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AN ANALYSIS OF HEALTHCARE FACILITY BIOWASTE AND LEAN SIX SIGMA-BASED IMPROVEMENTS FOR MANAGEMENT

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Abstract

This study analyzes bio-waste generated in hospitals to comprehensively understand its types, quantities, and associated environmental and public health risks. Through a systematic examination of relevant literature and data, it explores various origins and categories of hospital bio-waste, including medical, sharps, and pharmaceutical waste. The research scrutinises bio-waste management strategies employed by hospitals, emphasising both their advantages and disadvantages. Recognising hospitals as pivotal waste generators, the study underscores their role in formulating efficient waste management protocols to ensure safety, reduce environmental impact, and foster eco- friendly practices. Furthermore, the project employs Lean Six Sigma approaches to enhance the cost-effectiveness of bio-waste disposal in hospitals. By identifying and minimising waste, streamlining processes, and improving overall efficiency, this strategy aims to lower disposal costs, optimise resource utilisation, and promote sustainability in healthcare settings. The study draws insights from a reputed private hospital in Tamil Nadu, India, utilising the DMAIC technique to assess waste across various hospital departments. The research provides valuable insights into applying lean methodologies in healthcare waste management, offering practical guidance for businesses seeking to enhance their bio- waste disposal practices.

Keywords: Healthcare waste management, Lean Six Sigma, DMAIC technique.

1. Introduction

India generates the world's highest amount of solid waste from cities. India produced an estimated 277.1 million tonnes of waste in 2016, and is expected to generate 387.8 million tonnes in 2030 and 543.3 million tonnes in 2050. During the peak of the COVID-19 pandemic in May 2021, 33% of the biomedical waste generated in India was related to the virus. The biological waste treatment system, already overwhelmed, seems to have been strained further by this.[1], [2], [3]. Based on available statistics, India generated 56,000 metric tonnes of biomedical waste as a result of COVID-19 between June 2020 and June 2021[4]. A rough estimate based on information obtained by the CPCB through the BWM App indicates that in the year before May 10, 2021, 45,954 tonnes of COVID-19 waste were generated nationwide. The nation has produced 126 tonnes of COVID-19 waste every day since the pandemic's first wave, or around 20% of the 614 tonnes of biomedical waste produced at any one moment[5], [6].

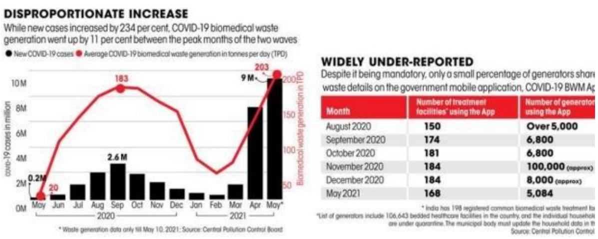

Fig. 1. Increase in Biowaste during COVID-19 [7]

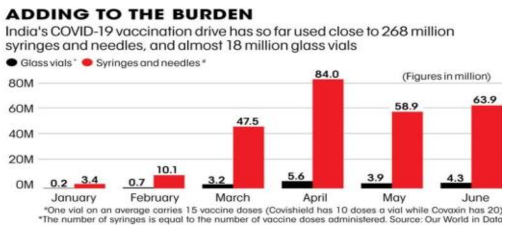

Fig. 2. Increase in Glass vials, syringes, and needles during COVID-19. [7]

