ORIGINAL RESEARCH

A Study on biomedical waste management in the healthcare sector: A pathway towards sustainability

Ammna Rakshanda, Vahid, Saad Bin Azhar

Section 1

Introduction

The main aim of this research is to analyze the "healthcare waste" that is generated during the process of healthcare delivery. It also emphasizes the need for awareness amongst the general population and, primarily, the hospital staff to ensure less errors and more efficiency in the disposal of biomedical waste. By understanding the complex nature of healthcare waste, we can devise sustainable solutions to mitigate its adverse effects on human health. This has become a critical concern worldwide, due to its potential implications on public health and the environment, leaving us with only one safe choice: proper disposal and management.

Our research endeavor is socially useful, as it attempts to highlight the fact that public health is indeed a basic need for humanity. The healthcare sector plays an essential role in providing required medical services, ranging from hospitals and clinics to research institutions and diagnostic laboratories. Whenever a person falls sick, they rush to the hospital to see a doctor and get treated before it is too late. Imagining how many such cases are seen in one day at one hospital is an uphill task because they can add up to the thousands.

When sick persons are treated at a hospital, waste is generated. To compute the total waste generated in 24 hours, the waste generated by one person is then multiplied by the total amount of patients. The amount of waste may weight up to many tons. Private and public hospitals, which are burgeoning year after year, generate a substantial amount of waste, including hazardous and infectious agents, pharmaceuticals, chemicals, and radioactive substances, inadequate management of which can lead to devastating circumstances, which include the destruction of our habitat.

In general, healthcare waste may contain various pathogens- such as bacteria, viruses, parasites, as well as cytotoxic substances and residues of pharmaceutical substances. Contamination cases can become very common if the biomedical waste is not safely discarded. The spread of infectious diseases among workers, staff, patients and even the general population, and the release of toxic substances in the water affect both human as and flora/fauna populations.

We often talk about climate change and the change in atmospheric gases that can contribute to our imperilment but fail to realize that this is also an effect of incineration and land filling practices in biomedical waste management.

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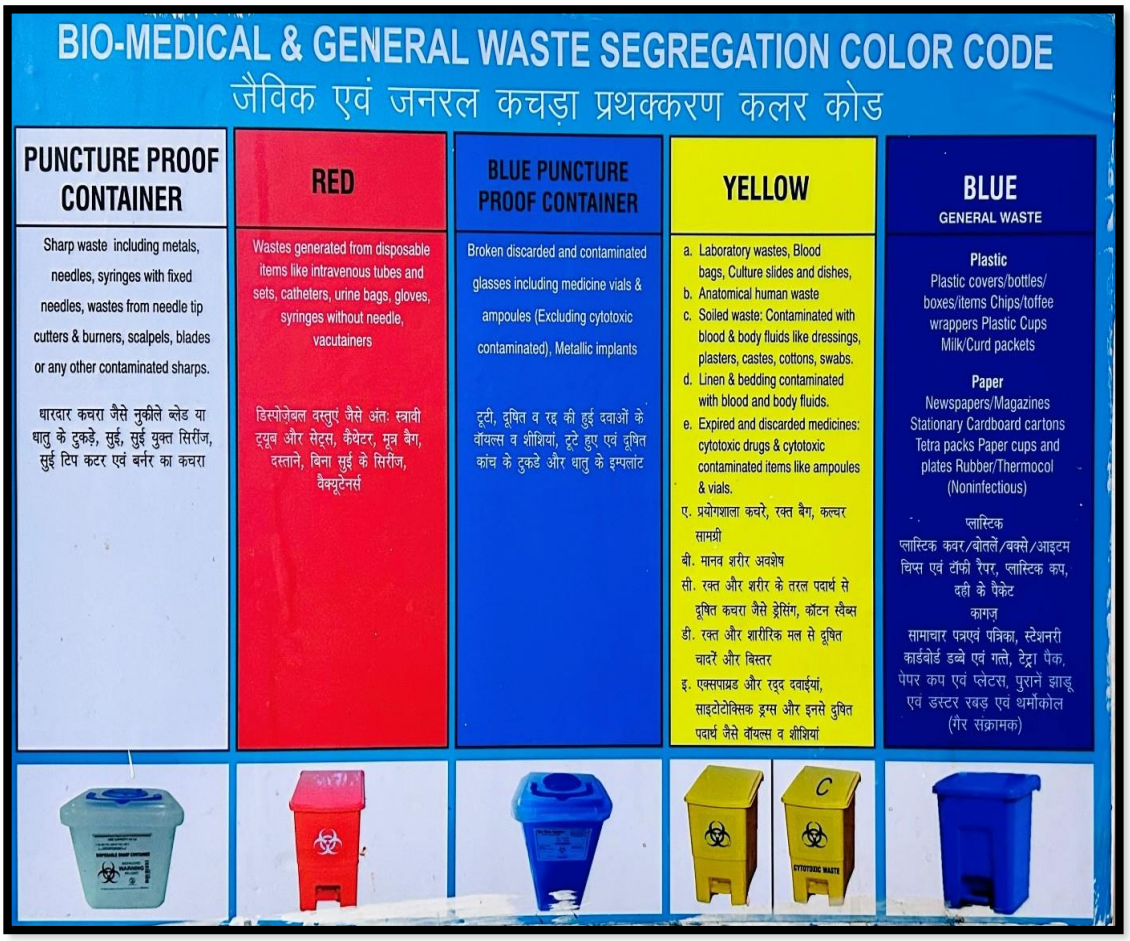
Figure -1
Color-coded Segregation of Healthcare Waste



