE

RESULTS

3.1 MEDICAL WASTE MANAGEMENT
3.2 MEDICAL WASTE GENERATION RATES
3.3 RESULTS OF HEPATITIS B SEROLOGICAL TESTS
3.4 COMPOSITION OF MEDICAL WASTE

CHAPTER THREE
RESULTS

3.1 MEDICAL WASTE MANAGEMENT

3.1.1 Hospital waste management policy

No well-defined policies related to medical waste (MW) management in hospitals surveyed were in effect. However, Al-Injili hospital has some written instructions about handling and collection of MW. Hospitals also received from Nablus Municipality brief written instructions as to how MW off-site transportation to the incinerator should be executed. The administrative directors in all surveyed hospitals have the direct responsibility for monitoring MW management.

3.1.2 Waste segregation, collection, and storage

Table 3.1 shows segregation methods of MW in the four hospitals studied. Collection and transportation of MW (in addition to other solid waste in the hospitals) are managed by waste care workers who collect medical waste from different departments and store them in special locked containers placed outside the hospital (Nablus Municipality property). The latter are evacuated daily (except Fridays) which transports the filled containers to the incinerator which functions between 10 and11 a.m. daily. The

resulted ashes are transported to the general waste dump of Nablus Municipality.

Table 3.1 Segregation of medical waste in the hospitals surveyed.

Waste	Procedures
Sharps	Put in plastic bottles in most hospital departments, but in Ittihad hospital laboratory sharp boxes are used. In Al-Injili hospital sharp boxes are used for needles.
Pathological	Fetus, amputating organs (sometimes placenta) are given to the patient family for bury. Sectioned organs (e.g., appendix, tumors, gall bladder,..etc.), disposed with medical waste after cytology test.
Infectious	Infectious cultures (plates, tubes) are autoclaved in some hospitals (Rafidia, Al-Watani, Al-Ittihad) before disposing off in yellow bag with medical wastes.
Chemical	Liquid wastes are disposed off in wastewater channels.
Pharmaceutical	Expired drugs are disposed off directly with medical waste or returned to the factories.
Pressurized	Disposed off with medical or ordinary waste without any care.

3.1.3 Waste care workers in Nablus hospitals

Information about waste care workers is presented in Table 3.2. The total number of waste care workers was 62 (43 male, 19 female), 12 workers in Al-Watani Hospital, 20 in Rafidia Hospital, 11 in Al-Injili Hospital and 19 in Al-Ittihad hospital (Figures 3.1, 3.2, 3.3, and 3.4).

Table 3.2: Distribution of waste- care workers in the four hospitals by sex, age, marital status, and education.

Feature		Al-Watani Hospital	Rafidia Hospital		Al-Ittihad Hospital	Total
Sex	Male	10	15	6	12	**43**
	Female	2	5	5	7	**19**
Age of workers	20-40	11	16	10	11	**48**
	> 40	1	4	1	8	**14**
Marital status of workers	Married	9	11	7	12	**39**
	Single	3	8	4	5	**20**
	Divorced	-	1	-	1	**2**
	Widower	-	-	-	1	**1**
Education (number of school years)	< 6	4	7	3	8	**22**
	6 - 9	6	7	5	4	**22**
	9 -12	2	5	3	7	**17**
	> 12	-	1	-	-	**1**

3.2 MEDICAL WASTE GENERATION RATES

3.2.1 Medical waste generated at four hospitals during March, April, May, and June 1999

Data on medical waste generated at four hospitals are presented in Table 3.3. The total mean of generated medical waste calculated from 11 sampling times in k/day, were 96.16 in Rafidia, 93.75 in Al-Watani, 57.66 in Al-Ittehad, and 32.91 in Al-Injili hospitals (Figures 3.5 and 3.6).

Table 3.3 Daily quantities (kg) of generated medical waste in the four hospitals

Hospital		March 1999 20	23	Average	April 1999 6	10	13	Average	May 1999 8	11	13	Average	June 1999 5	8	10	Average	Total mean
Rafidia	MW	97	91	**94**	104	98	94	**98.66**	92	89	111	**97.33**	94	96	104	**94.66**	**96.16**
	Number of in-patients	92	108	**100**	100	110	108	**106**	97	93	101	**97**	95	98	103	**98.66**	**100.41**
	Total number. of patients	261	301	**281**	321	268	323	**304**	291	292	263	**282**	281	298	228	**269**	**284**
Al-Watani	MW	92	84	**88**	121	95	99	**105**	96	93	84	**91**	93	91	89	**91**	**93.75**
	Number of in-patients	80	61	**70.5**	90	70	64	**74.66**	78	61	57	**65.33**	57	76	71	**57**	**66.87**
	Total number. of patients	275	233	**254**	289	268	242	**266.33**	301	240	273	**271.33**	245	267	302	**271.33**	**265.75**
Al-Ittihad	MW	60	64	**62**	59	61	56	**58.66**	61	46	52	**53**	57	55	59	**57**	**57.66**
	Number of in-patients	40	60	**50**	51	42	56	**49.66**	44	53	45	**47.33**	51	51	53	**51.66**	**49.66**
	Total number. of patients	61	86	**73.5**	78	73	58	**69.66**	64	83	71	**72.66**	71	85	82	**79.33**	**73.79**
Al-Injili	MW	30	28	**29**	34	38	36	**36**	39	37	33	**36.33**	31	32	28	**30.33**	**32.91**
	Number of in-patients	22	14	**18**	32	26	28	**28.66**	25	23	21	**23**	27	28	44	**33**	**25.66**
	Total number. of patients	99	36	**67.5**	68	117	63	**82.66**	112	59	67	**79.33**	117	65	106	**96**	**81.37**

Table 3.4 shows generation rates (GR) (kg/bed/day, kg/in-patient day, and kg/total patients/day) of medical waste during March- June 1999.

Generation rate (kg/bed/day) was 0.67 in Rafidaia, 0.83 in Al-Watani, 0.76 in Al-Ittihad, and 0.69 in Al-Injili hospitals.

Generation rate (kg/in-patient day) was 0.96 in Rafidia, 1.34 in Al-Watani, 1.18 in Al-Ittihad, and 1.37 in Al-Injili hospitals.

Generation rate (kg/total patient day) was 0.34 in Rafidia, 0.35 in Al-Watani, 0.78 in Al-Ittihad, and 0.40 in Al-Injili hospitals.

Table 3.4 Generation rates (GR) of medical waste during March – June 1999.

