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Bio-Medical Waste Management Processes and Practices Adopted by Select Hospitals in Pune

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ABSTRACT

The 21st century is said to have been a particularly eventful century with spectacular changes all around the world. The population is on a steady rise and as expected this rise in inhabitants has resulted in the need for the best-in-class medical facilities. This study has been undertaken to explore biomedical waste management process, practices and disposal chain adopted by selected hospitals with special reference to the city of Pune, India. There is a mandate laid down by the Government of India for the Bio-Medical waste (BMW) with regard to its proper management, collection, segregation, storage, disposal and incineration of medical waste in private as well as public hospitals. The secondary study has indicated multiple issues associated with waste handling and management, which led to healthcare and hygiene implications. So as a part of this study researcher's aim to answer whether it is unawareness or negligence which is leading to such causalities. Also, are the processes & practices adopted at Public & Private sector hospitals varies significantly or not? A checklist was prepared to study the BMW Management process and practices followed by different hospitals in Pune City of India. The results showed a significant difference between their process & practice of Biomedical Waste Management. Also, random sampling about knowledge of BMW showed that government hospitals and their healthcare staff are casual in their approach towards implementing the Biomedical Waste Management process as compared to private sector hospital.

Keywords: *bio-medical waste management, hospital, awareness, process, practices, disposal chain*

1. INTRODUCTION

The increasing population and rising stresses on resources have caused the environment dearly. These effects have implications on humans in form of deteriorating health condition. And this has given birth to an increasing number of the hospital around us to cater to those health problems. This has sharply increased the Medical waste generated from the hospital. The rising amount of waste demands an effective process of its disposal. Proper disposal is necessary to avoid outbreak of any kind of epidemic that is detrimental to human life. The disposal chain should be isolated enough to avoid contamination of its surroundings. The timely disposal of bio-medical waste plays a crucial role in the entire disposal chain because its accumulation can cause contamination of the surroundings and spread of foul smell. The end product of the disposal chain should be reutilized to reduce the environmental impact of the disposal process. With creating a waste minimization program about hospital waste; the negative impact of the wastes must be eliminated that will affect people health and environmental health (Cebe *et al.*, 2013).

According to USEPA, United States Environment Protection Agency (USEPA Report, 2013), the medical waste is defined as all the waste material generated by healthcare facilities (like laboratories, hospitals, clinics, dental, physician's office, blood banks and veterinary) that includes a wide range of material such as used syringes and needles, dressings (soiled), blood, chemicals, body parts, diagnostic sample, medical devices, radioactive materials

and pharmaceuticals. Indian Bio-Medical Waste Management Act defines bio medical waste the same way.

The bio-medical waste is generally divided into two categories: general waste and hazardous waste. The hazardous waste is the most dangerous and needs a proper mechanism for its disposal strictly according to the rules laid down by the regulatory agency of any particular country. A recent report by (WHO, 2013) states that around 80% of medical waste generated is comparable to the domestic waste while remaining 20% is considered hazardous because it being infectious, toxic or radioactive. Here infectious waste constitutes the major chunk (15%) from all healthcare activities. Pharmaceuticals and chemicals constitute around 3% and the remaining 2% is constituted by heavy metals, genotoxic waste and sharp objects.

This infectious waste if not properly disposed of poses a great health risk to public health, furthermore its improper management can lead to spread of infection and unpleasant smell, also can foster environmental pollution (water, air, soil and etc.) and growth of rodents, worms and insects. The most common diseases that can spread through improper management of biomedical waste is typhoid, cholera, HIV and hepatitis. The Biomedical waste scattered in and around the hospitals invites flies, insects' rodents, cats and dogs that are found to be responsible for the spread of diseases like Plague and Rabies (Dhote, 2016).

Many incidents are reported in the local newspaper about small clinics throwing biomedical waste at general waste disposal facilities of the locality and hence becoming a potential source of spreading infection and diseases, where rag pickers and stray animals are potential weak links in getting prone to and spreading those infections and diseases. The plight of government hospitals is also same as small clinics where much of the attention is not paid to the disposal of bio-medical waste and often it is mixed with domestic waste and disposed of. But there are few hospitals that have laid down proper mechanism for disposal of waste because they care for the environment in which they operate, own good health for the patients and have the brand reputation to maintain. These are the well reputed private hospital and they maintain a state of the art mechanism for proper disposal of biomedical waste generated by them. They strictly follow the guidelines laid in the (Bio-Medical Waste Management Act, 2016).

One of the important factors above all is the attitude of the staff in strictly following these rules laid down by hospital authorities. Hospitals fail to identify the critical factors of inpatient service quality in a hospital and to develop the HospitalQual theoretical model to measure inpatient service quality (Itumalla *et al*., 2014). But the real onus lies in the hands of the management in laying out a proper training structure for its health care employees and sensitizing them about the criticality of the issue. If healthcare employees remain motivated and perform their duties well, the chances of an outbreak of any hazard can be reduced. The training offered should be continuous and comprehensive, integrated and well designed as per the nature of work involved. The knowledge & attitude of the people creates all the difference (Mishra *et al*., 2016). Adequate training among health care workers can improve the biomedical waste management and handling practices at hospital settings (Ananthachari *et al*., 2016).

In the city of Pune, most of the private hospitals are strictly following waste disposal practice laid down by the erstwhile ministry of health under the Biomedical Waste Management Act, 1998. They have their well-defined training mechanism and disposal chain for biomedical waste management practice. But the condition is not similar to the government hospital where practices are loosely followed and it creates a high risk of causality. On observation of the practices followed by small clinics, very disappointing results were obtained. Small clinics are mixing the biomedical waste generated by them and are throwing the same in their locality. Knowledge, attitude and practices regarding biomedical waste management of class IV employees were found to be very low in other states of the country as per the study of Anand *et al*. (2016).

Pune Municipal Corporation has given the contract for biomedical waste collection from different hospitals in Pune to PASSCO on a contractual basis. PASSCO is biomedical waste management company, they collect waste from different hospitals in Pune and perform incineration and autoclaving of biomedical waste collected. Transportation of all the biomedical waste of all Pune city i.e. of 6000 hospitals is under the Pune Municipal Corporation's Passco Environmental Solutions Private Ltd (Jaysingpure *et al*., 2017). They have an excellent track record for error-free disposal chain and are the supplier of colored bags and barcodes to the hospitals.

The primary objective of the present study undertaken is:

i. To explore and compare the Bio-Medical Waste Management Process and Practices adopted by hospitals in the city of Pune.
ii. To compare the awareness of Bio-Medical Waste Management processes among the healthcare workers of Public vs Private sector hospitals.

2. LITERATURE REVIEW

Healthcare has turned out to be one of India's biggest sector both as far as revenue and employment. The industry is developing at an enormous pace attributable to its reinforcing scope, services and increasing investment by public and private players. The aggregate industry is estimated to grow from USD 160 billion in 2017 to USD 280 billion by 2020 (IBEF, 2017) (KPMG, 2015). In spite of the tremendous growth in this sector, Indian healthcare cannot be compared with some of the developed and developing nations mainly because of unequal access, low quality and increasing expenses. Also, increasing cases of Nosocomial infections are creating a ruckus by doubling the challenges faced by hospitals today and remain a looming danger for patients. National Nosocomial Infections Surveillance system defines a nosocomial infection as a "localized or systemic condition that results from an adverse reaction to the presence of an infectious agent (s) or its toxin (s) that was not present or incubating at the time of admission to the hospital" (Richards *et al*., 1999) (Choudhuri *et al*., 2017). Lacking cleanliness and patient-isolation protocols in operating rooms (OTs) and intensive care units (ICUs), inadequately looked after hardware, understaffing makes hospitals and clinics a ripe rearing ground for microbes.