The benefits are many. Effective strategies can contribute to resource conservation and energy efficiency, as well as climate change mitigation. If appropriate interventions are not carried out, public health shall have to face adverse effects, such as:

Healthcare-Associated Infections (HAIs):

Improper management of healthcare waste, particularly infectious waste, increases the risk of HA Infections, also known as Nosocomial infections. Pathogens present in health care waste can spread to health care workers, patients, waste handlers, and the general public, leading to infections such as blood stream infections, respiratory tract infections, and gastrointestinal infections and surgical site infections.

Transmission of Blood-borne Pathogens:

Sharps waste, such as needles and syringes, poses a significant threat for the transmission of blood borne pathogens like the hepatitis B virus (HBV), the hepatitis C virus (HCV), and the human immune deficiency virus (HIV). The inadequate handling and disposal of sharps increases the likeliness of needle stick injuries and subsequent infection transmission.

Air borne and Water-borne Contamination:

The inadequate management of healthcare waste, including improper incineration or disposal

of hazardous waste, can release harmful substances into the air and water. This can result in the pollution of ambient air, water bodies, and groundwater, potentially exposing the public to toxic chemicals and disease-causing microbes.

Community Health Impacts:

Improper disposal practices, such as open dumping or uncontrolled burning of healthcare waste, can adversely affect the health of nearby communities. The residents living near healthcare facilities or waste disposal sites may experience respiratory problems, skin irritations, and other adverse health effects due to exposure to hazardous substances and pathogens.

In short, healthcare waste management requires combined efforts from doctors, nurses, paramedics, housekeeping staff, waste management authorities and policy makers, as well as the public. Training programs and awareness campaigns are needed to educate healthcare workers about the role they need to play, including segregation, storage, transportation, treatment and, finally, disposal.

Section - 2
Literature Review

This literature review is divided into two sections. In the first section, the text-book literature is reviewed to underline its main features. A map of the different types of healthcare waste is outlined. The literature on treatment and disposal factors is also summarized. The factors influencing waste generation rate and the impacts of biomedical waste are also collated. In the second section, we summarize the findings of different authors on biomedical waste.

2.1 Textbook Literature
What goes where?

Types of Healthcare waste:

There are multiple types and kinds of wastes in a hospital setting, which are generated during patient treatment. The main types of wastes are:

1. Infectious waste –

Waste contaminated due to the presence of pathogens, blood, body fluids, cultures, discarded infectious materials and laboratory specimens. Some examples are the cultures and stocks of infectious agents, contaminated laboratory waste, waste from isolation/general wards and rooms, and dressings, cotton and bandages from infected wounds.

2. Hazardous waste –

Radioactive materials, cytotoxic substances, and mercury-containing devices which have the potential to cause harm. These include chemical waste (expired/not in use chemicals, solvents, and reagents) and pharmaceutical waste (expired/unused vaccines and medicines, and the radioactive waste used in medical imaging, diagnostics, or treatments).

3. Cytotoxic waste

Drugs used in cancer treatment.

4. Sharps waste –

Waste consisting of sharp objects. Needles, syringes, scalpels, blades, surgical instruments, broken glass, and other materials with the potential to cut must be collected and disposed of in puncture-resistant containers.

