

**Evaluation of Different Healthcare Waste Management Practices and
Problems among Primary and Secondary Hospitals in Mianwali**



SUPERIOR UNIVERSITY

Thesis Submitted to

The Superior University Lahore

In Partial Fulfilment of the

Requirement for the Degree of

Master of Science in Allied Health Sciences

By

(MOHAMMAD ASAD BILAL)

Roll No. SU91-MSAHW-S23-075

Session: 2023-2025

Faculty of Allied Health Sciences

2025

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SU91-MSAHW-S23-1075

FAHS

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Author's Declaration

I hereby state that my MS thesis titled “**Evaluation of different healthcare waste management practices and problems among primary and secondary hospitals in Mianwali**” is my work and has not been submitted previously by me for taking any degree from this University,

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Certificate of Approval

This is to certify that the research work presented in this thesis, titled “**Evaluation of different healthcare waste management practices and problems among primary and secondary hospitals in Mianwali**” was conducted by “**Muhammad Asad Bilal**” under the supervision of “**Dr. Muhammad Adnan Hafeez.**”

No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Faculty of Allied Health Sciences, The Superior University, Lahore in partial fulfillment of the requirements for the degree of Master of Science in the field of “**Allied Health Sciences**” in Faculty of Allied Health Sciences at The Superior University, Lahore.

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Signature: _____

DEDICATION

This thesis is dedicated to my beloved family, whose unwavering support, encouragement, and sacrifices have been the cornerstone of my academic journey.

To my parents, whose love and guidance have inspired me to strive for excellence in every endeavor, and to my siblings, who have been my constant source of motivation and cheer.

To my teachers and mentors, whose wisdom and patience have shaped my intellectual growth and instilled in me a passion for learning and discovery.

Lastly, this work is dedicated to the countless healthcare professionals whose dedication to patient safety inspires research and progress in the field of infection control.

With deep gratitude and respect, I humbly offer this work to all who have been a part of this journey.

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Mohammad Asad Bilal

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LIST OF ABBREVIATIONS

HCWM	Healthcare Waste Management
LMICs	Low- and Middle-Income Countries
WHO	World Health Organization
PPE	Personal Protective Equipment
SPSS	Statistical Package for the Social Sciences
EPA	Environmental Protection Agency
HIV	Human Immunodeficiency Virus
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus
UN	United Nations
UNEP	United Nations Environment Program
NHS	National Health Service
kg/day	Kilograms per Day
MW	Medical Waste
ICT	Information and Communication Technology
EIA	Environmental Impact Assessment
SARS	Severe Acute Respiratory Syndrome
COVID-19	Coronavirus Disease 2019
EU	European Union
OSHA	Occupational Safety and Health Administration
UK	United Kingdom
USA	United States of America
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
NHSR	National Health System Regulations
MOH	Ministry of Health

ABSTRACT

Background: Healthcare waste management is a critical component of public health, particularly in developing countries like Pakistan, where inadequate waste handling poses significant risks to healthcare workers, the environment, and the community. Primary and secondary hospitals often face different challenges due to variations in infrastructure, resources, and waste volume. This study evaluates healthcare waste management practices and identifies associated problems in primary and secondary hospitals in Mianwali.

Objectives: To evaluate and compare healthcare waste management practices in primary and secondary hospitals in Mianwali.

Methods: A cross-sectional study was conducted in public hospitals of Mianwali. A total of 120 participants, including staff from both primary (n=59) and secondary (n=53) hospitals, were selected through simple random sampling. Data were collected using structured questionnaires and quantitative observations. Key areas assessed included waste segregation, storage, transportation, treatment methods, staff training, and compliance with regulations. Data were analyzed using descriptive and inferential statistics, with results summarized as frequencies, percentages, and p-values.

Results: Primary hospitals demonstrated higher compliance with segregation practices (80% using color-coded bins) compared to secondary hospitals (70%). However, secondary hospitals had more frequent training sessions (93% of staff trained) and generated higher volumes of hazardous waste (20% compared to 15% in primary hospitals). Challenges reported included lack of resources (70-75%), inadequate infrastructure (11.7-5%), and insufficient enforcement of regulations. Significant gaps were observed in the disposal of pathological, cytotoxic, and liquid waste, with secondary hospitals more likely to use outdated incineration methods (85% vs. 60%).