In a situation like this, it's critical to understand the goal of Lean Healthcare: to adapt to the ever-changing healthcare landscape by providing high-quality, flexible, and affordable care at the right time—all of which are first steps toward high efficiency. However, due to differences within the hospital, it may be difficult to determine which lean tools, if any, to deploy in specific situations while adhering to their principles. Healthcare must be made more effective and of higher quality while keeping costs down. Lean methodology, which is applied in assembly lines, may also be utilised in the healthcare industry to streamline complex networks that are present in both clinical and non-clinical domains of the industry[8]. First and foremost, we want to cut waste management expenses. Lean Six Sigma combines the administrative concepts of Lean and Six Sigma. While Six Sigma concentrates on enhancing interaction yield quality by locating and removing error sources and minimising process changeability, Incline often focuses on minimising the eight types of waste (or "muda"). Keeping in mind that hospitals are one of the biggest generators of trash, they are in a unique position to create, implement, and model appropriate waste management processes that keep patients and staff safe, reduce environmental damage, and encourage ecologically friendly practises[10]. The goal of this project is to reduce the cost of hospital biowaste disposal using Lean Six Sigma. The Hospital hosted the implementation of this initiative, and data were collected to improve knowledge of lean healthcare. DMAIC was used in its implementation. The adoption of VSM, SIPOC, and root cause analysis was a further lean technique. The Central Pollution Control Board stated in a 2020 document submitted to the National Green Tribunal that 101 metric tonnes of India's 609 metric tonnes of healthcare waste consisted of COVID-19 medical waste every day. Typical clinical facilities used to dispose of between half a kilogram and three-quarters of a kilogram of hazardous materials per patient station every twenty-four hours prior to the global health crisis. The current production of BMW has increased to 2.5–4.5 kg[11]. To ease the load on incinerators designed to handle BMW waste, this research suggested separating general waste from BMW waste. The authors sought to compile pertinent issues arising from COVID-19 waste and presented the best solutions to mitigate them. The primary goal of Six Sigma is to reduce variability in processes and products through design for Six Sigma (DFSS), a design/redesign technique and a continuous improvement methodology. The former goes through the following stages: control, measure, analyse, improve, and define. The DMAIC technique is the name of this strategy, which is used in current products and processes. However, when designing or redesigning processes or products, design for six sigma uses the IDOV (identify, develop, optimise, and verify) technique.

Table 1. State-wise waste generated from June 2020 to June 2021 [9]

State	**Waste (in tonnes)**
Maharashtra	8317
Kerala	6442
Gujarat	5004
Tamil Nadu	4835
Delhi	3995
Uttar Pradesh	3881
Karnataka	3133

2. Methodology and Experimental Work

The research was conducted in two sequential stages: the first focused on identifying and formulating the problem statement, and the second employed the DMAIC (Define, Measure, Analyse, Improve, Control) methodology to implement real-time data collection at that hospital. Throughout these stages, a systematic approach was adopted, involving the execution of specific procedures corresponding to each phase of the DMAIC framework.

Define Phase: Defines the issue and establishes the project's objectives. Reducing operational costs, increasing efficiency, and ensuring compliance with waste-disposal standards are the main goals in biomedical waste-disposal cost reduction. The scope, stakeholders, and project schedule are all defined at this phase as well.

Measure Phase: The goal of the Measure phase is to gather relevant data to help researchers better understand how the biomedical waste disposal process currently operates. Metrics may include the amount of waste generated, the disposal cost, and the time required for disposal. This information offers a starting point for assessing performance.

Analyse Phase: During this stage, the team will find the main reasons for the high disposal costs. Process mapping, value stream analysis, and statistical methods may be used in this to identify inefficiencies. Overuse of disposable products, ineffective waste segregation, or poor disposal techniques are all potential contributing reasons.

Implementing remedies to address the identified concerns is part of the improvement phase. This can involve implementing Lean and Six Sigma concepts, such as process improvement, waste minimisation, and staff training in efficient waste disposal. Consideration may also be given to working with suppliers to develop cost- and eco- efficient disposal techniques.

Control: The team creates tactics to maintain improvements during the Control phase. To ensure ongoing adherence to the optimized waste disposal process, implement monitoring systems, develop standard operating procedures, and develop training programmes. To monitor continuing performance, regular audits and feedback methods have been implemented.