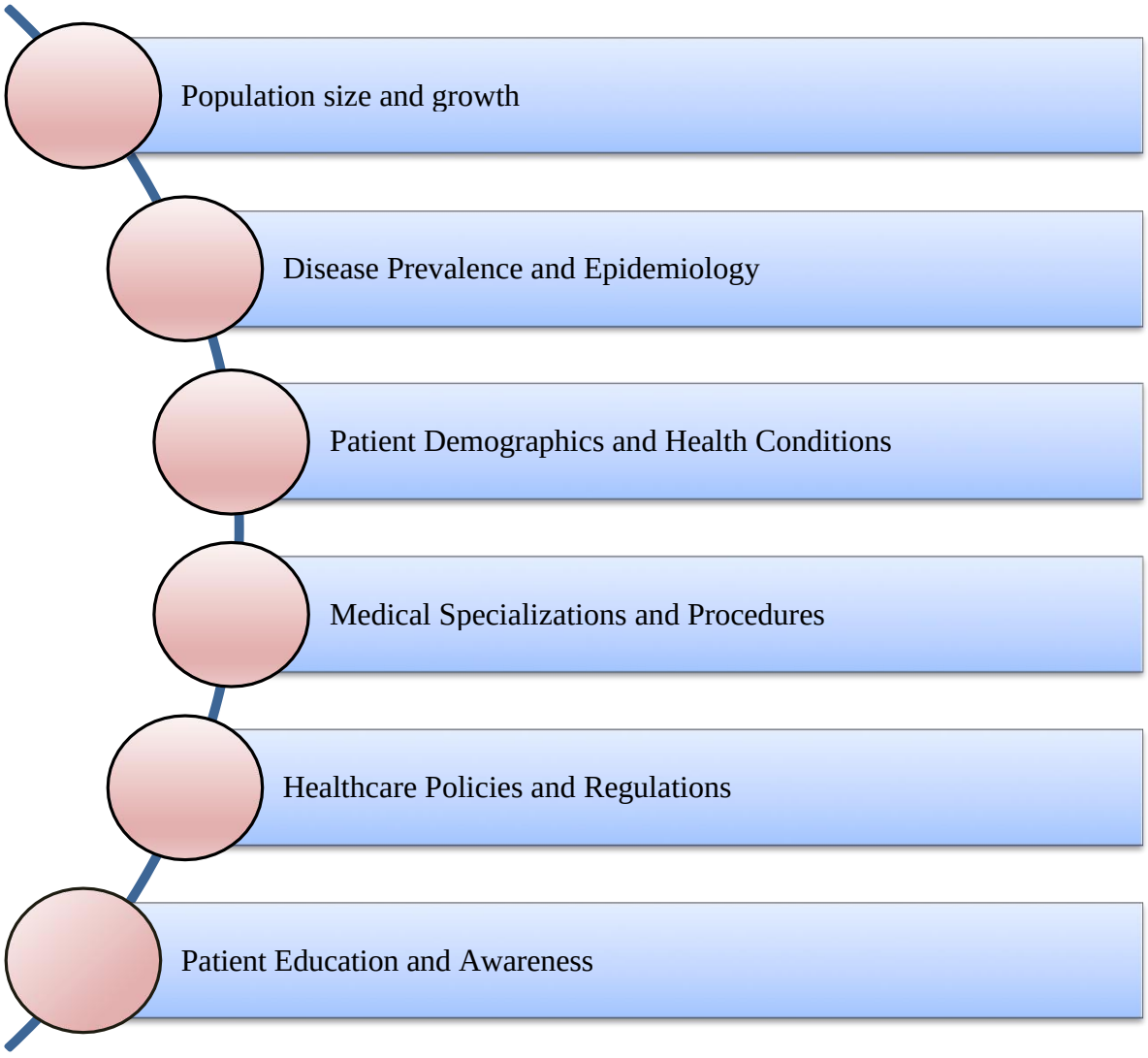
5. Pharmaceutical waste -

Unused, contaminated, and expired drugs that are disposed of to avoid unnecessary usage. These include expired or unused medications, spilled products, and pharmaceutical packaging materials.

6. Non-Hazardous general waste –

It is also known as regular waste, and includes paper, cardboard, plastic (excluding hazardous plastics, which are decomposable), food waste, packaging materials (such as wrappers), as well as all other non-infectious, non-toxic waste.

Factors influencing Waste Generation Rates



Treatment and Disposal factors

Treatment and disposal methods for health care waste vary depending on the type of waste and side effects it has the potential to produce. Here are some commonly used methods:

Incineration:

Incineration is a widely used treatment method for healthcare waste, especially for infectious and hazardous waste. It involves the combustion of waste at high temperatures, typically between 800 to 1,200 degrees Celsius. Incineration helps reduce the volume of waste, also destroying pathogens, toxic chemicals, and pharmaceutical residues.

Autoclaving:

Autoclaving is a treatment method that uses high-pressure steam to sterilize healthcare waste by effectively killing microorganisms and rendering the waste safe for disposal. Autoclaving is commonly used for infectious waste, sharps waste, and certain laboratory waste.

Chemical Treatment:

Chemical treatment methods are employed for specific types of health care waste, such as

liquid waste or pharmaceutical waste. Chemical disinfection or neutralization processes can be used to inactivate pathogens or neutralize hazardous substances in the waste.