Conclusions: The study highlights disparities in healthcare waste management practices between primary and secondary hospitals. While primary hospitals excel in segregation compliance, secondary hospitals face challenges in resource allocation and infrastructure. The resolution of these problems demands focused training methods

along with stricter regulatory enforcement while also requiring investment in advanced waste treatment systems.

Keywords: Healthcare Waste Management, Primary and Secondary Hospitals, Waste Segregation Practices, Environmental Health Risks, Mianwali Public Hospitals

Chapter 1

INTRODUCTION

Healthcare waste management (HCWM) is a key element of public health infrastructure, especially in low- and middle-income nations (LMICs), in which improper treatment of waste poses an essential environmental and health threat [1]. Proper healthcare waste management is of great significance in order to avert the transmission of infectious illnesses, reduce healthcare workers' exposure to occupational risk, and promote environmental sustainability [2]. The World Health Organization (WHO) has identified healthcare waste as a significant public health threat, especially in resource-scarce settings where improper disposal practices such as open dumping and uncontrolled incineration are common [3].

Pakistan, as with other developing countries, faces colossal challenges in having an effective HCWM system. The healthcare waste of the country consists of hazardous and non-hazardous wastes such as sharps, infectious waste, chemical waste, and pharmaceutical waste [4]. In spite of the existence of national policy for hospital waste management, there is poor compliance with it due to the lack of infrastructure, inadequate financing, and inadequate training of healthcare professionals [5]. Evidence shows that a majority of the hospital waste in Pakistan is unsorted and contributes to the risks of cross-contamination and environmental pollution [6].

Mianwali, the Punjab district in Pakistan, presents an interesting scenario for the observation of HCWM practice at primary as well as secondary healthcare centers. Primary hospitals are likely to offer primary medical care to the local population and produce relatively less amounts of healthcare waste compared to secondary hospitals, which handle more complicated medical procedures and produce a wider range of hazardous waste [7]. Differences in working scale, material availability, and health care waste handling policies between the primary and the secondary hospitals pose huge challenges in implementing standardized HCWM practices. Inefficient disposal of medical waste in Pakistan has been explained by a number of systemic issues, including a lack of uniform segregation techniques of waste. Segregation of medical waste at the source is significant in reducing the risks presented by toxic chemicals. However, evidence has shown that healthcare facilities in Pakistan commingle toxic and innocuous waste due to poor sensitization and training of healthcare providers [8]. The process contaminates recyclable materials and contributes to the workload on

waste management facilities. The second key issue concerns the inappropriate capacities of waste management. Several health facilities across Pakistan, and rural areas specifically, do not possess advanced technologies of waste disposal like autoclaving and microwave treatment, but employ outdated and toxic incineration technologies which release dangerous chemicals into the ecosystem [9]. Incineration of medical wastes in open setups releases toxic pollutants, such as dioxins and furans, which represent a major public and occupational hazard to healthcare practitioners and surrounding populations [10].

Additionally, financial constraints restrict the ability of hospitals to make investments in updated HCWM facilities. Most public healthcare hospitals have limited resources, and investments in proper storage, transportation, and disposal of waste are difficult to make [11]. In the absence of proper funds, hospitals cannot adhere to national and international guidelines for waste management, and hence the healthcare waste disposal issues become more complex. Healthcare waste management (HCWM) in Pakistan is governed by different national and international regulations, but their compliance is not uniform because there are weak mechanisms for enforcement and a lack of awareness among the healthcare staff. The Hospital Waste Management Rules 2005 and the Pakistan Environmental Protection Act (PEPA) 1997 provide the legislative guidelines for the proper handling, transportation, and disposal of healthcare waste. Nevertheless, research indicates that most of these health institutions, particularly those in rural areas, do not meet these specifications due to poor training, a lack of inspection, and weak waste treatment infrastructure [12].

The World Health Organization (WHO) and United Nations Environment Programme (UNEP) emphasize that a well-functioning HCWM system should have the aspects of reducing waste, proper segregation, secure transport, and environmentally sound treatment and disposal options [13]. Although these guidelines offer a healthy basis for dealing with healthcare waste globally, low-income countries like Pakistan are grappling with their practice due to insufficient funds and insufficient technical expertise. In some hospitals, the color-coded system of bins to segregate wastes is available but compliance is variable, with inappropriately discarded waste causing cross-contamination and increased risks of infection transmission [14].