Patients who have recently undergone surgery are quite vulnerable to getting infected while in hospital. In response to such infections, doctors release progressively strong anti-

microbial/ anti-biotic to disinfect, which in turn makes the microbes drug-resistant. Cases of Nosocomial infections can double or quadruple the average length of patient's hospital stay thereby increasing consumption, expenditure on medications and diagnostics. Nosocomial infection, therefore, is one of the main causes of hospital morbidity and mortality. (Richards *et al*., 1999) Also, the recurrence of ICU-obtained contamination in low and mid-income nations is a few times higher than in developed nations. The nosocomial infection is transmitted through the viruses, parasites, pathogenic bacterias, pathogenic protozoans (Dhote, 2016). Hence it becomes imperative for Indian hospitals for proper biomedical waste management as the quality of the hospital is measured by its adherence to guidelines of asepsis, cleanliness, and awareness of care protocols and employee's sense of duty regarding protection of patients from nosocomial diseases. Sadly, cases of nosocomial infections are rarely published by clinics and hospitals leaving patients oblivious. Unflattering reports on Hospital-acquired infections rates by World Health Organization and journals of epidemiology in the media have significantly discolored the picture of India as a Health Tourism destination.

Among the 35 million healthcare specialists around the world, three million experience needlestick and sharps injuries consistently (Yacoub *et al*., 2010). The World Health Organization has estimated that "exposure to sharps in the workplace accounts for 40 % of infections with HBV and HCV and 2-3 % of HIV infections among health care workers" (World health organization, 2002). In a year approximately more than 100,000 needle stick and sharps injuries are reported in UK healthcare facilities posing a grave risk for the transmission of more than 20 kinds of blood-borne pathogens, including hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) (US Department of health and human services, 1999). The intensity of Nosocomial infections is seen as the highest among patients admitted to the critical care unit. In spite of the fact that the Intensive Care Units (ICUs) represent less than 10% of aggregate beds in many healthcare facilities, over 20% of every nosocomial disease are obtained in ICUs (Ulu-Kilic *et al.,* 2013). As indicated in published literature the most pervasive nosocomial contaminations among patients in ICU are "urinary tract disease (UTI), pneumonia, bloodstream infection, skin and soft skin contaminations, gastroenteritis, hepatitis and central nervous system infections like meningitis" (Pratham *et al.,* 2011) (Crossley et al., 2000) (Emori *et al*., 1986-1990) (Richards et al., 1999).

Hospital staffs despite their best intentions, often become a harbinger of infections. They suffer from the less known "Omo syndrome" wherein they feel that they are sterile and get disappointed when cases of poor hygiene practices are exposed. Hospitals, therefore, should follow proper protocols to prevent unwanted growth of microbes and related issues.

Biomedical waste (waste that arises in health care institutes) if not properly disposed of can create grave repercussions. According to reports from developed nations approximately 1-5 kg of waste is produced per bed, while in a developing country such as India 1-2 kg of waste is generated (Saini *et al*., 2005) (Qureshi *et al*., 2007). In similar lines, some recent studies have shown low awareness level among health care staff with regards to waste management. The nosocomial infections or Hospital Acquired Infections (HAI) are commonly caused by organisms such as antibiotic-resistant gram-negative bacilli, gram-positive staphylococci, enterococci and Candida species which are reported to affect an average of 7% to 10% of patients admitted to hospitals and up to 30% of critically ill patients" (Deshmukh *et al*., 2016). Therefore, the management of biomedical waste should keep in the tab the regulations listed by the government.

The segregation of Bio-medical waste is done at the beginning of its generation. Subsequently, they are to be color coded for transportation, storage, treatment and disposal. Some of the methods of disposal include "autoclaving, chemical treatment, microwaving and incineration" (Compendium of Technologies for Treatment/Destruction of Healthcare Waste, 2012).

The government of India in 1998 declared the "Biomedical waste (management and handling) Rules" to streamline the collection, processing and disposal practices of biomedical waste in India. Several changes were made as and when required by the government. The latest revision was done on March 28, 2016, wherein several changes were made to improve waste management and disposal practices. The roles of Occupier and Operator have been clearly defined in BMW Rules 2016. Also, the revised rules have the arrangement to shape an advisory committee for the state or union territory and the monitoring committee at district level under the chairmanship of district collector/district magistrate or deputy commissioner/additional district magistrate to screen the compliance of the provisions of these guidelines. Two categories of biomedical waste (Glassware and Metallic body parts) have been added to the list of 11 categories. One (Incineration ash) of them has been omitted. Waste categories are colour coded as "yellow, red, white and blue and black is not in use anymore. Importance is given to training workers, immunization, health check-up and occupation safety (Kharat, 2016).

The recent changes in rules of biomedical waste management by the Government of India has brought in clarity in terms of waste managing process and roles of hospital staff and government institution. As it has already been established unattended biomedical waste is the major cause of Hospital-acquired infections, Hospitals and clinics should, therefore, abide by these rules to bring in a healthier atmosphere both for patients and themselves (Rashleigh, 2016). Hence, it is of prime importance to inculcate proper management and handling techniques of these wastes to eliminate any likely chances of the proliferation of communicable disease or vectors, which includes proper training regarding the biomedical waste management and handling (Mahananda, 2015; Deshmukh *et al*., 2016).

Healthcare institutes should keep track of their nosocomial infections in order to measure the quality of their biomedical waste management. This, however, becomes a difficult task in India mainly because of the population size and poor medical infrastructure. Studies have shown that proper biomedical waste management can reduce the generation of infectious and general waste (Almuneef *et al*., 2003). A hybrid supply chain system has to adopt environmentally-sustainable principles whenever possible, seeking to increase reliance on renewable inputs, reduce toxic outputs and maintain biodiversity (Krejci *et al*., 2010).

Hospital staffs should, therefore, understand the gravity

of such issue and should perform their daily task with utmost care. Hospitals should also give emphasis on regular training in terms of biomedical waste and their management to their staffs, and also conduct a regular inspection to check on the quality of the process of waste management. By prioritization, firms [Hospital] will have an idea of flexibility dimensions having more impact or importance in achieving supply chain flexibility in the organization (Singh *et al*., 2014).

The present study tries to look at how various hospitals in Pune city, India have accommodated the latest changes in their biomedical waste management process. Some of the questions that the researchers have tried to look at through this study are:

i. Are hospital staff trained regularly, and if yes, then do they understand the significance of these training sessions?
ii. Are Private hospitals better off in terms of waste management than Government hospitals? If yes, then where is the lack?
iii. Can there be any changes that can be included in the biomedical waste management rules? Or how can they be improved?
iv. How effective is the waste management process?
v. Do hospital staff try to reduce the amount of waste generated at the source, if yes, then what are the basic principles followed and can they be improved?

This study can be further improved by correlating the number of cases of nosocomial infections of a hospital to the quality of the process they follow when it comes to biomedical waste management. Such a study of understanding the quality of hospitals in terms of their waste management has been conducted in Delhi (within India) and developed nations. As Pune is one of the fastest growing cities in India, such studies to understand the waste management of hospitals becomes imperative and also the reason for the researchers to work in this area.