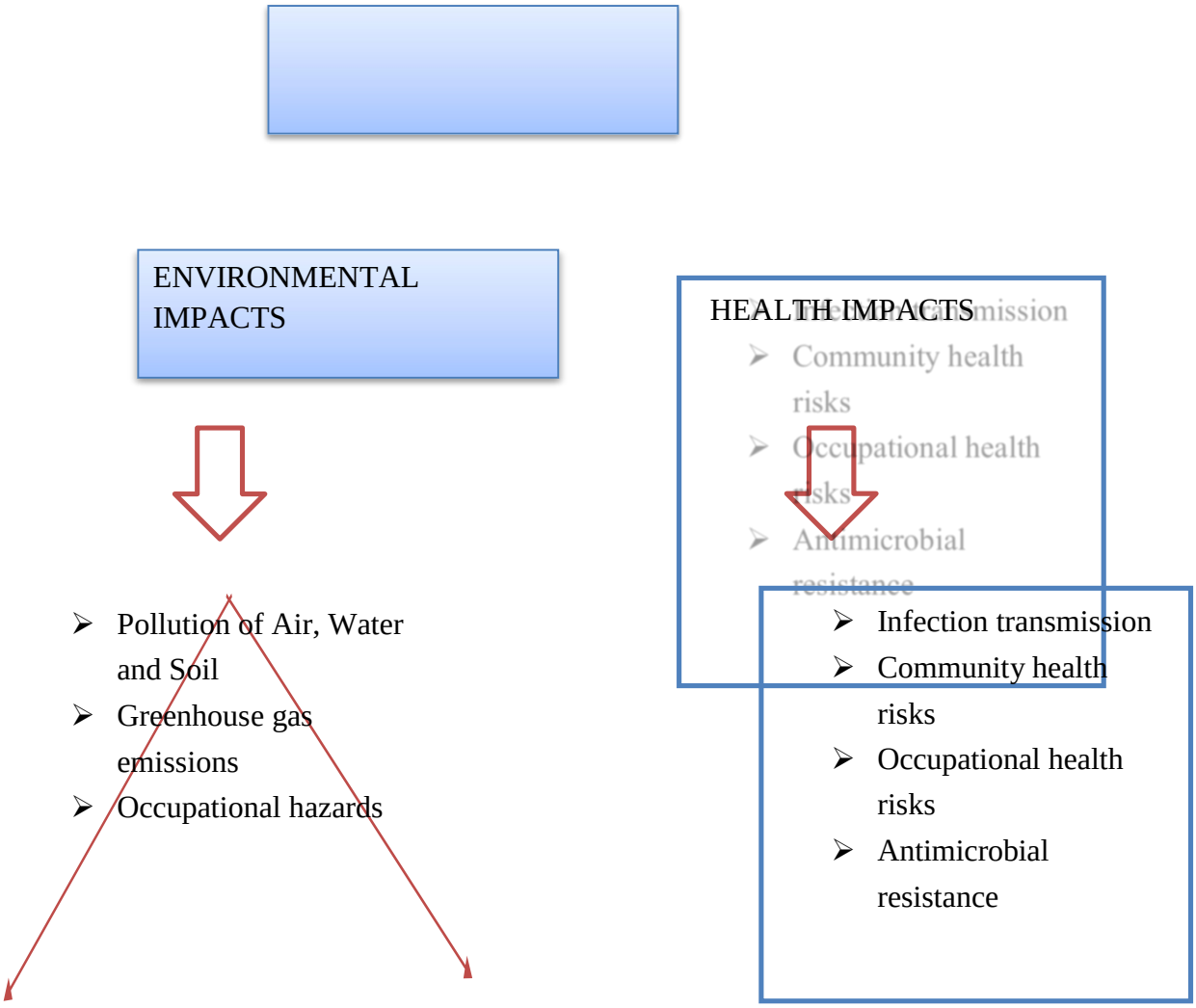
Landfilling:

Land filling is a commonly used disposal method for non-hazardous healthcare waste that has undergone appropriate treatment. Treated waste is deposited in designated sanitary landfills that comply with environmental regulations and are engineered to prevent environmental contamination. Land filling is often used for general non-infectious waste, such as packaging materials or non-hazardous plastics.

Recycling and Reuse:

Certain types of healthcare waste, such as plastics, paper, and packaging materials, can be recycled or reused. This can reduce harmful environmental impact and cut down on the total amount of waste produced.

Impacts of Biomedical Waste



2.2. Journal Literature

In this section, eight authors and journals are reviewed. The summary of these authors' findings on biomedical waste is presented below:

In one study, it was found that if biomedical waste management is done correctly, the aforementioned problems can be avoided. Segregation, storage, processing, transportation, and disposal of biomedical waste are all common practices undertaken as part of healthcare waste management. To achieve better results, we must raise the level of training and education regarding biomedical waste and environmentally sustainable healthcare as quickly as possible (Bengali, Shridhar & Gowri Shankar, Bychapur & Bagali, Sachin. (October 2021 in A Review on Biomedical Waste Management).

Another study argues that health care workers should have proper knowledge and training regarding collection, segregation, and disposal of biomedical waste. The best management practices should be followed, especially when disposing of hazardous wastes. This article provides a detailed overview of biomedical waste management in medical and dental settings, while emphasizing the importance of public health stake holders and how they play a role in developing society (Hasan, Shamimul & Saeed, Shazina & Choudhury, Priyadarshini, November 2015, in Biomedical Waste Management – a Public Health Hazard: An Overview of Literature).

A study of the implementation of various processes that comply with the statutory provisions of Bio Medical Waste Management Rules, 2016, asserts that the total waste generated during the period of October 2016 to May 2017 was 21579 kilograms. This comes down to 0.51 kg per patient, per day (Singh, Riva & Singh, Gurjeet & Singh, Kanwarjit & Student, Mha, July 2018, in A Study of the biomedical waste management in a teaching hospital (NCMC and Hospital, Panipat).