2.1 Technical Specifications

The purpose of this project is to use Lean Six Sigma to lower the cost of disposing of biomedical waste produced in the healthcare industry. Growing patient numbers put strain on the work environment, and the Lean tool helps relieve that strain. To eliminate non- value-added jobs, reduce waste, lower process errors and variability, and improve process dependability and agility, the healthcare industry adopted Lean Six Sigma. Six principles—a continuous improvement attitude, value creation, unity of purpose, respect for front-line workers, visual tracking, and flexible regimentation—represent the basic dynamics of lean management. This lowers expenses while enhancing the effectiveness and quality of treatment. This improves the efficacy and calibre of care while reducing costs. Lean healthcare and lean production have parallels that suggest potential benefits. The need to do more with less appears to have been the driving force for lean in the healthcare industry. To develop a good or service, both healthcare and production involve several divisions, lengthy, sequential, complex procedures with variable process durations, lineups, and resource sharing.

2.1.1 Methods

Care must be taken when managing waste from coronavirus containment units. To reduce contamination, items that come into contact with an infected individual's bodily fluids must be disposed of in hands-free, colour-coded containers designated for viral pathogens. Furthermore, regular waste should be collected separately from medical waste. Personal hygiene items, face masks, and napkins used by individuals infected with the virus likely contain respiratory secretions; therefore, they should be disposed of in amber-coloured trash bags for proper incineration.

Trash produced in home care or home quarantine facilities: Patients with COVID-19 who are classified as extremely mild, presymptomatic, or asymptomatic may be kept at home in isolation. General trash is divided into three categories: biodegradable, non- biodegradable, and household hazardous waste, as stated in the 2016 SW guidelines. Both biodegradable and non-biodegradable waste should be disposed of in specially coloured bags, which are picked up by ULBs or the municipality's solid waste collection service. General waste from COVID-19 patients receiving home care or in-home quarantine should be classified as general solid waste. The only materials that should be disposed of as biomedical waste are used masks, gloves, tissues, or swabs contaminated with blood or bodily fluids of COVID-19 patients. In addition to the ones already mentioned, this protocol also covers used needles, drugs, and other supplies that are related to them. A municipal sanitation worker, specifically trained for this job, must collect the protective face coverings worn by infected people and place them in a golden-coloured biological risk pouch.

Sewage treatment facilities: Personal protective equipment (PPE), gloves, masks, and goggles should be worn by everyone working in wastewater treatment facilities and effluent treatment plants. Educating employees about universal safety measures, pulmonary hygiene, hand sanitisation, and related protocols is an important way to reduce the risk of accidental contact. During a pandemic, it is best to avoid reusing wastewater.

Diagnostic facilities, specimen collection sites, and immunisation study centres are required to adhere to stringent protocols for the management of hazardous materials. Laboratory consumables, such as blood collection tubes, viral shipment buffers, micropipette attachments, microcentrifuge vials, and nasal sampling swabs, necessitate decontamination via chemical sterilization, pressurised steam, microwave irradiation, or hydroclaving. After neutralization, these items are transferred to the crimson-coded waste stream for final disposal. Double bags should be placed in colour-coded bins operated by foot. The site supervisor is responsible for tracking the number and quantity of bags. All experimental material must first be decontaminated before being turned over to sanitation staff. For the purpose of sterilising synthetic containers, micro-capillary attachments, centrifuge vials, microbiological colonies, primary lineages, and lancets, pressurised steam sterilisation is effective. Usually, this thermal procedure calls for maintaining 121°C for at least 30 minutes while applying 15 psi.

Liquid waste disposal: All hospitals and inpatient health care facilities must construct an effluent treatment plant (ETP) on site in accordance with BMWM regulations from 2016. Institutions and people who disobey the law face penalties, such as fines and jail time. The WHO divides hospital wastewater into three categories: stormwater, greywater (sullage from laundry, washing, and laboratory activities), and blackwater (sewage). Comprehensive recording of all COVID-19- related waste is obligatory, with a stringent need for same-day processing or treatment following collection. Daily sanitisation of vehicles, trolleys, and storage areas with 1% sodium hypochlorite is required. It is recommended to update the COVID19 tracking app with the daily report.