3. RESEARCH METHODOLOGY

The present study is descriptive and explorative in nature. An empirical study was conducted in Public and Government sector hospitals of Pune, India. A checklist and a questionnaire were prepared to study the Bio-Medical Waste Management Process after proper consultation with the experts in this field. The checklist highlights various process and practice that a hospital has to follow for proper disposal of Bio-Medical Waste as per the new Biomedical Waste Management law of India, 2016. And the questionnaire is based on basic of Bio-Medical Waste Management Practice, segregation process, healthcare workers training, transportation and storage of medical waste, which was designed after consultation with the experts in the field of Bio-Medical Waste Management. This questionnaire is to test the awareness of Biomedical Waste Management Practice by the healthcare staff.

3.1 Study Sample

A pilot study was conducted at few hospitals and clinics in Pune city to understand the waste disposal chain of these healthcare facilities after obtaining formal approval from the hospital authorities. The disposal mechanism of different hospitals was compared using a checklist prepared after duly going through the new biomedical waste management act. The sole purpose was to observe the best practices followed by the hospital. The survey for comparative analysis of awareness about Bio-Medical Waste among healthcare was conducted in five different hospitals of Pune. Three of which are private sector hospitals and the remaining two are run by the state government.

3.2 Study Methods and Tools

The entire study was conducted in two phases. The first phase was entirely concentrated towards observation where three different private hospitals and two different government hospitals were visited and their respective disposal chains were traced. The observations were recorded on a checklist prepared. The observations were recorded under 6 different categories (parameters). Six visits were made for each category and average was taken to capture the mean score for a concise picture of the practice followed by hospital and then, the mean percentage of the score was used for analysing. The percentage score obtained in each category was compared under government vs private sector hospitals using independent t-test. In the second phase comparative analysis of awareness of biomedical rules among healthcare staff of private sector and government hospital was done. Random sampling was done at private and government hospital. Questionnaires were given to healthcare workers only after taking prior permission from the hospital authorities for conducting the survey. Many refused to fill the survey but a good response from 115 respondents was collected. The responses include 65 respondents from the different private hospital and 50 respondents from a government hospital. Photographs were clicked during the entire research to showcase the practice in real time. Discussions were performed with the respective hospital administration to understand the respective disposal chain of every hospital.

3.3 Data Analysis

The data collected from the survey and the checklist were checked for completeness and consistency. The data collected was entered into excel and multiple independent t-Tests were used to carry out statistical analysis using IBM SPSS Statistics (v. 22). Bar graphs were also used along with a statistical test to perform a comparative analysis of awareness of biomedical waste management practice among healthcare workers of Private and Government Hospitals.

4. RESULT AND DISCUSSIONS

4.1 Observations Collected in Checklist

The prepared checklist was divided into 6 parameters. Each category has “yes” or “no” type questions.

Six visits on random days were made to understand whether the hospitals were following the process and practice as described under the Bio-medical Waste Management Rules, 2016. For every question under each parameter, six observations were made. If the observation was found satisfactory then “Satisfactory” is assidned to that particular question else “Unsatisfactory”. Six observation were made for every question. If 50% or more observations are “Satisfactory” then one mark is given to that particular question.

There are six categories are as listed below:

- Basic Requirement for Biomedical Waste (contains14 questions). Scores were satisfactory in private hospitals although it was found that government hospitals don't have some basic requirements to be met for biomedical waste disposal.
- Manpower dedicated for Biomedical Waste (contains 5 questions). This appeared to be area of improvement as only in two cases it met satisfactory remark.
- Training for Biomedical Waste (contains 5 questions). Training was taken seriously in private hospitals however for government hospitals their no referesher training conducted.
- Waste Generation (contains 6 questions). This aspect was followed seriously in all category of hospitals.
- Treatment & Disposal (contains 6 questions). This aspect was ignore partly by governement and private both hospitals as per the study.
- Management of different waste streams (contains 21 questions). Other than one hospital under study others were observing it more seriously.

The tables given in the appendix are summary of all the observation made under each category (Refer Table 4 to 8 given in Appendix). Mean average percentage score of different categories of BMW management for different hospitals (Private and Government) is summarized below:

The results obtained indicate that government hospitals are lagging behind in following the process & practices mentioned under the bio-medical waste management Act, 2016. The focus area of attention at government hospitals is the training of staff on biomedical waste management at priority basis. However other parameters have to strictly take care of especially Basic requirement for biomedical waste management, Man-power dedicated for biomedical waste management & Treatment & disposal of waste. These parameters become more critical at ICUs in both private & government hospitals. The overall average score indicates that in private hospitals Wards are much cleaner & follow bio-medical waste management practice religiously. Although ICUs also have a considerable score in comparison forwards in private hospitals. In government hospitals condition is very poor at both wards & ICUs. Hence, there must be mandated to make government hospitals follow the best practices of biomedical waste management. The culture is top driven and management at government hospitals have to take initiatives to implement the best biomedical waste management practices in the hospital.

4.2 Measures

The mean scores recorded in percentage is used in SPSS to compare different parameters of processes followed by Government vs Private Sector Hospital. Each parameter is checked for its significance level using independent t-test while doing a comparison among Government vs Private Sector Hospital. Also, the responses collected from the survey were compared using independent t-test in between government and private sector hospitals.

The results show that there is a significant difference in the biomedical Waste disposal process and practices of private and government sector hospital. The BMW management rules are strictly followed at the private sector hospital as compared to the government sector. The main reason observed behind this is the absence of a regulating department at government hospitals to controls the implementation of procedures of Biomedical Waste disposal.

The main reason for the second research hypothesis to get accepted is that government sector hospital doesn't follow all procedural guidelines of BMW management but bare minimum that is sufficient to run the disposal chain. Similarly, government hospitals do not have a separate and well-structured department to run BMW management practice but they are running such practices with the autonomy of healthcare workers.

Table 1 Mean score of different category

Hospitals→	**Private Hospital 1**		**Private Hospital 2**		**Private Hospital 3**		**Government Hospital 1**		**Government Hospital 2**		**Overall Score of Category**
Parameters ↓	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	
Basic Requirement for Biomedical Waste	93%	64%	86%	71%	79%	64%	57%	50%	57%	50%	**67%**
Man-Power dedicated for Biomedical Waste	100%	80%	100%	100%	60%	60%	20%	20%	40%	40%	**62%**
Training for Biomedical Waste	100%	100%	100%	100%	80%	80%	0%	0%	20%	20%	**60%**
Waste Segregation	100%	100%	83%	83%	100%	100%	83%	100%	100%	100%	**95%**
Treatment & Disposal	83%	83%	83%	83%	33%	33%	33%	33%	50%	50%	**57%**
Management of different waste streams	90%	90%	86%	86%	71%	71%	67%	67%	71%	71%	**77%**
Overall Score of Area	**94%**	**86%**	**90%**	**87%**	**71%**	**68%**	**43%**	**45%**	**56%**	**55%**	