Hospital	Generation rate	March 1999	April 1999	May 1999	June 1999	GR for total months
Rafidia	kg/bed/day	0.65	0.68	0.67	0.65	0.67
	kg/ in-patient/day	0.94	0.93	1.00	0.99	0.96
	kg/ total-patient/day	0.33	0.32	0.34	0.35	0.34
Al-Watani	kg/bed/day	0.78	0.93	0,81	0.81	0.83
	kg/ in-patient/day	1.20	1.41	1.40	1.36	1.34
	kg/ total-patient/day	0.34	0.39	0.33	0.33	0.35
Al-Ittehad	kg/bed/day	0.82	0.78	0.70	0.76	0.76
	kg/ in-patient/day	1.28	1.20	1.13	1.10	1.18
	kg/ total-patient/day)	0.84	0.84	0.73	0.71	0.78
Al-Injili	kg/bed/day	0.60	0.75	0.75	0.63	0.69
	kg/ in-patient/day)	1.68	1.26	1.68	0.97	1.37
	kg/ total-patient/day	0.43	0.43	0.45	0.31	0.40

Generation rates (GR) differed significantly between the four hospitals, in GR kg/bed/day: df = 3, 40, $p \leq 0.000$, and in GR kg/in-patient/day: ($F(df = 3,40)=2.84$, $p \leq 0.001$) (Tables C.1, C.2, C.3, C.4 – Appendix C).

During March 1999, generation rates (kg/bed/day) between the four hospitals showed significant differences (df= 3,4, $p \leq 0.005$) while GR (kg/in-patient/day) showed no significant differences ($F(df=3,4)=6.59$, $p \leq 0.264$)(Tables C.5-7- Appendix C).

During April 1999, generation rates (kg/bed/day and kg/in-patient/day) between the four hospitals showed significant differences (for GR kg/bed/day: $F(df=3,8)=4.07$, $p \leq 0.12$, while for GR kg/in-patient/day: $F(df=3,8)= 4.07$, $p \leq 0.44$) (Tables C.8-11 - Appendix C).

During May 1999, generation rates (kg/bed/day) between the four hospitals showed no significant differences, while GR (kg/in-patient/day) showed significant differences ($F(df=3,8)=4.07$, $p \leq 0.211$) (TablesC.12-14 – Appendix C).

During June 1999, generation rates (kg/bed/day) between the four hospitals showed significant differences ($F(df= 3,8)=4.07$, $p \leq 0.001$) while GR (kg/in-patient/day) showed no significant differences ($F(df = 3,8)=4.07$, $p \leq 0.120$) (Tables C15-17- Appendix C).

3.2.2Total medical waste generated at four hospitals during November and December 1999

Data on combined medical waste generated at four hospitals based on 11 sampling dates are presented in Table 3.5. The average of generated medical waste in the four hospitals was 270.7 kg/day, while the mean production of waste for in-patients was 246.18 kg/day, and the mean generation for total patients was 685.36 kg/day. Hence, the specific generation rates were 0.71 kg/bed/day, 1.12 kg/in-patient day, and 0.39 kg/total -patient/day.

Table 3.5 Daily quantities of medical waste generated at four hospitals surveyed determined on 11 consecutive days.

Sampling Dates	Generated MW (kg) in four hospitals	Total No. of In-patients	Total No. Of patients	Generation rate Kg/bed/day	Generation rate Kg/ In-patient/day	Generation rate Kg/total/ patient/day
30/11/1999	294	241	670	0.77	1.22	0.44
1/12/1999	263	250	674	0.69	1.05	0.39
2/12/1999	283	222	605	0.74	1.27	0.46
4/12/1999	302	252	757	0.79	1.19	0.39
5/12/1999	254	246	659	0.66	1.32	0.38
6/12/1999	272	254	648	0.71	1.07	0.42
7/12/1999	231	263	723	0.61	0.87	0.32
8/12/1999	263	245	656	0.69	1.07	0.40
9/12/1999	227	222	638	0.59	1.02	0.35
11/12/1999	303	253	785	0.79	1.19	0.38
12/12/1999	286	260	724	0.75	1.10	0.39
Mean	**270.7**	**246.18**	**685.36**	**0.70**	**1.12**	**0.40**

3.2.3 Volume and density of medical waste generated from the four hospitals during November and December 1999

Data on combined volume (m^3) and density (Kg/ m^3) of medical waste generated at four hospitals, before incineration, are presented in Table 3.6. The mean density of medical waste generated was 168.73 kg/ m^3.

Table 3.6 Volume and density of total medical waste generated in the four hospitals surveyed.

Date of generation	Volume of the medical waste(m3)	Medical waste generated (kg)	Density of the medical waste (kg/m3)
Tuesday 30/11/1999	1.6	294	185.4
Wednesday 1/12/1999	1.4	263	188.4
Thursday 2/12/1999	1.6	283	178.5
Saturday 4/12/1999	1.8	302	163.4
Sunday 5/12/1999	1.5	254	163.5
Monday 6/12/1999	1.7	272	144.6
Tuesday 7/12/1999	1.4	231	165.5
Wednesday 8/12/1999	1.8	263	144.9
Thursday 9/12/1999	1.3	227	170.2
Saturday 11/12/1999	1.8	303	166.9
Sunday 12/12/1999	1.7	286	166.7

3.3 – RESULTS OF HEPATITIS B SEROLOGICAL TEST

Results of serological tests for Hepatitis B in waste care workers are presented in Table 3.7. Sixty one waste care workers

(12 in Rafidia, 10 in Al-Watani, 14 in Al-Injili, and 18 in Al-Ittehad hospitals) were negative for hepatitis B. Only one worker was positive (at Rafidia hospital) for the disease 1/62.

Tables 3.7 Results of Hepatitis B (HbS Ag) test of waste care workers in Nablus hospitals:

Hospital	Number of waste care workers tested	Positive result (+)	Negative result (-)
Rafidia	13	1	12
Al-Watani	10	0	10
Al- Injili	14	0	14
Al-Ittihad	18	0	18
Total	(62)	(1)	(61)

3.4 COMPOSITION OF MEDICAL WASTE

The composition contents of medical waste generated from Nablus hospitals were:

1- Plastics: sacks of intravenous and dialyses fluids, syringes, waste sacks, laboratory tubes and dishes, and other surgical disposals.

2- Sharps: needles, blades, knives, infusion sets, etc.

3- Pressurized waste: aerosol cans, cartridges.

4- Infectious waste: cultures and stocks of infectious agents from laboratory, autopsies on patients with infectious diseases and dialysis unit.

5- Pathological waste: human tissue, organs, body parts, human fetuses, blood, and body fluids.

6- Pharmaceutical waste: unused, split pharmaceutical products, drugs, and sera.

The weight percentage of each kind of medical waste was not determined in this study. However, it seemed to vary from one hospital to another depending on the type of hospitals. Mainly in surgical and maternity hospitals (Rafidia, Al-Ittihad, and Al-Injili), pathological waste (example: placenta, body parts and organs) constituted about 15% of the medical waste generated, while in internal medicine hospitals (Al-Watani), the laboratory waste was about 20%.