1. Trash produced during the duration of home confinement may also be contagious. It is necessary to ensure their safe disposal.
2. Robust remediation methods are necessary for all waste generated by COVID-19-specific facilities, including intensive care units, isolation units, and quarantine sites.
3. Safe burial or cremation of deceased COVID-19 patients is required, as this is a sentimental and safety concern.
4. If sewage lines malfunction, the virus that is shed in faeces may contaminate drinking water. Human exposure to sewage aerosol can occur during sewage overflows during periods of severe rainfall or flooding. The long- term effects of COVID-19 viral shedding in patient faeces are also a cause for concern, as it affects the ecosystem.
5. Increasing the use of detergents, liquid soaps, biocidal chemicals, or just plain water to wash infected materials poses a risk to water bodies during the COVID-19 pandemic.
6. The environmental consequences resulting from the increase in COVID-19-related waste require extensive mitigation efforts.
7. The extensive utilisation of personal protective equipment (PPE) by the general populace and non-clinical sectors—such as hospitality, corporate, and transportation personnel—has created a demographic frequently devoid of formal training in PPE protocols and the biohazardous hazards linked to improper disposal.
8. The high viral titers seen in COVID-19 diagnostic and vaccine research laboratories require rigorous biosafety standards, as any procedural errors could lead to disastrous public health consequences [12].

2.2 Design Approach Details

The method is broken down into two stages: the second involves problem resolution using Six Sigma tools,while the first uses lean tools such as SIPOC, root cause analysis, and VSM. SIPOC diagrams and VSM are lean approaches in phase one that can serve as benchmarks for other methods. The application of VSM improved healthcare productivity. After mapping the waste flow phases using the VSM, each map was produced through simulation. Material handling tasks are integrated with data streams and other pertinent linked data in VSM, a work environment proficiency tool. For any organisation embarking on a lean journey that needs to plan, execute, and improve, VSM is an essential lean tool. VSM helps customers build a robust execution plan that optimises their available resources and ensures materials and time are utilised efficiently [13]. Driver inquiry uses tools and techniques to address the root cause of a problem. When a cycle's outcomes are unfavourable, there's usually a problem at the bottom that, taken together, creates a situation and a logical chain of events that lead to unfavourable outcomes. We have attempted to achieve effective outcomes in healthcare by utilising Six Sigma. Using the gathered data, DMAIC or DMADV is applied in phase two to develop a solution. Nonetheless, because DMAIC utilises available resources, it is used in this project. When specific creative approaches are used to address the issue, DMADV is applied [14]. The efficiency of the accepted model has to be maintained and observed in the following steps. There is little doubt that society would benefit greatly from a well-thought-out, sustainable, continuous-improvement approach that emphasises value creation and improvements in hospital staff members' well- being. Tight documentation of generated trash, barcoded and GPS-tagged bags, and routine visits by SPCB and internal BMWM inspectors to check compliance at all levels are all essential components of compliance monitoring. Authorities tasked with the advancement of contemporary COVID-19 isolation and quarantine infrastructure are required to either create efficient communication pathways with licensed Common Bio-medical Waste Treatment Facilities (CBWTFs) for effective waste collection or to deploy on-site treatment systems for biomedical waste management. A nodal officer for managing biological waste should be appointed. CPCB developed the COVID19 BWM app to provide daily information on COVID-19 waste management and follow-up.