Primary hospitals, with their lower patient volumes and less complex medical procedures, tend to have better compliance with waste segregation regulations than secondary hospitals, which produce larger quantities and more varied types of medical

waste [15]. Both hospitals, however, have significant problems with trash collection, storage, and treatment. The issue is compounded by inefficient government surveillance, as the enforcing agencies are unable to properly check HCWM operations, especially at secondary hospitals with more demanding streams of wastes calling for stringent regulating measures [16]. Unproper waste handling in the health sector brings extreme risks to health workers as well as to the environment. Waste operators, cleaning operators, and nurses working in healthcare units are seriously vulnerable to workplace exposure to dangerous materials. The improper disposal of sharps, infectious waste, and chemicals poses a significant risk of needle-stick accidents and exposure to bloodborne viruses like Hepatitis B (HBV), Hepatitis C (HCV), and Human Immunodeficiency Virus (HIV) [17]. Most of the waste workers in Pakistan work without appropriate personal protective equipment (PPE) like gloves, masks, and protective attire, hence making them more susceptible to infection [18]. Another significant occupational hazard is exposure to toxic fumes from incinerators. Most hospitals, particularly secondary healthcare facilities, use outdated burning techniques that emit harmful pollutants, such as dioxins and furans, into the air [19]. These pollutants have been linked to respiratory disease, immune system dysfunction, and increased cancer risk in healthcare workers and surrounding populations [20]. Research has shown that a significant majority of secondary hospitals in Pakistan operate low-temperature incinerators with inadequate filtering systems, leading to the release of particulate matter and hazardous chemicals into the atmosphere [21]. In addition to occupational hazards, improper HCWM poses severe environmental concerns. Dumping untreated medical waste on land pollutes the land and water sources, especially in rural areas where there are no specialized waste treatment plants in healthcare facilities [22].

Liquid medical wastes, such as chemical residues, pharmaceutical waste, and lab effluents, are typically discharged into municipal sewage systems or nearby rivers in an inadequately treated form [23]. The method has significant risks to aquatic life and may lead to the development of antimicrobial resistance (AMR) because of the release of antibiotic residues into waste water [24]. A study conducted in Karachi showed that about 30% of the hospitals drain their liquid waste straight into water bodies, leading to severe contamination of drinking water resources [25]. This situation is further exacerbated by the unavailability of central waste treatment facilities in most parts of Pakistan, prompting hospitals to use makeshift methods of disposal which tend to

neglect environmental safety norms [26]. To break these challenges, there is a need for healthcare institutions in Pakistan to implement sustainable and environmentally friendly waste management systems. The reliance on outdated incineration technology has to be substituted with advanced waste treatment technologies, including autoclaving, microwave treatment, and chemical disinfection [27]. Autoclaving is a steam treatment process that effectively sterilizes infectious waste without producing dangerous emissions, while microwave treatment uses electromagnetic waves to neutralize medical waste, reducing environmental pollution [28].

Chemical disinfection is the utilization of disinfectant solutions in eradicating germs in liquid and solid waste prior to disposal [29]. Adoption of these alternatives requires extensive investment in infrastructure and training programs for ensuring compliance with national and international waste management standards. Staff training in segregating waste, safe handling, and disposal practices has to be a priority for hospitals in order to avoid occupational hazards and environmental pollution [30]. Studies have indicated that regular training programs can significantly increase compliance with HCWM practices, resulting in safe and efficient waste handling and disposal measures [31].

Public-private partnerships (PPPs) can also help fill the gap in HCWM infrastructure by covering funding and technical assistance for the construction of advanced waste treatment facilities [32]. Most industrialized countries have been able to implement waste-to-energy solutions, where medical waste that is not recyclable is converted to usable electricity, reducing environmental impact while generating economic gains [33].