Table 2 Hypothesis testing

Hypothesis	t-value	P value	Results
(Process and Practices)			
H_{a1}: There is a significant difference between the Biomedical Waste Management process and Practice adopted by the Private vs Government sector hospital.	4.947	.000	Accepted
H_{a2}: There is a significant difference between the basic tools available for Biomedical Waste Management at Private vs Government sector hospital.	3.665	.006	Accepted
H_{a3}: There is a significant difference between the manpower dedicated to Biomedical Waste Management at Private vs Government sector hospital.	4.838	.001	Accepted
H_{a4}: There is a significant difference between the training provided to healthcare workers for Biomedical Waste Management processes followed at Private vs Government sector hospital.	11.952	.000	Accepted
H_{a5}: There is a significant difference between the waste segregation techniques used for Biomedical Waste Management at Private vs Government sector hospital.	-.253	.807	Rejected
H_{a6}: There is a significant difference between the treatment and disposal technique used for Biomedical Waste at Private vs Government sector hospital.	2.158	.069	Rejected
H_{a7}: There is a significant difference between the Management of different Biomedical Waste streams at Private vs Government sector hospital.	3.485	.012	Accepted
(Awareness among Healthcare Personnel)			
H_{a8}: There is a significant difference between the awareness of Biomedical Waste Management process and practice among healthcare workers at Private vs Government sector hospital.	15.239	.000	Accepted
H_{a9}: There is a significant difference between the awareness of Biomedical Waste Management process and practices among healthcare workers in different Private sector hospitals.	-.363	.718	Rejected
H_{a10}: There is a significant difference between the awareness of Biomedical Waste Management process and practice among healthcare in different Government sector hospitals.	-.147	. 884	Rejected

The results of the fourth hypothesis show that government hospitals don't have a structured training program to sensitise their healthcare workers about the criticality of the issue. Although, fifth research hypothesis highlights that the segregation techniques used by both government and private sector hospitals are similar. Again, biomedical waste collected from hospitals is treated in a similar way at both the hospitals, as Pune Municipal Corporation has given tender to PASSCO for collection and disposal of biomedical waste from every hospital in Pune city.

The seventh research hypothesis highlights that private sector hospital has predefined the steps to be taken after needle-stick injury, where to report after injury and record it. They are managing their disposal chain such efficiently that no two-different categories of waste are intermixed with each other.

On analyzing the survey results it was identified that healthcare staff at both private and government sector hospitals are unequally aware of the biomedical waste management practices. The healthcare workers at government hospital aren't trained properly, their superior inform them of the basics and rest they observe and practice. There is no separate formal training program running for them. Although, healthcare workers at government hospital get slowly aware of all the biomedical waste management practices they don't comply with it. The behavior and attitude play a major role for someone to follow any particular instruction. If sufficient motivation isn't timely imparted to an individual, he/she becomes complacent in his current state and fails to perform his duty religiously. At times it is also observed having knowledge of the process doesn't necessarily mean it will be practiced by an individual.

4.3 Questionnaire Analysis

4.3.1 Have you been trained in Bio-Medical Waste Management Practice?

As illustrated in Figure 1, it was found out that in private hospital all the staff is trained and in government hospital, more than 90% of the staff said that they were trained in bio-medical waste management practice. Thus, it can be interpreted from the results that most of the staff is trained whether it is a private or government hospital. But this training might be done at any place from their graduate school to the previous employer. However, every hospital should frame a policy of regular training of its employee on biomedical waste management practices as laid down in the mandate released by the government of India.

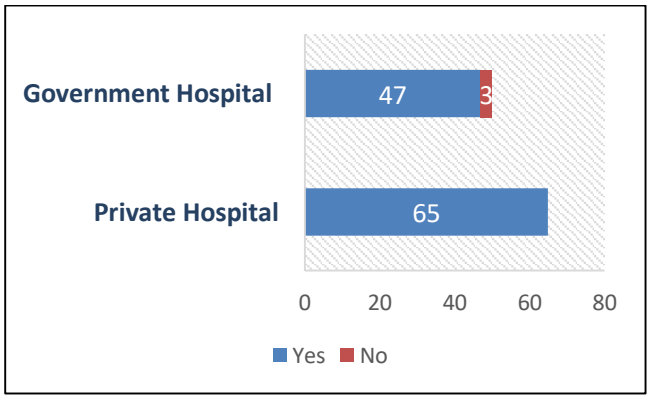

Figure 1 Biomedical waste management training

4.3.2 At which place did you receive your training?

Results showed that almost all the workers in private hospital are trained through special training sessions organised by the hospital authorities (Figure 2). The problem is with the government hospital where few said training was inside the hospital and organised by hospital authorities. Other section told that it happened outside the hospital it means either they were trained during their internship at other hospitals or were experienced nurses coming from the different hospital. But the problem is 16% of the workers told they didn't receive any professional training from the hospital authorities, they were just told by their senior staff what to do and they are following that. The government hospital is not focussed towards training their healthcare workers on bio-medical waste management practice.

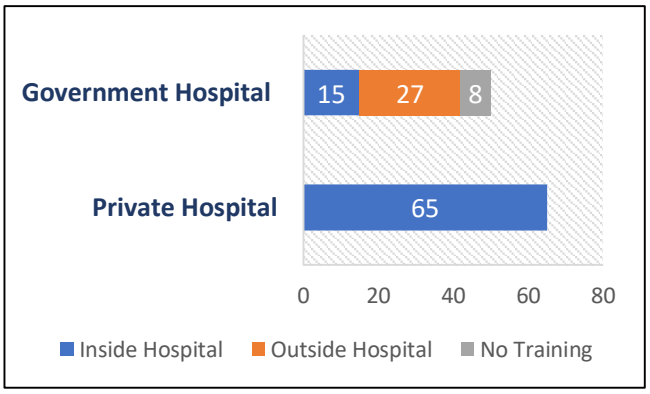

Figure 2 Biomedical waste management training location

4.3.3 What was the duration of Training Period?

The results as indicated in Figure 3 showed that the private sector hospital runs a standard format of training their healthcare workers for almost a week. In government sector hospital there is a huge variation in training duration. For some healthcare workers, it was an internship period under which they were trained that runs for either a month or a quarter before they were inducted as permanent staff. But again for 46% of the healthcare staff says it runs for less than a week. Private sector hospitals have a predefined training set for a week and in a government hospital, they don't have a training module run by authorities but they include internship of their healthcare workers as the training period. In a private hospital, these training are repeated yearly but in a government hospital, it is never getting repeated and retrained.

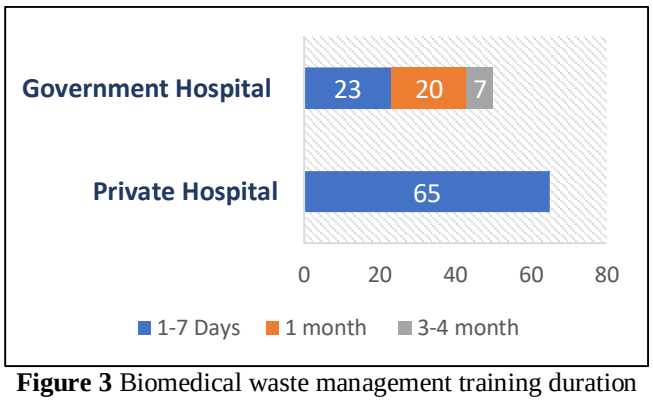

Figure 3 Biomedical waste management training duration

4.3.4 Is medical waste segregated?

As indicated in Figure 4, the results show that there a is proper segregation of the biomedical waste generated in the private hospital and the government hospital as well this segregation takes place. The hospitals have taken the initial effort of segregation takes place and there are well-defined dustbins where this waste can be put in. Segregation is critical as a different type of waste has a different disposal chain. Most of the hospitals in Pune have a tie-up with POSCO for disposal of the waste generated in the hospital. Figure 4 illustrates the answers of the respondents regarding the waste segregation in both government hospital and provate hospitals.