3. Result and Discussions

The DMAIC concept, a five-step process, was chosen for the case study on Lean healthcare. The case study in Lean healthcare was chosen for implementation using the DMAIC concept, a five-step process. The study was conducted at that private hospital from February to April 2022. Since its founding in 1965, the hospital has seen about 150–200 inpatients and 400– 600 outpatients per day. It has 250 patient beds and employs 830 people, including physicians, nurses, and other administrative staff. The hospital is a multispecialty facility with room for improvement in several areas. This effort was undertaken to reduce the cost of disposing of healthcare biowaste. Hospital staff collaborated on the project. "Define" is the first stage in the suggested process. At this stage, we examined waste production, from inventory distribution to facilities that treat and dispose of biomedical waste. We used a SIPOC diagram, a process improvement tool that aids in defining a complex project that might not be successfully scoped by identifying all important factors before work begins[15]. SIPOC stands for supplier, input, process, output, and client. Define Phase: Defines the issue and establishes the project's objectives. Reducing operational costs, increasing efficiency, and ensuring compliance with waste disposal standards could be the main goals for cost reduction in biomedical waste disposal. The scope, stakeholders, and project schedule are all defined during this phase.

Fig. 3. Yellow bin of the hospital

Fig. 4. Red bin of the hospital

Fig. 5. White bin of the **hospital**

Fig. 6. Blue bin of the hospital

In the second step, "Measure," with guidance from the head nurse and the assistant nurse, we conducted a brainstorming session to identify the causes of the high cost of bio-waste disposal. Measure Phase: The goal of the Measure phase is to gather relevant data to help researchers better understand how the biomedical waste disposal process currently operates. Metrics may include the amount of waste generated, the disposal cost, and the time required for disposal. This information offers a starting point for assessing performance. After that, the same was given a root cause analysis. Additionally, data on sources, monthly weight statistics, and contractor information related to the disposal of biomedical waste were obtained.

Table. 2. Waste classification of the hospital

Sr. No	Waste Colour	Waste
1	Yellow Bag	1) Anatomical Human waste • Human tissues, Organs, Body parts, and Fetus below the viability period. • Soiled Waste. • Items Contaminated with Blood & Body. 2) Bags containing residual or discarded blood and blood components, such as dressings, plaster casts, and cotton swabs. Bedding, Mattresses, and discarded linen contaminated with blood or bodily fluids. 3) Expired or Discarded medicine Pharmaceutical waste like Antibiotics, Cytotoxic Drugs, items contaminated with cytotoxic Drugs- Glass or Plastic Ampoules, Vials, etc. 4) Chemical Waste Used or Discarded Disinfectants, Microbiology, Biotechnology, and other clinical laboratory waste Laboratory cultures, Specimens of microorganisms, Live or attenuated vaccines, Human cell cultures, Dishes/devices used for cultures[16].
2	Red bag	Contaminated waste (Recyclable) Waste generated from disposable items such as • Tubing • Bottles • IV tubes • IV sets, Catheters, Urine Bags • Syringes (without needle and fixed Glassware: needle syringes), broken or discarded, and • Vacutainer with contaminated glass, their needles cut Medicine vials & Gloves[17]
3	White (Puncture and Leak-proof Container)	• Waste Sharps, including Metals Needles • Syringes with fixed needles from the tip cutter or the burner • Scalpels, Blades, Any other Contaminated, used, discarded sharp objects[18]
4	Blue Bag	• Broken or discarded and contaminated glass medicine Vials and Ampoules (except those contaminated with cytotoxic wastes). • Metallic Body • Implants
5	Green Bag	• Paper plastic • Kitchen Waste • Food waste[19]

Table 3. Hospital Biomedical Waste Management SIPOC

Supplier	Input	Process	Output	Customer
General warehouse Pharmacy Department Patients	5) Doctors 6) Nurses 7) Patients 8) Other medical staff	4) Through prescriptions to patients. 5) Injections and other supplements for admitted patients. 6) Inventory used in different departments.	6) Yellow waste 7) Red waste 8) White waste 9) Blue waste 10) Green waste	3) Contractors of waste management. 4) Bio farm owners.