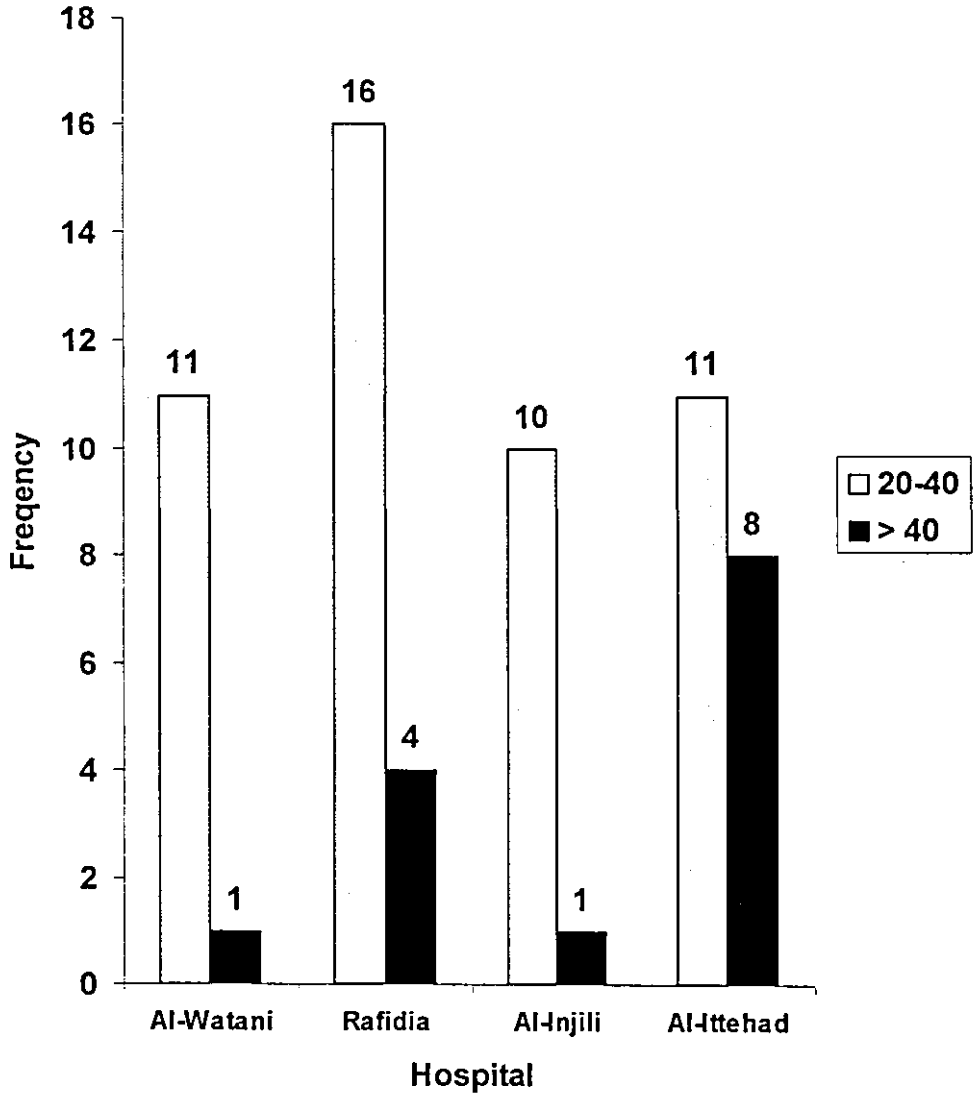

Figure 3.1 Distribution of waste care workers in Nablus hospitals according to age in years

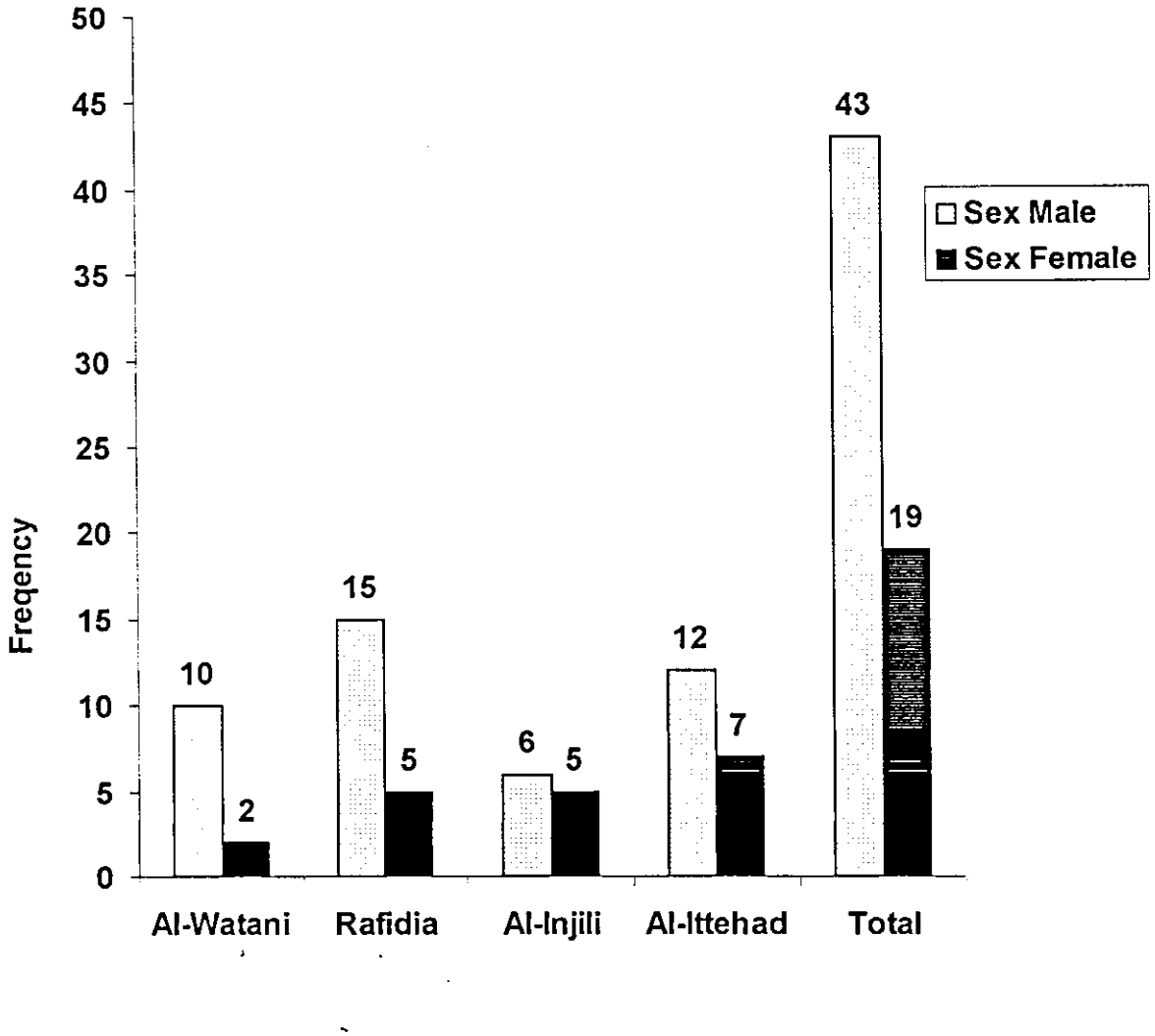

Figure 3.2 Distribution of waste care workers in the four hospitals in Nablus according to sex