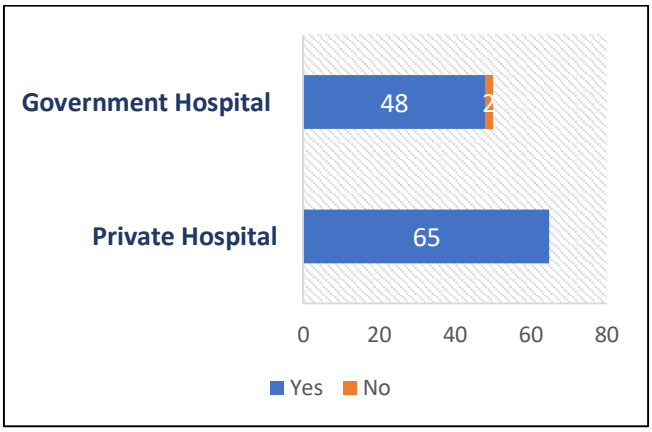

Figure 4 Biomedical waste segregation

4.3.5 Who segregates medical waste?

For the private hospital, it is clear that the Medical staff segregate the biomedical waste at the source of generation (Figure 5). But in the government hospital, few say that it is the responsibility of medical staff and others say it is the duty of cleaning workers and also there were mixed responses that it is the duty of both to segregate waste. The varied results obtained in case of government hospital is because of the fact that in a few wards of government hospital there aren't present different coloured dustbin wherein different type of biomedical waste can be put in. So, at such wards, the biomedical waste is collected in common bin and is later on segregated while disposing of in the bin.

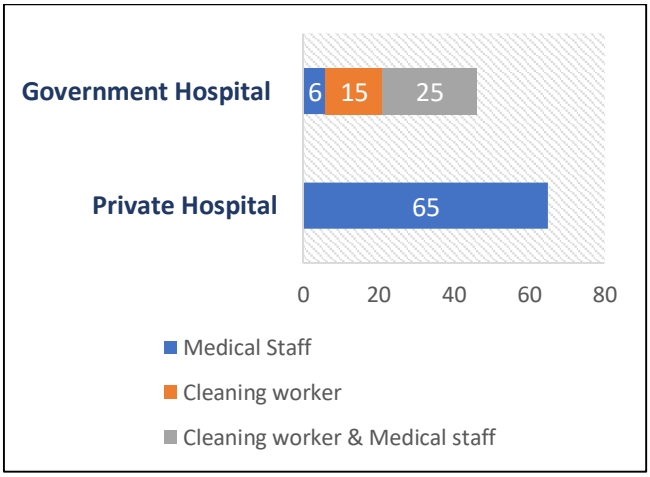

Figure 5 Biomedical waste segregation resources

4.3.6 At which place segregation of medical waste starts?

It was found that in private hospital the biomedical waste is segregated at the beginning near the source of generation whereas in the government hospital most of the segregation happens by cleaning staff after all the waste is collected. Because waste collection dustbins of different types aren't there at the source of generation at government hospital so mostly waste gets segregated after it is collected. As per the rule in the biomedical waste management Act, the waste should be segregated at the source of generation only. The staff should be well trained in segregation of the waste.

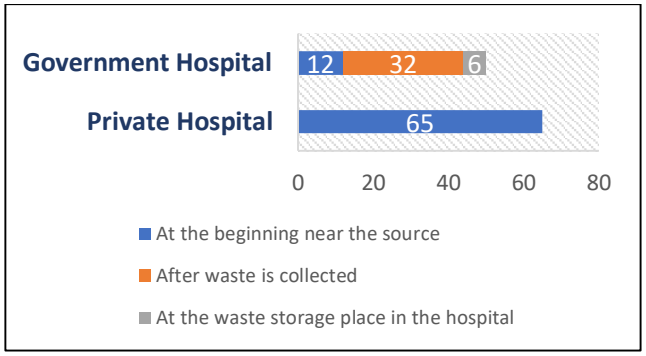

Figure 6 Location of biomedical waste segregation

4.3.7 Are containers identified & distinguished properly?

As shown in the graph all private sector hospital focus on labelling bins properly whereas government hospitals aren't that concerned about labelling. Because waste collection dustbins of different types aren't there at the source of generation in a government hospital. Identification forms a critical parameter in segregation of waste. If containers aren't differentiated properly the entire disposal chain could get disturbed. Hence, proper labelling, colour coding of dustbins, & sign board should be there for staff to identify & dispose of waste easily.

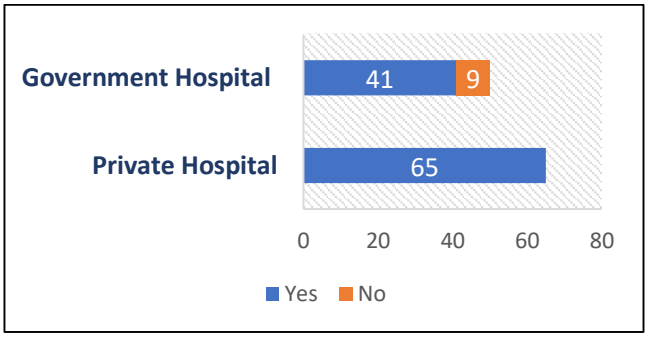

Figure 7 Identification of disposal container

4.3.8 Is biomedical waste storage facility specially marked in the hospital?

Results show that in private hospital it is marked properly but not in a government hospital. The casual attitude can be a reason for government hospital not following such guidelines laid down by the biomedical waste management law. Identification of storage facility is a must for easy movement of waste from the hospital ward to the disposal area. It also creates easy identification for waste collection truck to point out waste collection zone while visiting the hospital for biomedical waste collection.

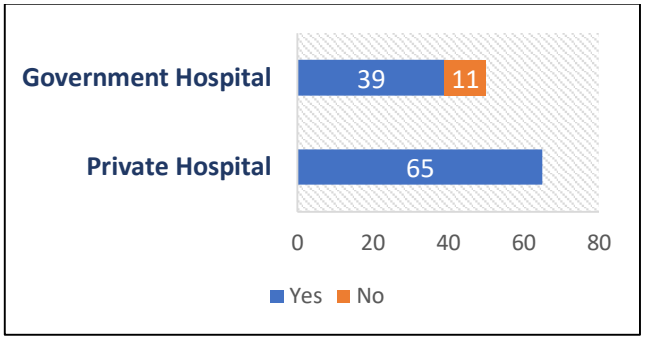

Figure 8 Demarcation of storage facility

4.3.9 Human body parts, organs, blood contaminated cotton, body fluid, cytotoxic drugs, blood bags etc. should be disposed of in?

Results show that in private hospital healthcare worker are aware of this fact but in a government hospital, unsatisfactory results were obtained. Government hospital needs to be careful about this fact as it can cause catastrophic damage at later stages and they need to train their healthcare workers on this. A signboard should be kept in every ward of the hospital for staff to easily identify which biomedical waste to be disposed of in which container. This avoids any kind of confusion that can happen because of waste disposal.

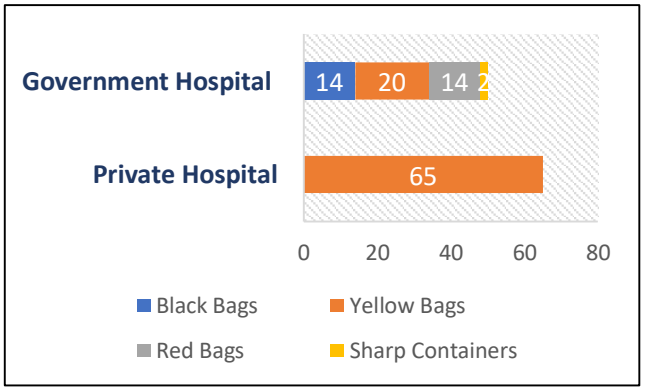

Figure 9 Yellow bag disposal

4.3.10 Waste generated from disposable items (other than waste sharps) such as tubes, catheters, gloves, IV sets, all types of plastic waste etc. should be disposed of in?