Another article studies the classification, legislation, and management practices around biomedical waste in India. In India only 1 to 1.5% of the total amount of solid waste generated in a city is biomedical waste, of which 10-15% is considered infectious. This article aimed to create awareness by providing information about its potential side effects (Tiwari, Anurag Kadu, Prashant. (January 2014, in A Review of Biomedical Waste Management Practices in India).

In 2012, the WHO conducted a survey on the BMWM status, which included a literature search, as well as a review of relevant publications, newspaper articles, and other sources of information. The status of each country on each of the five main areas of BMWM - namely, management, training, policy and regulatory framework, technologies implemented, and financial resources in the field of management, training, and policies to ensure effective management - was assessed. (Priya Datta, Gursimran Kaur Mohi, and Jagdish Chander, January-March 2018, in Biomedical Waste Management In India: A Critical Appraisal).

A checklist, which included 29 parameters relating to various functions to be carried out at source of generation by a HCW for BMW management, was prepared by a researcher and used after validation to record. The presence of the wrong kind of waste in a particular container nullifies the efforts of appropriate waste disposal. Thus, in order for waste to be properly segregated and disposed of, waste bins must be labeled with appropriate numbers, specific color-coding, and placed at accurate locations (Rajiv Kumar, Anil Gupta, Arun Aggarwal, and Ashok Kumar, 2014 in A Descriptive Study on Evaluation of Bio-Medical Waste Management in a Tertiary Care Public Hospital of North India).

Medical centers, including hospitals, clinics, and other places where diagnosis and treatment are carried out, generate highly hazardous waste materials which put people under risk of fatal diseases. Health risks associated with waste and its by-products include radiation burns, sharps-inflicted injuries, poisoning, and pollution through the release of pharmaceutical products - in particular, antibiotics and Cytotoxic drugs (K.K. Padmanabhan and Debabrata Barik, November 2018 in Health Hazards of Medical Waste and its Disposal).

Another study focused on the in-depth planning of collection, transportation, processing, and disposal of hazardous and non-hazardous biomedical waste. Specifically, its focus was on the effective management of biomedical waste through the incorporation of an appropriate waste reduction and neutralization component. The main goals of waste management are to clean up the surrounding environment and to identify efficient and effective methods for waste neutralization (Nikos E. Mastorakis, CarmenA. Bulucea, Tatiana A. Oprea, Cornelia A Bulucea, Philippe Dondon March 2014 in Environmental and Health Risks Associated with Biomedical Waste Management).

Section – 3

Research Objectives and Methodology

The present article follows four objectives:

1. The purpose of this research is to study the knowledge level regarding Biomedical Waste management and the adoption of safe practices in nurses, paramedics, doctors, and the housekeeping staff of the hospitals in South Delhi,
2. To examine their knowledge regarding potential side effects like NSI- Needle Stick Injury and transmission of STD's due to improper segregation and disposal of healthcare waste,
3. To check whether the staff is fully inoculated against Hepatitis B, and
4. To give desirable suggestions to make our country sustainable and green.

Study Design and Method

This study used a descriptive and analytical research design. A simple random sampling technique was applied to a total of 75 respondents to carry out a cross-sectional study of the hospitals of South Delhi. Seven of these belonged to the housekeeping department, another seven were Paramedics, 23 were Doctors, and 38 were Nurses. A pre-designed, priorly tested, close-ended questionnaire was prepared, uploaded as a Google form, and circulated amongst the staff. Some people were approached in person to avoid cheating or bias in the answers given. This tool was used to understand the knowledge level of the hospital staff.

The questionnaire was divided into 3 sections:

1. Knowledge regarding BMW practices and adoption of safe practices
2. Knowledge regarding the side effects of unsafe practices like NSI, and
3. Assessment of whether the staff is fully vaccinated against Hepatitis-B

The data collected was coded in Microsoft Excel for tabulation and analysis. Descriptive analysis was done using SPSS- Statistical Package for Social Science.

Section – 4

DATA ANALYSIS –

BMW Management, NSI and Inoculation against Hepatitis - B

In this section, the questionnaire responses are organized and presented in charts, through which we ascertain the awareness and knowledge of the issue surveyed amongst the hospital staff.