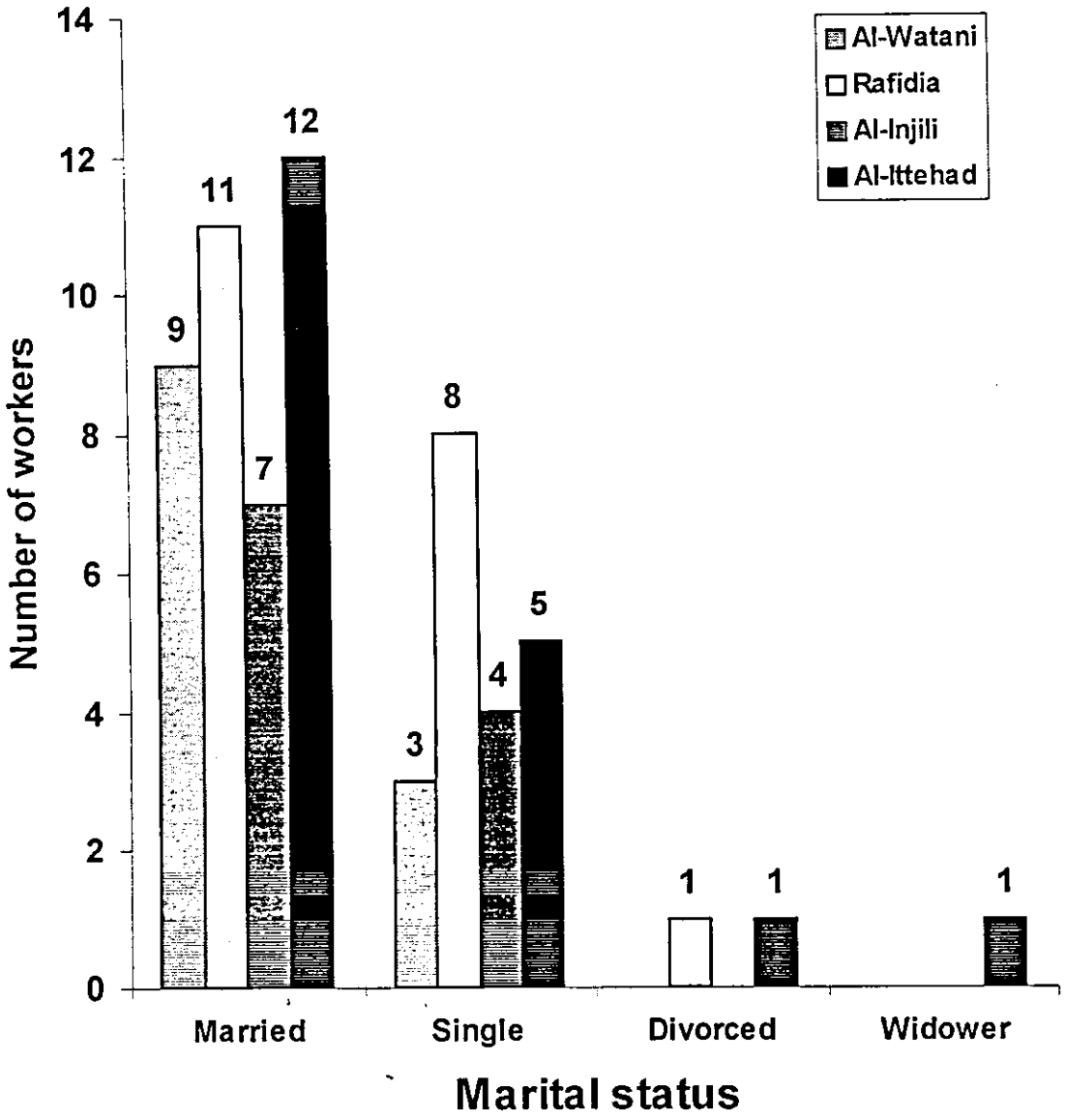

Figure 3.3 Distribution of waste care workers in Nablus hospitals according to marital status

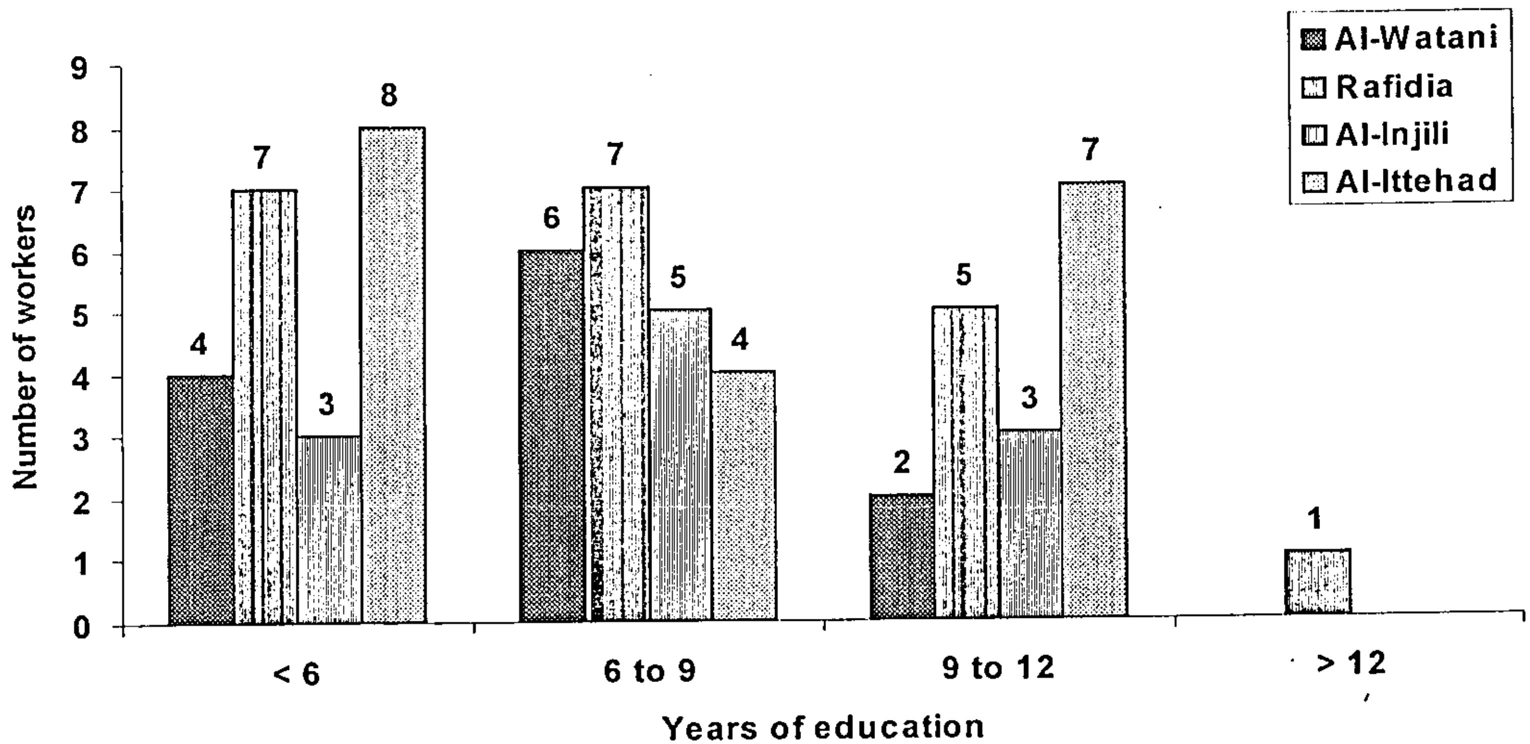

Figure 3.4 Distribution of waste care workers in Nablus hospitals according to education in years