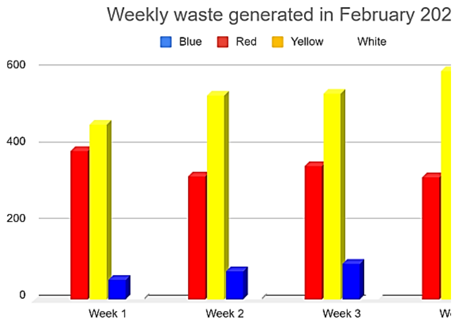

Fig. 7. Waste generated in Feb 2022

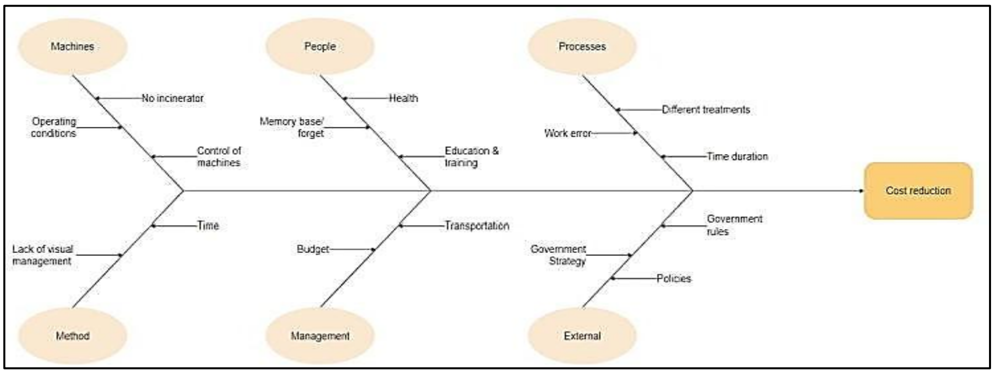

Fig. 8. Root Cause Analysis

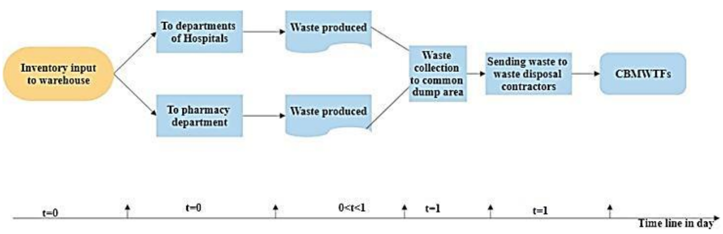

Fig. 9. Stream map of Waste generation.

The "Analyse" element of the third step is when we examined the primary wards where garbage is generated. It was found that the waste generated in the operating room (OR) for a single procedure is 2.5 times that generated in the ward each day. A VSM was then created to determine the present bio-waste disposal procedure.

Implementing fixes to address the identified problems constitutes the Improve phase. This can involve introducing Lean and Six Sigma concepts, including process improvement, waste management, and employee training. It can also be thought of as working with suppliers to develop economical and environmentally friendly disposal techniques. The fifth phase, "Control," entails putting the improved process in writing and attempting to put it into practise. It also entails ensuring that steps were taken to promote ongoing development and that the results were examined and adjusted. Control Phase: During the Control phase, the team creates plans to maintain gains. To ensure ongoing adherence to the optimised waste disposal process, implement monitoring systems, develop standard operating procedures, and develop training programmes. To monitor continuing performance, regular audits and feedback systems are also put in place.

To determine the cause of the problems, the acquired data were verified and analysed. An ideal solution was then identified using data, a literature review, web searches, expert recommendations, observations, and discussions with front-line employees. Reduce the use of disposable aprons and increase the use of reusable ones. Also, make sure to disinfect them after each use. Reduce the use of shoe covers and increase the use of separate slippers in emergency rooms. Use disposable bed linens solely for treating infectious patients. To reduce the main reasons individuals forget to collect waste or to speed up the process, the use of ducts or waste and linen transfer systems can be implemented. To minimise HAIs, dispose of yellow waste promptly in an incinerator. Several government initiatives can have a significant impact, such as CBMWTFs in every area, which can lower transportation costs, improve waste disposal, and reduce pollution. High fuel costs are a key driver of the high disposal costs for biodegradable waste.