Table – 1
Distribution of Sample Respondents into Professional Categories (Number and percentage)

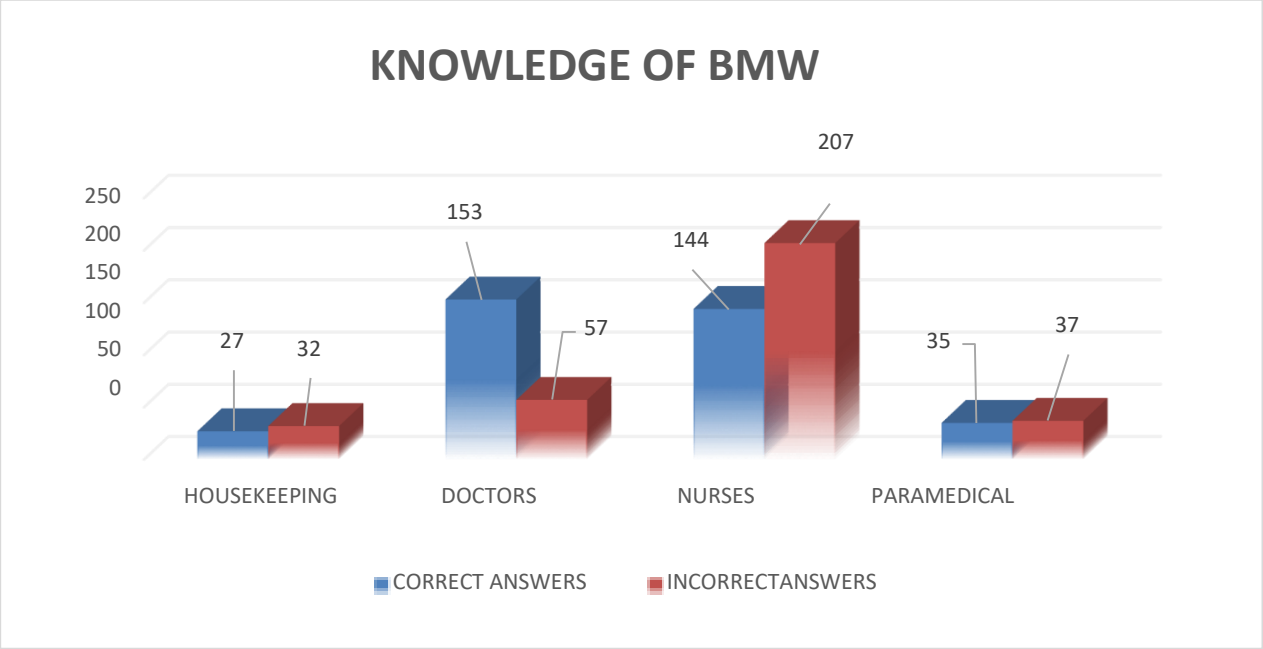
Staff Category	Number of Sample	Percentage of Sample	Cumulative percentage
Doctor	23	30.7	30.7
Housekeeping	7	9.3	9.3
Nurse	38	50.7	50.7
Paramedical	7	9.3	9.3
Total	75	100.0	100.0

The questionnaire contained three categories of questions: biomedical medical waste management, needle stick injuries and the status of inoculation. There were a total of 75 respondents, out of which 30.7% were Doctors, 9.3% were Paramedics, 9.3% were from the housekeeping department, and 50.7% were Nurses.

Table – 2
Number of correct and incorrect answers to questions regarding biomedical wastes

Staff Type	Correct answers	Incorrect answers	All Answers
Housekeeping	27	32	59
Doctors	153	57	210
Nurses	144	207	351
Paramedical	35	37	72

Bar Diagram – 1
Division of correct and incorrect answers among the sample category of staff respondents



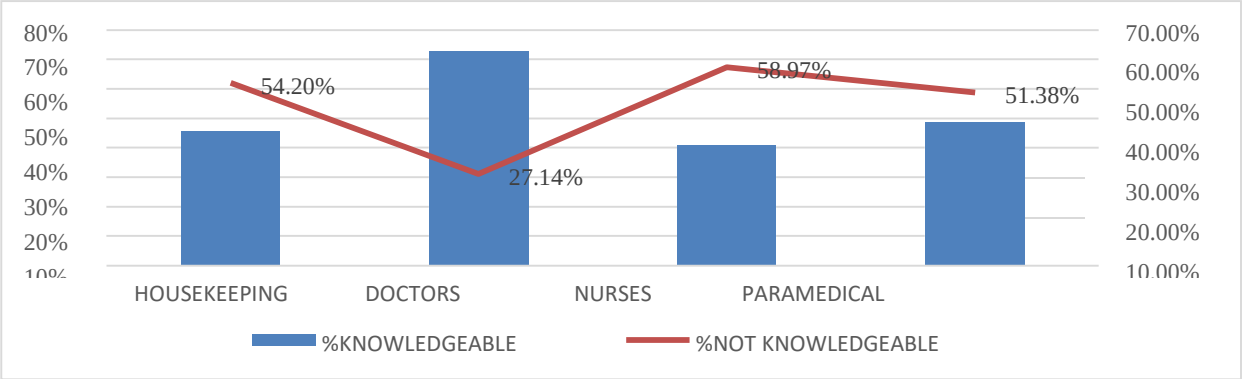
We found that Doctors gave the most correct answers, as compared to the other staff members. Nurses could correctly answer only 144 questions out of 351 questions. Housekeeping staff could correctly answer 27 questions out of 59, and paramedics answered only 35 questions correctly.