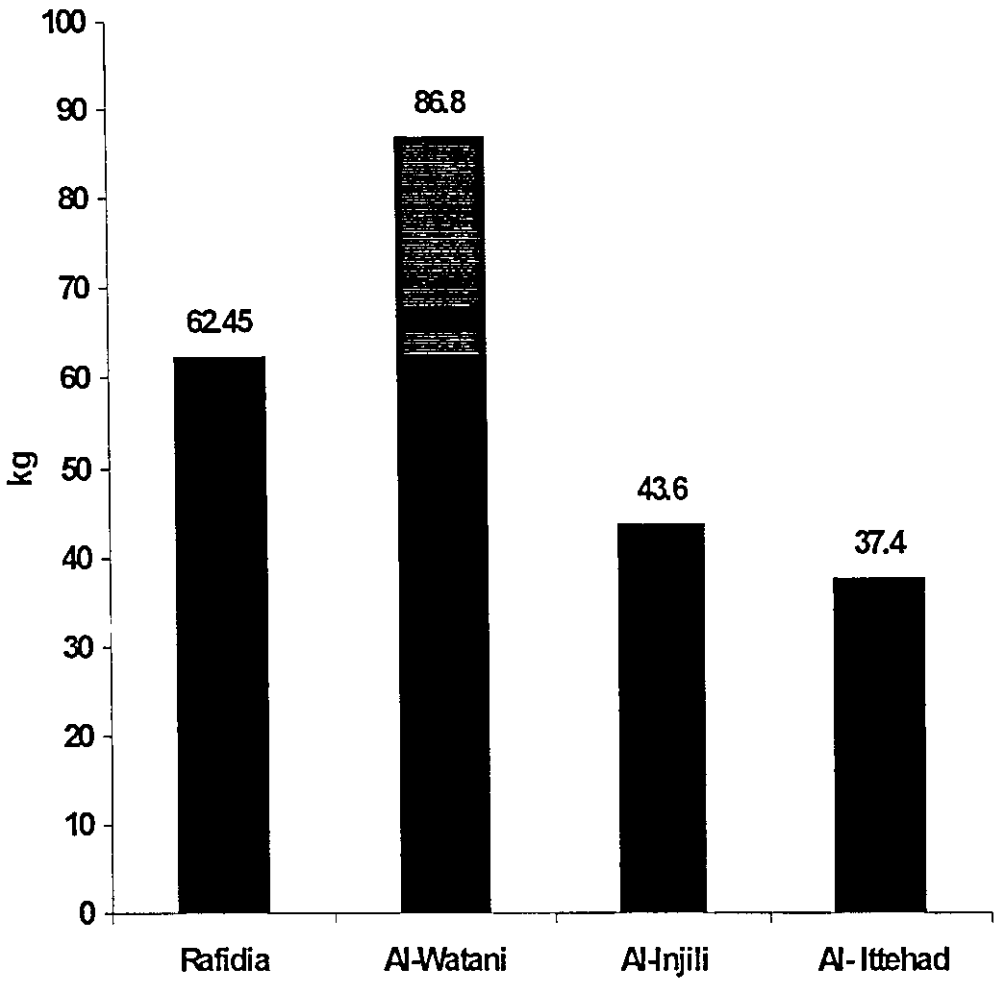

Figure 3.5 Mean of generated medical waste (kg) in Nablus hospitals during March, April, May, and June 1999

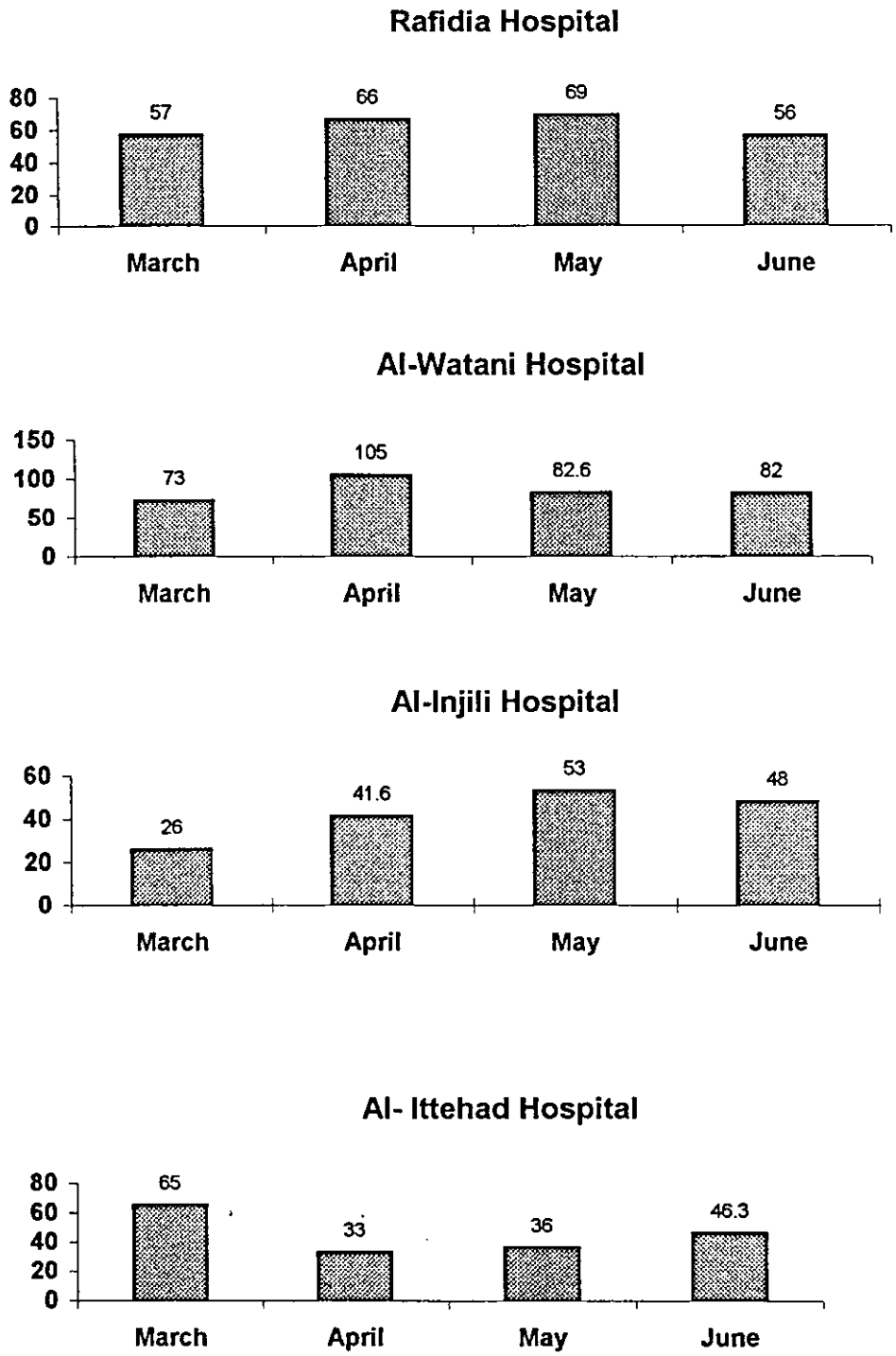

Figure 3.6 Generated medical waste (kg) in Nablus hospitals During March, April, May, and June 1999