Many wastes are treated as dangerous even though they are not, according to the research. Government regulations can be implemented in certain areas to support direct recycling. They must be disposed of according to bio-waste procedures, which results in losses. VM is the initial phase in the continuous improvement process. VM is a crucial technique for ongoing development. By providing context for your team's work, highlighting their progress and emphasising areas for development, and simplifying complex concepts into understandable symbols to communicate ideas, visual management may help your team. The DMAIC is again used in accordance with the highlighted areas for improvement.

This study demonstrates that using DMAIC has improved our understanding of the factors that affect the cost of disposing of biomedical waste produced in the healthcare industry. A cost reduction of more than 32% is anticipated after the solutions are implemented, with the government's active involvement. Lean and Six Sigma, combined with DMAIC, proved effective in solving the issue. Lean Six Sigma can save significant money when used effectively to manage the disposal of biomedical waste. Healthcare institutions can cut costs and promote environmental sustainability by methodically addressing inefficiencies and streamlining operations. To ensure a comprehensive and lasting solution, it is essential to involve key stakeholders throughout the DMAIC process, including healthcare employees, waste management professionals, and regulatory organisations. Other related healthcare processes can be included in the study's scope. Both governmental and non-governmental entities should acknowledge the issue of biowaste. Lean's primary objective is to increase organisational effectiveness while keeping costs low and reasonable. Future studies should examine the effects of government initiatives to improve healthcare efficiency in developing nations such as India, the factors influencing DMAIC application in the healthcare industry, and how it can enhance biowaste management among public healthcare providers. Healthcare offers many opportunities to adopt lean thinking, and more research is needed on the simplicity and alternatives for disposing of biomedical waste. The value of continual improvement appears to be underappreciated in the healthcare industry. Due to time constraints and the inability to conduct case studies or collect data at numerous other hospitals, we adopted most of the tools but were still unable to fully understand the work required for lean practice. The disposal of biomedical waste in the healthcare industry can be more economically managed through a systematic, data-driven methodology called the DMAIC approach. Healthcare facilities can increase efficiency, cut costs, and encourage environmentally friendly waste management practises by defining clear objectives, assessing existing performance, identifying root causes, implementing improvements, and establishing controls.