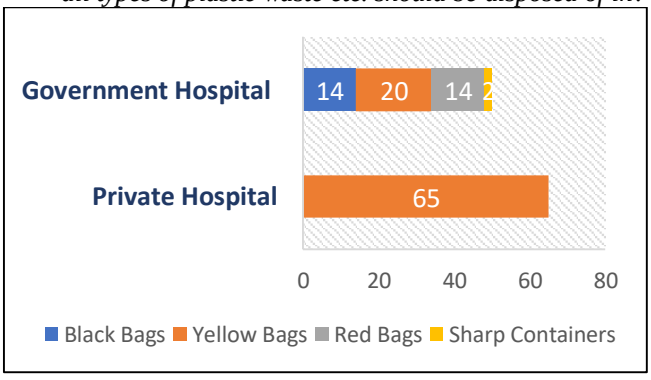

Figure 10 Blue bag disposal

For this category, private sector hospital needs to be cautious as people are confused between blue and red bags. But when we see the results of government sector hospital,

they are confused too much. Again, the healthcare professional of both government and private sector needs to be retrained on this. A signboard should be kept in every ward of the hospital for staff to easily identify which biomedical waste to be disposed of in which container. This avoids any kind of confusion that can happen because of waste disposal.

4.3.11 Needle, Syringes, scalpels, blades, or any other sharp object shall be disposed of in?

Results show that in private hospital healthcare worker are aware of this fact but in a government hospital, unsatisfactory results were obtained. Government hospital needs to be careful about this fact as it can cause catastrophic damage at later stages and they need to train their healthcare workers on this. Needle prick injury will be a concern every time waste is placed in the wrong bag. A signboard should be kept in every ward of the hospital for staff to easily identify which biomedical waste to be disposed of in which container. This avoids any kind of confusion that can happen because of waste disposal.

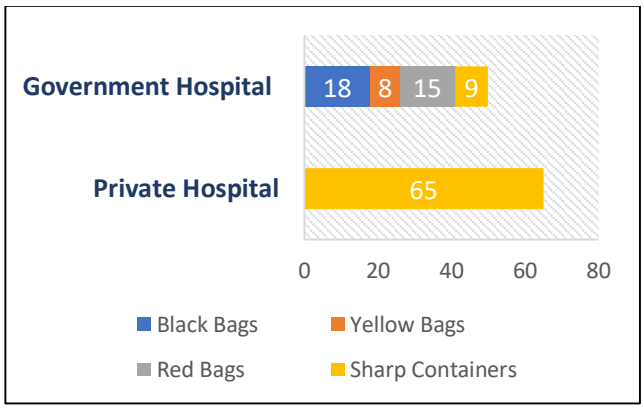

Figure 11 Sharp container disposal

4.3.12. Where should be normal waste disposed of in?

Results show that in private hospital healthcare worker are aware of this fact but in a government hospital, unsatisfactory results were obtained. Government hospital needs to be careful about this fact as it can cause catastrophic damage at later stages and they need to train their healthcare workers on this. A signboard should be kept in every ward of the hospital for staff to easily identify which biomedical waste to be disposed of in which container. This avoids any kind of confusion that can happen because of waste disposal.

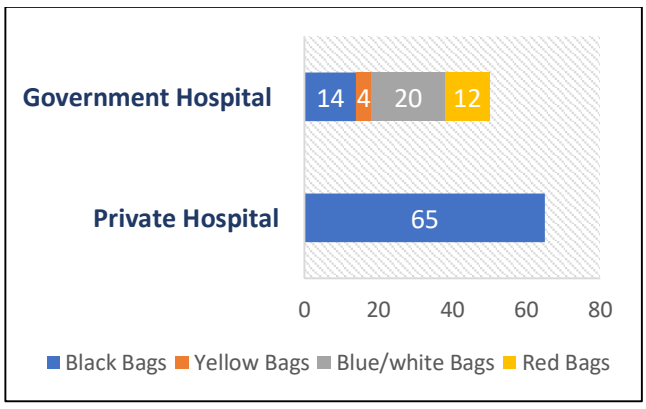

Figure 12 Black Bag Disposal

4.3.13 Bio-Medical waste management rules were proposed in which year?

Results show that healthcare staff of both the institute whether it is private or government are confused by the answer to this question. It is good if the healthcare person knows the answer to this question but it is not mandatory as laid down by the rules. This points out the way in which hospital staff is educated for the concept. A proper training department should be made in all hospitals to regularly train staff on biomedical waste management process & practice.

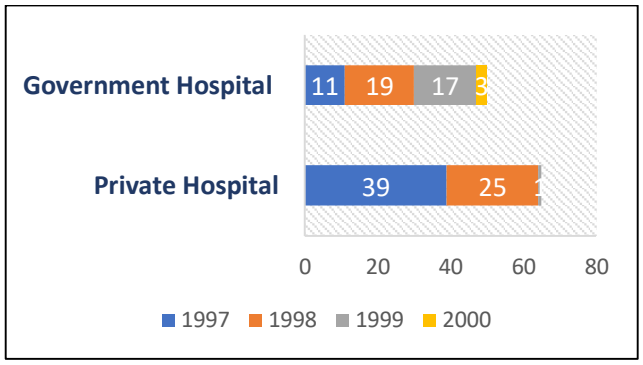

Figure 13 Biomedical waste management rule proposal year

4.3.14 Latest amendments to Bio-Medical Waste Management were made in?

Results show that healthcare staff of both the institute whether it is private or government are confused by the answer to this question. It is good if the healthcare person knows the answer to this question but it is not mandatory as laid down by the rules. This also points to awareness among the staff about biomedical waste management practice. Regular training of hospital staff is to get regularly updated with any amendments that are made in the biomedical waste management Act.

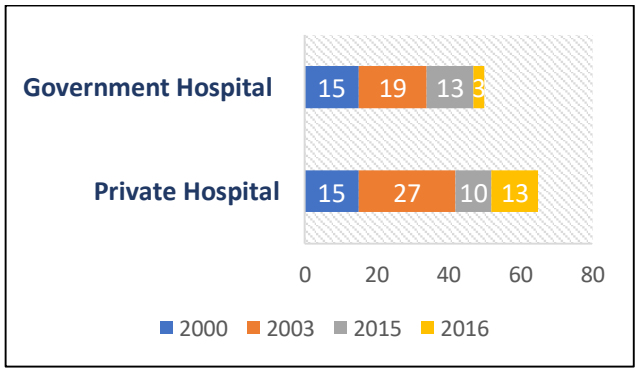

Figure 14 Biomedical waste amendment year

4.3.15. According to BMW management rules, waste should not be stored for a certain maximum period

Results show that healthcare staff of both the institute says it should not be more than 12hrs or 24 hrs, the rule says it should not be more than 48 hrs. Hence all hospitals are taking care of disposing of waste as early as possible. Hospitals have a fixed time of collection of waste from every ward which is usually once a day. Hence, this a good practice which is followed by the hospital.