CHAPTER FOUR

DISCUSSION

4.1 MANAGEMENT, LEGISALATION, POLICY, AND REGULATIONS
4.2 MEDICAL WASTE GENERATION RATES
4.3 PREVALANCE OF HEPATITIS B
4.4 RECOMMENDATIONS

4.1 MANAGEMENT LEGISALATION, POLICY, AND REGULATIONS

The present study (at Nablus hospitals) reveals that no Palestinian national legislation, policy, or regulations about handling and management of medical waste are lacking. In the West Bank (WB), the Jordanian Health Law (1957) is still applied. Some regulatory instructions or procedures are applied in some hospitals of the WB. The new Palestinian Environmental Law (1999) designates medical waste as a part of hazardous waste without any special regulations or procedures for its safe management.

Regulations may include requirements of medical waste generation, transport, treatment, destruction and disposal facilities (Jankins, 1990)

The present study demonstrates clearly the need for legislation and policy, and regulation aspects are very important for segregation, collection, storage, and management to minimize or prevent the hazards and risks of medical waste.

The Basel Convention, signed by more than 100 countries (WHO, 1999), concerns transboundary movements of hazardous waste. National legislation is the basis of improving health care

practices in any country. Ministries of health and of environment are involved in addition to environmental agencies.

4.2 MEDICAL WASTE GENERATION RATES

4.2.1 Generation rates in the study hospitals

In this study, generation rates (kg/bed/day) of medical solid waste in Nablus hospitals slightly differed. The highest was Al-Watani (GR=0.83) followed by Al-Ittihad (GR=0.76), Al-Injili (GR= 0.69) and Rafidia (0.67). Differences between the hospitals could be attributed to type of services, type of hospital (governmental or none governmental), and to difference in number of beds in each hospital.

4.2.2 Comparison between generation rates in the study hospitals and other Jordanian and European hospitals

Generation rates of medical waste seem to differ from one country to another and from one hospital to another in the same country.

This study demonstrates that generation rates of medical solid waste (without kitchen solid waste or paper) in the surveyed

hospitals are comparable to those of other hospitals from other countries.

In middle and low-income countries, medical waste generation is usually lower than that in high-income countries (Economopoulos, 1993). Table 4.1 shows medical waste generation in several types of hospitals in high-income countries in Europe.

Table 4.1, Medical waste generation (kg/bed/day) in some high-income European countries*.

Source	Generation rate (kg/bed/day)
University hospital	4.1- 8.7
General hospital	2.1- 4.2
District hospital	0.5- 1.8
Primary health-care center	0.05- 0.2

* After: WHO (1999)

In the present study at Nablus hospitals, the generation rates are comparable to those of the district hospitals in those European countries (Tables 4.2, 4.3).

Table 4.2 Generation rates of medical waste in four hospitals in Nablus.

HOSPITALS	GR (kg/bed/day)	GR (kg/in-patient/day)
Rafidia	0.67	0.96
Al-Watani	0.83	1.34
Al-Ittehad	0.76	1.18
Al-Injili	0.69	1.37

According to Atyani (1996), clinical proportion was found to be 36% of total solid hospital waste. So total solid waste generated in Nablus Hospitals will be clear in Table 4.3.

Table 4.3 Generation rates of total solid waste in studied hospitals in Nablus.

HOSPITALS	GR (kg/bed/day)	GR (kg/in-patient/day)
Rafidia	1.86	2.67
Al-Watani	2.3	3.72
Al-Ittehad	2.1	3.28
Al-Injili	1.92	3.8

Table 4.4 Generation rates of total solid waste in two main hospitals in Amman (Qusus, 1988).

HOSPITALS	GR (kg/bed/day)	GR (kg/in-patient/day)
University of Jordan hospital	3.5	4.84
Al-Hussein Medical City	4.89	5.53

Generation rates (GR) of medical waste in Nablus hospitals in present study those reported are slightly higher than Jordan , that may be attributed to the differences between this study (1999) and Qusus study (1988), and to differences of specialization of the hospitals and differences in several conditions between the two countries.

4.3 PREVALANCE OF HEPATITIS B IN WASTECARE WORKERS

The present study shows that only one of 62 non- vaccinated wastecare workers showed anti-HBs seropositivity. However, the incidence of the disease may well be higher than revealed by this work because waste-care workers are usually employed by special care companies for one year and many of them leave work during their first year.

The disease has a long occupation period (up to 6 months) and hence some of the workers could have been positive but without showing the disease.

In a study Hepatitis B Virus among high-risk groups in Northern of West Bank (Jadallah, 1998), the Hbs AG prevalence rates were 9.6% among unvaccinated healthcare workers. Occupational exposure to contaminated blood and equipment's may account for this finding. In the same study, out of 156 healthcare workers, 52 were non-vaccinated, and all vaccinated healthcare workers were seronegativeity rate.

4.4 RECOMMENDATIONS

1- Establishing of legislation for the proper management of medical waste, which should include:

- Definition of medical waste including components including health and environmental risks.
- Categorization of medical waste.
- Establish national standards of risks associated with waste handling by The National Authority.
- Written practical procedures for the safe management.

2- Establish a monitoring agency and team for monitoring and supervision from Ministry of Health (MOH) and ministry of environment and none- governmental organizations (NGO's).

3- Application of safety practices for health care personnel and waste care workers inside the hospitals and medical centers and clinics as protective clothes, gloves, and facemasks. In addition to do gradual medical and laboratory tests.

4- Promote the awareness and education for the health providers and people.

5- Vaccination of all health providers (especially physicians, nurses, laboratory technicians, waste care workers) against Hepatitis B virus according to the WHO recommendations.

6-Training of health providers, administrative personnel, vehicle drivers, and waste care workers for implementation and monitoring the management plans in all health care institute, in addition to the training of supervisors to make them responsible for the monitoring of the implementation of the hospital special plan of medical waste management.

7-Each health care institute, should have its Internal waste management policy.

8-A color –code system for storage and collection of high risk waste should be adopted on the national level.

9-Vehicles that are used for medical waste transportation should be dedicated for this purpose.

10- Incineration of medical waste can be considered as good options for medical waste treatment.