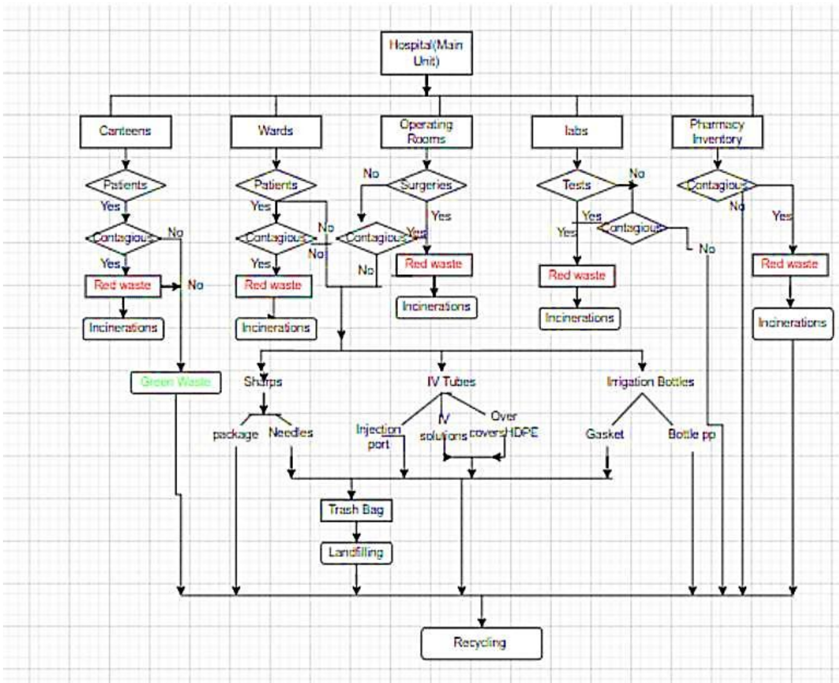

Fig. 10. Biomedical Waste Management Process Flow

4. Conclusions

Major Garbage Source: The operation room is identified as the primary contributor to biomedical waste generation.
Reducing Risk of HAIs: Limiting the use of mattresses and bedcovers to patients with infectious disorders, and burning yellow waste in incinerators can minimize waste, lowering the risk of Hospital Acquired Infections (HAIs).
Technology Adoption: Hospitals are encouraged to implement technology such as trash and linen transfer systems and ducts for efficient waste management.
District CBMWTFs for Efficiency: Establishing Common Biomedical Waste Treatment Facilities (CBMWTFs) in each district can enhance waste disposal efficiency, reduce transportation costs, and minimize pollution.
Alternative Disposal for Non- Hazardous Waste: If treating non- hazardous waste as biowaste leads to losses, explore and implement alternative disposal methods.
Communication and Awareness: Addressing the biomedical waste issue in India requires an effective communication strategy, awareness campaigns, and educational initiatives.
Source Isolation: Achieving source isolation could reduce the need for special treatment to only about 15% of biomedical waste.
Hygiene Improvement: To enhance public hygiene, efforts should focus on rendering infectious garbage as harmless as possible.
Adherence to Guidelines: Strict adherence to established norms and guidelines, along with identifying, isolating, and treating waste appropriately, is crucial.
COVID-19 Waste Management: Recent modifications and reviews include new facilities and adherence to the "Identify, Isolate, and Treat" approach, aligning with WHO principles.
Legal and Social Duty: Given the significance of COVID-19 waste as a public health issue, all stakeholders bear a legal and social responsibility.
Occupational Safety Concerns: Mixing biomedical waste with solid trash without active stakeholder involvement poses risks to healthcare workers, society, and the environment.

4.1 Scope for future work

4.1.1 Expansion of Recycling Programs

- Undertake comprehensive recycling programs and broaden research endeavours to explore innovative methodologies for the disposal and recycling of biomedical waste.

4.1.2 Replacement of PVC and Heavy Metal Management

- Investigate alternatives to PVC, considering its environmental impact during incineration.
- Develop methodologies for the efficient removal of toxic pollutants like benzene, dioxins, HCl, and hazardous heavy metals (cadmium, chromium, lead) from incinerator ash based on the quantity present in the waste.

4.1.3 Lean Implementation for Enhanced Efficiency

- Address programmatic challenges such as poor communication between interdisciplinary teams, low management staff involvement, and bureaucratic hurdles in the medical sector.
- Focus on Lean implementation strategies to streamline processes, enhance communication, and improve overall efficiency.

4.1.4 District-Level CBMWTFs for Sustainable Waste Management

- Propose the establishment of Common Biomedical Waste Treatment Facilities (CBMWTFs) in each district for more effective waste disposal.
- Emphasise the potential reduction in transportation costs and pollution associated with decentralised waste treatment facilities.

4.1.5 Alternative Disposal Methods for Non- Hazardous Waste

- Investigate and implement alternative disposal methods for non-hazardous biomedical waste to prevent financial losses and enhance overall waste management efficiency.

4.1.6 Communication strategy and Public Awareness

- Develop and implement an effective communication strategy to address India's biomedical waste challenge.
- Conduct awareness campaigns and educational initiatives to educate healthcare professionals, policymakers, and the public on proper biomedical waste management practices.

4.1.7 Source Isolation and Hygiene Improvement

- Explore strategies to achieve source isolation, aiming to reduce the proportion of biomedical waste requiring special treatment to approximately 15%.

- Emphasise the importance of rendering infectious garbage harmless to improve public hygiene and prevent the spread of infections.

In conclusion, future research and initiatives should focus on advancing recycling programs, addressing material-specific challenges, implementing Lean practices, establishing district-level waste treatment facilities, exploring alternative disposal methods, and enhancing communication and awareness to achieve a comprehensive, sustainable approach to biomedical waste management in India.

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