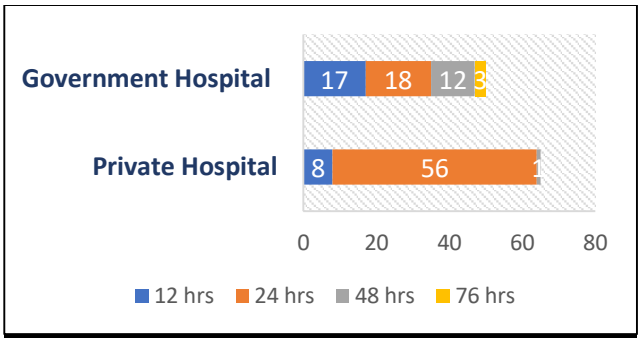

Figure 15 Biomedical waste storage time

4.4 Process Flow Chart: Bio-Medical Waste Disposal Chain

The process flow shown below highlights the different stages through which the Bio-Medical waste generated at the hospital goes for disposal. The waste is categorised into liquid & solid waste. The liquid waste goes to the effluent treatment plant, inside the hospital, for treatment and the treated water is discharged into sewage. The second type of waste is solid waste. The solid waste is further categorised & collected in three different colour bags. All the solid waste related glasses like broken or discarded ampoules & vials is put into a blue box. The solid waste generated due to tubing, IV sets, catheters, urine bags, syringes (without needle & fixed needle syringes) and vacutainers with the gloves is discarded into a red bag. The final category of solid waste which consists of Human body parts is discarded into a yellow bag.

These different colour solid waste bags after getting filled with Bio-medical waste are stored at a pre-designated location outside the hospital. Every day these waste bags are collected and disposed of. The blue colour bag which contains small glass pieces goes to Municipal Corporation for disposal after getting properly disinfected by sodium hypochlorite. The remaining two bags of red & yellow colour have special disposal mechanism, there is a special agency, PASSCO, in Pune which takes care of its disposal mechanism. The red bag along with waste is Autoclaved while yellow bag along with waste is incinerated at the burial site of PASSCO.

5. CONCLUSION

Biomedical waste management Act provides comprehensive guidelines about various aspects of waste management. It has made the categorization, segregation, storage, transport and disposal of various types of waste clear. In Pune, most of the hospitals are aware of the latest amendments and are following the act. Frequent training of healthcare workers can help reduce errors. Hospitals will have to make this priority along with other activities. Although the situation in government hospitals and small clinics are not up to the desired standards of the Bio-Medical waste management act, the authorities at these facilities have to make sure that the latest rules are strictly followed. Results show that there is an advert need to properly train healthcare workers in government hospitals and make sure that healthcare workers are aware of the criticality of the issue.
The government hospitals should pay considerable importance to the issue and develop efficient segregation, collection, transportation and storage disposal chain of Bio-Medical Waste. After that, it is must to incinerate the biomedical waste to stop the outbreak of any disaster. The hospital authorities should have their in-house incineration arrangement or tie up with the third party to ensure proper disposal of waste. Proper labelling of all bins for collecting waste and storing arrangement must be done to ensure unhindered flow in the disposal chain. The regular training and continuing education of healthcare personnel are must impart attitude among healthcare workers to follow processes laid down by the medical authority of India. Hospitals have to adopt supply chain basic principles to this disposal chain for its effective management.

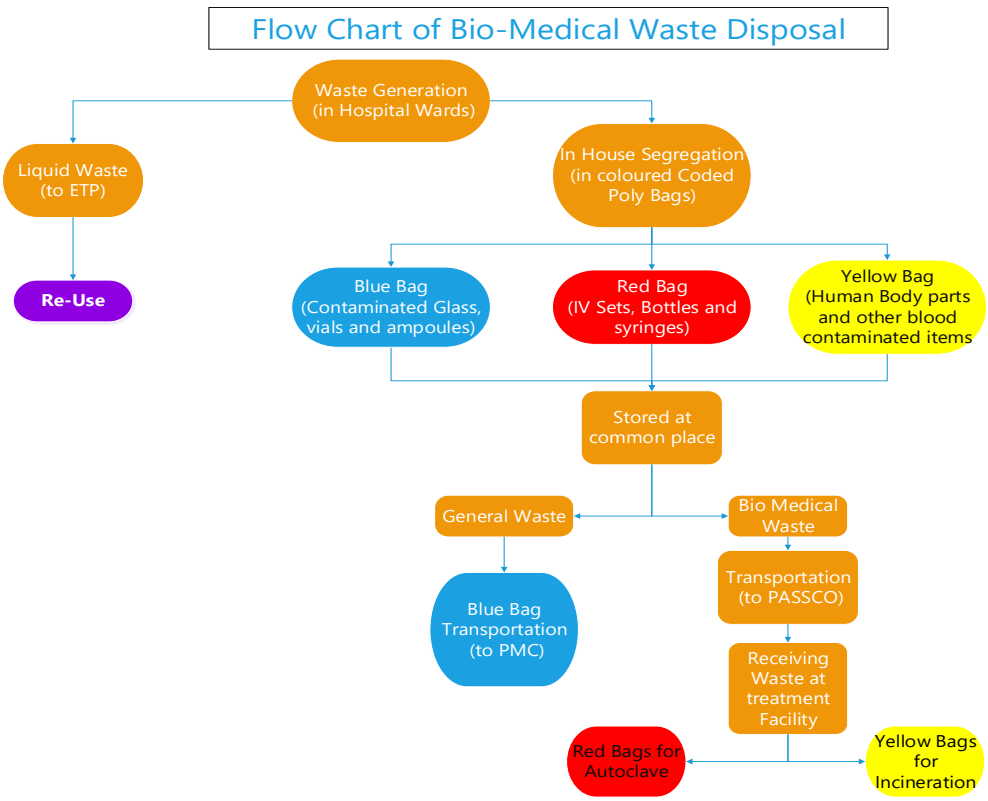

Figure 16 Flow chart of biomedical waste disposal

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APPENDIX 1: BASIC REQUIREMENT FOR BIOMEDICAL WASTE

In Q-1: Adequate no. of BMW Bins as per BMW guideline (Red, Yellow, Blue, Black & Green)?
In all the 6 visit to Private Hospital-1 in Wards Results were observed- "Satisfactory".
Hence the question was assigned one as 50% or more observations were found satisfactory.
Similar observations were done for each hospital for both Wards & ICU for all the questions under all six parameters.
The average score mentioned under each parameter is calculated using descriptive statistics.
At Private Hospital-1 in ward area, the average score is calculated by using formula

$$(1+1+1+1+1+0+1+1+1+1+1+1+1+1) / 14 = 0.93$$

Also, At Private Hospital-1 in ICU area, the average score is calculated by using formula

$$(1+1+1+0+1+0+1+0+0+0+1+1+1+1) / 14 = 0.64$$

Similar Calculations were made at Wards & ICU of each hospital.

Table 1 Basic requirement for biomedical waste

Basic Requirement for Biomedical Waste		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/No	ICUs Yes/No
1	Adequate no. of BMW Bins as per BMW guideline (Red, Yellow, Blue, Black & Green)	1	1	1	1	1	1	1	1	1	1
2	Puncture proof Containers for sharps	1	1	1	1	1	1	1	1	1	1
3	Mutilators (Needle cutters/Syringe Cutter)	1	1	1	1	1	1	1	1	1	1
4	Calibrated Weighing Machine for BMW	1	0	0	0	0	0	0	0	0	0
5	Use of Personal Protective Equipment (Gloves, Caps, Masks, Aprons & Gum boots etc)	1	1	1	1	1	1	1	1	1	1
6	Use of Disinfectant (1% hypochlorite) or Bleaching solution	0	0	1	1	1	0	0	0	0	0
7	BMW Record Register	1	1	1	1	1	1	1	1	1	1
8	Mercury Spill Management Kits	1	0	0	0	0	0	0	0	0	0
9	Blood Spill Management Kits	1	0	1	0	0	0	1	0	1	0
10	Post Exposure Prophylaxis Kits	1	0	1	0	1	0	0	0	0	0
11	BMW Storage with Lock & Key	1	1	1	1	1	1	1	1	1	1
12	BMW Licenses under MPCB (Maharashtra Pollution Control Board)	1	1	1	1	1	1	1	1	1	1
13	Incident Reporting Format (Needle Stick Injury, Blood exposure etc))	1	1	1	1	1	1	0	0	0	0
14	Steps to follow after Exposure	1	1	1	1	1	1	0	0	0	0
	Average	**0.93**	**0.64**	**0.86**	**0.71**	**0.79**	**0.64**	**0.57**	**0.50**	**0.57**	**0.50**