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APPENDIXES

APPENDIX A

DEFINITIONS OF MEDICAL WASTE

Hospital wastes are defined *as:* All wastes coming out of hospitals, out of which around 85% are actually non-hazardous waste, about 10% are infectious waste, and about 5% are infectious but hazardous waste (WHO, 1994).

Health –care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from minor or scattered sources- such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.) (WHO, 1999).

Medical wastes are: solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious, characteristics may cause or significantly contribute to an increase in mortality or increase in serious, irreversible, or incapacitating, reversible, illness, or pose a substantial present or potential hazard to human health or to the environment when improperly treated, stored, transport, disposed of, and otherwise managed. (USA Environmental Protection Agency (EPA), 1986).

Medical wastes in USA include: cultures and stocks of infectious agents, human pathological wastes, human blood and blood products, used and unused sharps implements, and contaminated animal waste. (USA Environmental Protection Agency (EPA), 1986).

HOSPITAL WASTE CATEGORIES

Classifications related to the sources of generation at hospital are:

Patient's departments: surgery, Internal medicine, pediatrics, maternity, dialysis unit, ENT, orthopedic, burn unit...

Support services: lab, X- ray unit, blood bank, pharmacy, laundry, operating theatre, emergency, outpatient clinics.

Administration

Nurses and doctors residences

Kitchen and cafeteria

These categories can be classified as: (WHO, 1999):

Pathological wastes: human tissues, organs, body parts, human fetuses and animal carcasses, blood and body fluids.

Sharps: sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, and nails.

Pharmaceutical waste: includes expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera. It also includes solvent solutions.

Genotoxic waste: is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. It includes cytotoxic drugs, chemicals, and radioactive materials.

Chemical waste: consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures.

Pressurized wastes: many types of gas used in health care stored in pressurized cylinders, cartridges, and aerosol cans.

Radioactive wastes. Usually cause no immediate effects unless an individual receives a very high dose. It includes the X-ray, α- and β- particles, and γ- rays emitted by radioactive substances.

Medical wastes: produced from patient's rooms, treatment rooms, nursing stations (Solid dressings, bandages, and swabs).

Infectious wastes: include cultures and stocks of infectious agents from laboratory activities, surgery, and autopsies on patients with infectious diseases, isolation rooms, and dialysis unit.

Classifications of medical waste according to the Health and Safety Commission (HSC). publication "Safe Disposal of Clinical Waste" (HMSO 1992) identifies five Categories of clinical waste:

Group A waste	a) All human tissues, including blood, animal carcasses and tissues from veterinary centers. Hospitals and laboratories, and all related swabs and dressings. b) Waste materials where the assessment indicates a risk arising from (example infectious diseases cases) c) Solid surgical dressings, swabs and other solid waste from treatment areas.
Group B waste	Discarded syringe needles, cartridges, broken glass and other contaminated disposable sharp instruments or items.
Group C waste	Microbiological cultures and potentially affected waste from pathology departments (laboratory and post-morterm rooms) and other clinical or research laboratories.
Group D waste	Certain pharmaceutical products and chemical wastes.
Group E waste	Items used to dispose of urine, faeces and other bodily secretions or excretions assessed as not falling within Group A. This includes used disposable bed-pans, incontinence pads, stoma bags and urine containers.

APPENDIX B

Questionnaire

General information's about the hospitals

Name of the hospital:
Kind of the hospital:

No. of beds :

Department	No. of beds	Department	No. of beds

No. of Management personnel

PERSONNEL	No.	PERSONNEL	No.	PERSONNEL	No.

Medical and Technical team:

PERSONNEL	No.	PERSONNEL	No.	PERSONNEL	No.

Annual number of patients:

Months	1996	1997	1998
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
Ttotal			

Questionnaire

Hospital Waste Management Policy

1-Is there any special instructions for solid waste Management in the hospital?

Yes or No ( )

If yes, What are they?

Please list the Legislative Act (s)

2-Is there any special procedures for solid waste management in the hospital?

Yes or No ( )

If yes, What are they?

Please list the Legislative Act (s)

3-Who is responsible for solid waste management in the hospital ?

3-Who is responsible for monitoring and follow up of waste management in the hospital ?

Questionnaire

Waste segregation, Collection, Handling, Storage, Transport, and Disposal

Describe briefly what happened between segregation (if any)

and final disposal of :

Sharps	
Pathological Wastes	
Infectious Wastes	
Radiological Wasts	
Chemical Wastes	
Pharmaceutical Wastes	
Pressuruized Wastes	

Questionnaire

Personnel involved in the Management of Hospital solid waste

Name of the hospital:

Kind of the hospital:
No of workers:

Name :	Date of birth	Address
Social condition :	No. of son :	No. of daughters:

No. of Years of education :	When start working :
Daily work hours :	

Last work :	where
the before work	where

wearing gloves	If no, why?
wearing special protecting clothes	If no, why?

Hepatitis B vaccination		No. of doses
Did he receive Jaundice before		When
did his wife receive Jaundice before		When
did any of his children receive Jaundice before		

Did he receive any wound during work	
Did he receive any scratches or punctures during work	
did he receive any infected wound	

Appendix C

STATISTICAL ANALYSIS RESULTS

Data on medical waste generation were analyzed using Analysis of Variance, One-way ANOVA test with Duncan test, to detect significant (p=0.05) differences between hospitals, sampling occasions, and number of patients, using SPSS computer program version 8.

Table C.1 One way analysis of variance (ANOVA) for generation rate kg/bed/day data from the four hospitals in Nablus based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
KG/B	Between Groups	0.172	3	5.743E-02	10.400	0.000
	Within Groups	0.221	40	5.522E-03		
	Total	0.393	43			

Table C.2 Duncan test results to detect significant differences between the four hospitals according to GR ' kg/bed/day' by running Duncan test based on table 3.4.

		Subset for alpha 0.05		
Hospital	**N**	1	2	3
Rafidia	11	0.6708		
Al-Injili	11	0.6932		
Al-Ittehad	11		0.7636	
Al-Watani	11			0.8336
Sig.		0.485	1.000	1.000

Table C.3 One way analysis of variance (ANOVA) for generation rates kg/in-patient/day between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
kg/in-patient/day	Between Groups	1.104	3	0.368	7.235	0.001
	Within Groups	2.036	40	5.089E-02		
	Total	3.140	43			

Table C.4 Differences between the four hospitals according to GR(kg/in-patient/day) by running Duncan test, based on table 3.4.

		Subset for alpha 0.05	
Hospital	**N**	1	2
Rafidia	11	0.9710	
Al-Ittihad	11		1.1723
Al-Iijili	11		1.3492
Al-Watani	11		1.3602
Sig.		1.000	0.071

Table C.5 One way analysis of variance (ANOVA) for GR kg/bed/day during March 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
KG/B/Day	Between Groups	5.898E-02	3	1.966E-02	23.787	0.005
	Within Groups	3.306E-03	4	8.265E-04		
	Total	6.228E-02	7			

Table C.6 Differences between the four hospitals according to GR (kg/bed/day) during March 1999 by running Duncan test, Based on table 3.4.