We found that only 41.02% of Nurses were knowledgeable, making them the least knowledgeable category amongst the 4 categories of Staff. They were followed by the housekeeping staff (46%) and Paramedics (48.61%). Doctors exhibited good knowledge (72.80%) about BMW management. Nurses weren't too sure which bag holds which kind of items; they didn't have much expertise on which methods are adopted for certain color-coded bags.

The main reasons identified for this situation are:

1. lack of monitoring by team leaders,
2. improper time management and over-hastiness, and
3. lack of training and absence from skill-building classes

Bar Diagram – 2
Percentage Distribution of Responses by Staff Categories

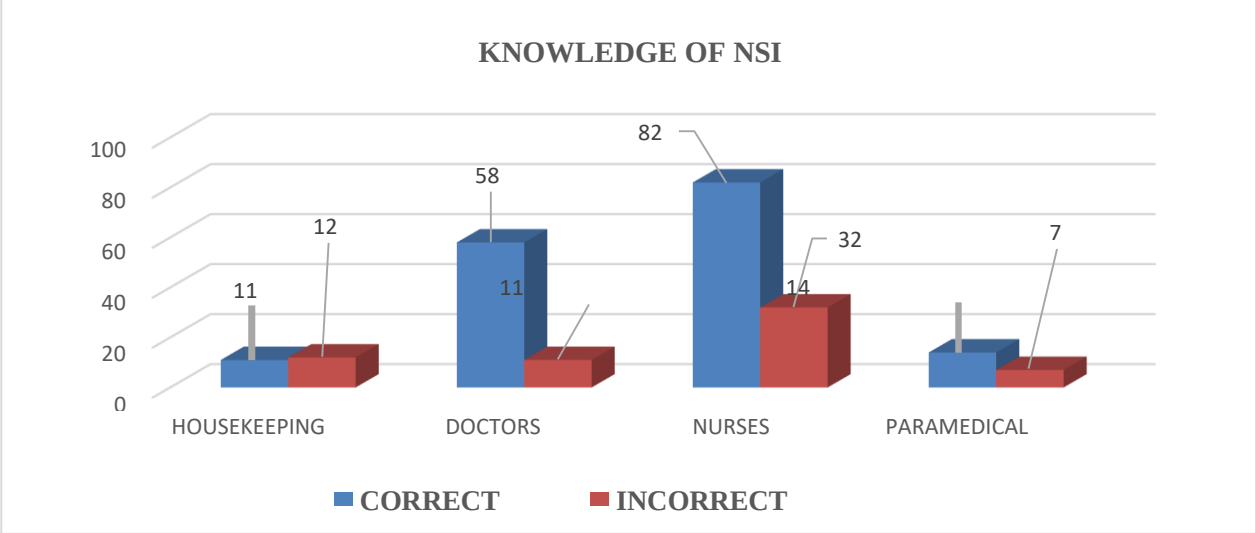


We found that, in general, the number of knowledgeable staff is quite low in relation to the not knowledgeable staff (54.20% of Housekeeping staff, 27.14% of Doctors, 58.97% of Nurses, and 51.38% of Paramedics have poor knowledge).

Table – 3
Number Of Correct And Incorrect Answers To The Questions Regarding The Side Effects Of Unsafe Practices Like Needle Stick Injuries

Staff Category	CORRECT	INCORRECT	All Responses
Housekeeping	11	12	23
Doctors	58	11	69
Nurses	82	32	114
Paramedical	14	7	21

Bar Diagram – 3
Distribution of Correct and Incorrect Responses (In Numbers)