APPENDIX 2: MAN POWER DEDICATED TO BIOMEDICAL WASTE

Table 2 Man power dedicated to biomedical waste

Man Power dedicated to Biomedical Waste		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/No	ICUs Yes/No	Wards Yes/No	ICUs Yes/No	Wards Yes/No	ICUs Yes/No
1	Available of a trained dedicated person for BMW Management	1	1	1	1	0	0	0	0	1	1
2	Trained and skilled BMW person for BMW Collection & Transportation	1	1	1	1	1	1	1	1	1	1
3	Dedicated and Trained Infection Controlled Nurse	1	0	1	1	0	0	0	0	0	0
4	Dedicated department to handle BMW	1	1	1	1	1	1	0	0	0	0
5	Floor managers to manage proper disposal at the point of generation	1	1	1	1	1	1	0	0	0	0
Average		**1.00**	**0.80**	**1.00**	**1.00**	**0.60**	**0.60**	**0.20**	**0.20**	**0.40**	**0.40**

APPENDIX 3: TRAINING FOR BIOMEDICAL WASTE

Table 3 Training for biomedical waste

Training for Biomedical Waste		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/No	ICUs Yes/No	Wards Yes/No	ICUs Yes/No
1	Availability of Training Department for BMW Management training	1	1	1	1	0	0	0	0	1	1
2	Trainings for Nurses disposing BMW at the point of generation	1	1	1	1	1	1	0	0	0	0
3	Trainings to other staffs (Housekeeping) to collect BMW	1	1	1	1	1	1	0	0	0	0
4	Trainings to BMW Department to update as per guidelines	1	1	1	1	1	1	0	0	0	0

Training for Biomedical Waste		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/No	ICUs Yes/No	Wards Yes/No	ICUs Yes/No
5	Monthly/Weekly Training schedules	1	1	1	1	1	1	0	0	0	0
Average		**1.00**	**1.00**	**1.00**	**1.00**	**0.80**	**0.80**	**0.00**	**0.00**	**0.20**	**0.20**

APPENDIX 4: WASTE GENERATION

Table 4 Waste generation

Waste Generation		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No
1	Is the waste disposed at the point of generation?	1	1	1	1	1	1	0	1	1	1
2	Is the sharp infection waste (needles, blades, broken glass etc) are disposed of in Blue puncture-proof containers?	1	1	1	1	1	1	1	1	1	1
3	Is the sharp infectious material (infected plastics, syringe, dressing, gloves, masks, blood bags & urine bags) are disposed of in Red plastics bins or bags?	1	1	0	0	1	1	1	1	1	1
4	Is Anatomical Infectious waste (Placenta, body parts) are disposed in Yellow bags?	1	1	1	1	1	1	1	1	1	1
5	Is general waste (syringes and needles wrapper, packing materials etc) are disposed of in Black bins?	1	1	1	1	1	1	1	1	1	1
6	Is the kitchen waste are disposed in Green bins?	1	1	1	1	1	1	1	1	1	1
Average		**1.00**	**1.00**	**0.83**	**0.83**	**1.00**	**1.00**	**0.83**	**1.00**	**1.00**	**1.00**

APPENDIX 5: TREATMENT & DISPOSAL

Table 5 Treatment and disposal

Treatment & Disposal		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
S.NO	Particulars to Check	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No	Wards Yes/ No	ICUs Yes/ No
1	Is the BMW Disinfected or Mutilated before final disposal?	1	1	1	1	0	0	0	0	0	0
2	Is the Anatomical waste to be kept buried/incinerated ?	1	1	1	1	1	1	1	1	1	1
3	Are the syringes being cut & chemically disinfected with 1% sodium hypo chloride solution at the source of generation before final disposal?	1	1	1	1	0	0	0	0	0	0
4	Are the infected plastics to be chemically disinfected or autoclaved, shredded & send for final disposal?	1	1	1	1	0	0	0	0	1	1
5	Is the general waste are chemically disinfected before final disposal?	0	0	0	0	0	0	0	0	0	0
6	Is there any separate area for BMW disposal and treatment?	1	1	1	1	1	1	1	1	1	1
	Average	**0.83**	**0.83**	**0.83**	**0.83**	**0.33**	**0.33**	**0.33**	**0.33**	**0.50**	**0.50**

APPENDIX 6: MANAGEMENT OF DIFFERENT WASTE STREAMS

Table 6 Management of different waste streams

Management of different waste streams		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
1	Is there any sharp injury reporting format in the hospital?	1	1	1	1	0	0	0	0	0	0
2	Is the staff aware of PEP?	1	1	1	1	1	1	0	0	1	1
3	Is the staff vaccinated to Hepatitis B & tetanus vaccine?	1	1	1	1	1	1	1	1	1	1
4	Is the sharp injury reported within 7 hours of exposure?	1	1	1	1	0	0	0	0	0	0
5	Does the staff take all measures of safety (such as gloves, marks etc.) before final disposal?	1	1	1	1	1	1	1	1	1	1
6	Is the practice of recapping or bending of needles done by staffs?	1	1	1	1	1	1	1	1	1	1
7	Is sharp is mixed with other waste?	1	1	1	1	1	1	1	1	1	1

Management of different waste streams		Private Hospital 1		Private Hospital 2		Private Hospital 3		Government Hospital 1		Government Hospital 2	
8	Is the infectious waste mixed with non-infectious waste?	1	1	1	1	1	1	1	1	1	1
9	Is the vials and ampoules disposed in sharp containers?	1	1	1	1	1	1	1	1	1	1
10	Is the waste disposed in different coloured plastic bags?	1	1	1	1	1	1	1	1	1	1
11	Is the infected plastic burned after disposal for treatment?	1	1	1	1	0	0	0	0	0	0
12	Is the final Black bin waste given to third party?	1	1	1	1	1	1	1	1	1	1
13	Is the final Yellow bin waste given to the third party?	1	1	1	1	1	1	1	1	1	1
14	Is the final Blue bin waste given to third party?	1	1	1	1	1	1	1	1	1	1
15	Is the final Red bin waste given to third party?	1	1	1	1	1	1	1	1	1	1
16	Is the final Green bin waste given to third party?	1	1	1	1	1	1	1	1	1	1
17	Is there any separate ways to handle Cytotoxic drug waste?	1	1	0	0	0	0	0	0	0	0
18	Does the hospital personnel visit the final disposal site to monitor proper disposal?	0	0	0	0	0	0	0	0	0	0
19	Is the institute uses Incinerators?	1	1	1	1	1	1	1	1	1	1
20	Is the handwashing practices followed after every disposal process?	1	1	1	1	1	1	1	1	1	1
21	Is the information of BMW disposal practice and amount generated available on their website?	0	0	0	0	0	0	0	0	0	0
	Average	**0.90**	**0.90**	**0.86**	**0.86**	**0.71**	**0.71**	**0.67**	**0.67**	**0.71**	**0.71**

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