		Subset for alpha 0.05		
Hospital	**N**	1	2	3
Rafidia	2	0.6042		
Al-Injili	2	0.6483		
Al-Watani	2		0.7411	
Al-Ittihad	2			0.8267
Sig.		0.200	1.000	1.000

Table C.7 One way analysis of variance (ANOVA) for generation rates (kg/in-patient/day) during March 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
KG/in-patient/Day	Between Groups	0.555	3	0.185	1.944	0.264
	Within Groups	0.381	4	9.519E-02		
	Total	0.936	7			

Table C.8 One way analysis of variance (ANOVA) for GR (kg/bed/day) during April 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/bed/day	Between Groups	0.106	3	3.539E-02	7.189	0.12
	Within Groups	3.938E-02	8	4.923E-03		
	Total	0.146	11			

Table C.9 Differences between the four hospitals according to GR (kg/bed/day) during April1999 by running Duncan test, based on table 3.4.

		Subset for alpha 0.05	
Hospital	**N**	1	2
Rafidia	3	0.6805	
Al-Injili	3	0.7500	
Al-Ittihad	3	0.7822	
Al-Watani	3		0.9375
Sig.		0.127	1.000

Table C.10 One way analysis of variance (ANOVA) for GR (kg/in-patient/day) during April 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/in-patient/day	Between Groups	0.367	3	0.122	4.287	0.44
	Within Groups	0.228	8	2.855E-02		
	Total	0.595	11			

Tables C.11 Differences between the four hospitals according to GR (kg/in-patient/day) during April 1999 by running Duncan test, based on table 3.4.

Hospital	N	Subset for alpha 0.05	
		1	2
Rafidia	3	0.9338	
Al-Ittihad	3	1.2031	1.2031
Al-Iinjili	3	0.7822	1.2699
Al-Watani	3		1.4162
Sig.		0.078	0.177

Table C.12 One way analysis of variance (ANOVA) for GR (kg/bed/day) during May 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/bed/day	Between Groups	3.402E-02	3	1.134E-02	1.885	0.211
	Within Groups	4.813E-02	8	6.016E-03		
	Total	8.214E-02	11			

Table C.13 One way analysis of variance (ANOVA) for GR (kg/in-patient/day) during May 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/bed/day	Between Groups	3.402E-02	3	1.134E-02	1.885	0.211
	Within Groups	4.813E-02	8	6.016E-03		
	Total	8.214E-02	11			

Tables C.14 Differences between the four hospitals according to generation rate (kg/in-patient/day) during May 1999 by running Duncan test, based on table 3.4.

Hospital	N	Subset for alpha 0.05		
		1	2	3
Rafidia	3	1.0015		
Al-Ittihad	3	1.1366	1.1366	
Al-Watani	3		1.4097	1.4097
Al-Iinjili	3			1.5800
Sig.		0.326	0.67	0.223

Table C.15 One way analysis of variance (ANOVA) for generation rate (kg/bed/day) during June 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/bed/day	Between Groups	5.957E-02	3	1.986E-02	18.723	0.001
	Within Groups	8.485E-03	8	1.061E-03		
	Total	6.806E-02	11			

Table C.16 Differences between the four hospitals according to generation rate (kg/bed/day) during June1999 by running Duncan test, based on table 3.4.

		Subset for alpha 0.05	
Hospital	**N**	1	2
Al-Iinjili	3	0.6319	
Rafidia	3	6.759	
Al-Ittihad	3		0.7600
Al-Watani	3		0.8125
Sig.		0.137	0.84

Table C.17 One way analysis of variance (ANOVA) for generation rates (kg/in-patient/day) during June 1999 between the four hospitals in Nablus, based on table 3.4.

		Sum of Squares	df	Mean Square	F	Sig.
Kg/bed/day	Between Groups	0.284	3	9.467E-02	2.650	0.120
	Within Groups	0.286	8	3.572E-02		
	Total	0.570	11			

Tables C.18 Differences between GR of medical waste generated from the four hospitals according to GR (kg/in-patient/day) during June 1999 by running Duncan test, based on table 3.4.

		Subset for alpha 0.05	
Hospital	**N**	1	2
Al-Iinjili	3	0.9758	
Rafidia	3	0.9929	0.9929
Al-Ittehad	3	1.1031	1.1031
Al-Watani	3		1.3608
Sig.		0.451	0.51

دراسة صحية بيئية للنفايات الطبية في مستشفيات مدينة نابلس

نابلس- فلسطين

يوسف صادق القاروط

إشراف

الأستاذ الدكتور محمد سليم علي-اشتية

الدكتور عصام الخطيب

خلاصة

تمت هذه الدراسة خلال عامي 1998- 1999 وهي دراسة صحية بيئية ميدانية عن إدارة النفايات الطبية في أربع مستشفيات في مدينة نابلس. لم تأخذ إدارة النفايات الطبية في فلسطين الاهتمام اللازم، حيث ما زال هناك نقص في التشريعات وعدم وجود سياسات التي تعرف وتحدد النفايات الطبية وكيفية تدبيرها. إن جميع النفايات الطبية يتم التخلص منها في مكبات النفايات العادية. لقد تم توزين النفايات الطبية المنتجة من المستشفيات الأربع (رفيديا، الوطني، الاتحاد، والإنجيلي) في مدينة نابلس مرتين لمدة ١١ يوما خلال أشهر آذار-حزيران ١٩٩٩، وخلال شهري تشرين ثاني- كانون أول ١٩٩٩، كما تم حساب معدلات إنتاج النفايات الطبية وحجمها وكثافتها . لقد تم عمل فحص مصلي مخبري خاص بالتهاب الكبد الفيروسي B لجميع عمال النفايات في المستشفيات الأربع المدروسة والبالغ عددهم ٦٢ عاملا وذلك خلال شهر كانون أول ١٩٩٩. أظهرت هذه الدراسة معدلات النفايات الطبية اليومية المنتجة من هذه المستشفيات الأربع الحكومية وغير الحكومية التي تمت عليها الدراسة. كما تم الاهتمام أيضا في الظروف الاجتماعية والصحية لعمال النظافة في هذه المستشفيات.إن معدلات إنتاج النفايات الطبية (كغم/سرير/يوم) كانت على التوالي 0.96 في مستشفى رفيديا، 1.34 في مستشفى الوطني، 1.18 في مستشفى الاتحاد، و 1.37

في مستشفى الإنجيلي. بينما كان معدل انتاج النفايات (كغم/ مريض داخلي/يوم) على التوالي 0.96 في مستشفى رفيديا، 0.83 في مستشفى الوطني، 0.76 في مستشفى الاتحاد، و 0.69 في مستشفى الإنجيلي. أظهرت نتائج فحص الدم الخاصة بالتهاب الكبد الفيروسي B في المستشفيات الأربع والبالغ عددهم 62 عاملا وعاملة (20 في مستشفى رفيديا، 12 في مستشفى الوطني، 19 في مستشفى الاتحاد، و11 في مستشفى الإنجيلي) بأن فقط حالة واحدة كانت نتيجتها إيجابية (من مستشفى رفيديا) . وهذا يعني أن مدى انتشار الإصابات بين هؤلاء العمال هو 1.16 %.