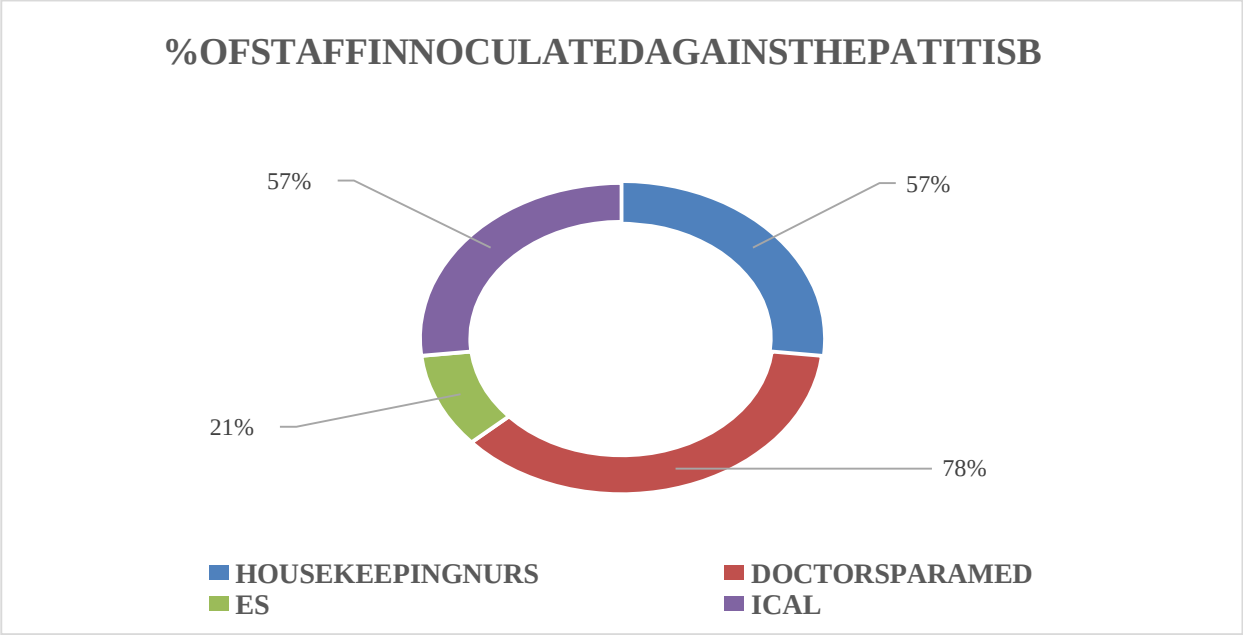
In terms of knowledge about side-effects like transmission of STD's due to Needle Stick Injuries, the staff had a fair to good knowledge regarding what can go wrong, and which threats they face daily. The percentage of correct answers for each staff category are as follows: Housekeeping (47.82%), Doctors (84%), Nurses (71.92%), Paramedics (66.66%). Doctors showed a high level of knowledge, Nurses and Paramedics showed a good level of

knowledge, and the Housekeeping staff showed a fair level of knowledge

Table – 4
Number of staff vaccinated against HEPATITIS – B by Staff Category

Staff Category	Inoculated Staffs	All Staffs	Percentage
Housekeeping	4	7	57%
Doctors	18	23	78%
Nurses	8	38	21%
Paramedical	4	7	57%

Pie Chart – 1
Percentage Distribution of Inoculated Staff among the Sample



The third objective of this study was an assessment of whether the staff was fully vaccinated against Hepatitis-B. This came out to be a surprising - in fact, a shocking – insight, as we did not expect such a low percentage to be the case. Only 4 out of 7 Housekeepers (57.14%), 18 out of 23 Doctors (78.26%), 8 out of 38 Nurses (21.05%) and 4 out of 7 Paramedics (57.14%) were inoculated against Hepatitis-B. These front-line workers who are continuously exposed to everyday threats must be vaccinated to prevent them from developing any kind of STD related to Needle Stick Injuries.

Section – 5

Conclusion and Policy Prescription

Research reveals that tertiary care hospitals generate around 300 kg of waste per day. For waste disposal to be efficient and effective, the knowledgeable staff should outweigh not-knowledgeable staff. This reduces the number of errors and mistakes and guarantees that the hospital doesn't have to deal with any potential side-effects and losses. It also guarantees that the

waste is properly disposed of following stringent norms and regulations.

Each type of waste- be it radioactive, pharmaceutical, or common, has different disposal methods, ranging from burial to incineration to autoclaving. Collection bins sealed with disposal polythene are recommended for the collection of solid radioactive waste, which is then buried in exclusive burial sites, where it naturally decays over time until it is no longer hazardous. General waste is usually autoclaved or incinerated to kill infectious microbes, or else recycled for its usage. This is, however, not the case in South Delhi hospitals. There, safe management efforts by hospital staff are considered an extra work burden, and more than half of respondents agreed that it increased the financial burden on the hospital management.

Biomedical waste management plays a crucial role in the creation of a more sustainable and greener environment in India. Proper management of biomedical waste not only prevents health hazards but also supports a cleaner and healthier ecosystem.

Here are some ways in which biomedical waste generation can be reduced to contribute to India's sustainability and green initiatives:

1. Hydrolytic bacteria have been known for their ability in reducing water pollution parameter values. The non-pathogenic ones play a key role in accelerating the degradation of biomedical wastes by limiting available nutrients, thus suppressing the growth of pathogenic microorganisms.
2. Encouraging healthcare facilities to adopt waste minimization practices such as using smaller needles and syringes when appropriate to reduce the volume of waste generated.
3. Use digital and electronic medical records instead of paper records to reduce the need for paper waste disposal.
4. In some cases, consider waste-to-energy technologies that can safely convert biomedical waste into energy, reducing the volume of waste for landfill disposal.
5. Disposable items should be dipped in 1% Hypochlorite solution to ensure disinfection.
6. Explore recycling options for certain types of biomedical waste, such as plastics and glass containers, which can be recycled safely.
7. Most importantly- Public Awareness and Education.

Awareness training regarding disposal of Biomedical waste should be a compulsory subject in all medical schools. Media campaigns can be used to promote and sensitize the community regarding the urgent need for safe biomedical waste disposal practices.

Incorporating these strategies can help India manage biomedical waste more sustainably, making the country greener and contributing to a healthier environment for its citizens.

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