Although these options might not be feasible for Pakistan in the near future due to cost constraints, pilot studies in urban hospitals could lead the way towards effective introduction of environmentally friendly waste disposal technologies [34]. With the growing healthcare waste burden in Pakistan, this research attempts to analyze and contrast HCWM practices at secondary and basic hospitals in Mianwali. Through the recognition of major impediments and gauging effectiveness of existing waste management systems, the project will provide evidence-based recommendations for better healthcare waste disposal in the region [35]. The specific research objectives for this study are to assess and compare HCWM procedures in primary and secondary hospitals, to determine the key challenges and loopholes in the application of HCWM protocols in both hospital types, to examine the role of waste management procedures

on occupational health and environmental safety, and to provide sustainable solutions for enhancing healthcare waste disposal and adherence to regulatory requirements [36]. This research will add to the growing body of literature on HCWM in Pakistan and will inform policy recommendations aimed at enhancing waste management infrastructure in public health facilities [37]. Resolution of these challenges is essential not only for the protection of healthcare workers and the environment but also for enhancing the overall quality of healthcare services within the country [38]. This research analyses healthcare waste management processes at Mianwali's primary and secondary medical facilities which serve as the primary focus of our investigation. Healthcare service specialization exists because secondary medical Centres treat complicated health problems while primary health institutions deliver basic services to surrounding communities. The diverse operational systems of these facilities cause distinctive waste management challenges through their production of various waste amounts and types [39].

AIM AND OBJECTIVES

Aim:

Research examined healthcare waste management procedures at Mianwali's basic and secondary hospitals. This aimed to discover critical operational problems that affect current waste management processes through evaluations which generate practical solutions ensuring safe disposal that satisfies sustainability goals and meets regulatory requirements. The research finds key obstacles in its analysis before providing concrete solutions which enhance environmental outcomes and advance public health standards.

Objectives:

1. To evaluate and compare the healthcare waste management practices in primary and secondary hospital Mianwali.
2. To identify the problems associated with healthcare waste management in primary and secondary hospital Mianwali.

Chapter 2

LITERATURE REVIEW

Healthcare waste management (HCWM) earns growing recognition worldwide because it serves vital functions in environmental preservation and public health protection. Managing healthcare waste/rejects needs a systematic process that integrates waste segregation together with handling protocols followed by waste treatment before its ultimate disposal [39]. In developing and emerging economies, the research on healthcare waste management both investigates waste handling issues and identifies managerial potential within Mianwali. This analysis observed present methods and reveals incomplete research fields to identify significant investigative pathways that integrate this research into larger academic talks about HCWM.

The research evaluated HCWM systems in primary and secondary healthcare facilities facing operational difficulties within the developing world. This study emphasized literature which aligns with South Asian jurisdictions especially Pakistan after establishing HCWM knowledge through a global understanding. Extensive analysis presents research results about waste segregation along with regulatory compliance and environmental as well as health consequences caused by substandard waste management practices. Research on sophisticated waste treatment techniques applied to wealthy nations but this study utilizes those findings to generate solutions which work well in limited resource environments.

Healthcare facilities worldwide produce various waste streams starting from general non-hazardous matter to infectious waste and including sharps and chemical compounds along with cytotoxic and radioactive substance types. The healthcare waste management infrastructures in Germany and Sweden combine tight regulatory systems with innovative treatment solutions and strong industry compliance. Medical waste recycling in Germany reaches 85% while their sophisticated incineration systems handle dangerous materials [40].

In its circular economy approach Sweden operates waste-to-energy systems which transform waste that cannot be recycled into renewable power. HCWM systems in low- and middle-income countries face challenges because they have restricted finances coupled with deficient infrastructure and weak regulatory enforcement [41].

Studies carried out in India and Nigeria and Ethiopia demonstrate that healthcare

facilities continue to battle unresolved issues regarding weak waste segregation efforts combined with untrained healthcare staff and obsolete incinerator technology without adequate pollution controls. Researchers have established that high- and low-income countries demonstrate significant differences in HCWM practices leading to an immediate requirement for customized interventions within resource-constrained environments [42].

The large segment of world population residing in South Asia experiences special obstacles in healthcare waste management. The healthcare systems in India along with Bangladesh and Pakistan create substantial amounts of healthcare waste because they have expanding medical operations. Medical waste containment problems intensify because medical institutions lack effective waste segregation practices and proper treatment protocols. Studies at Indian hospitals revealed that most facilities had proper waste segregation bins but staff members followed correct waste management practices only 60 to 70 percent of the time. The difference between ideal waste disposal and current practice stems from insufficient training along with weak executive oversight [43].

The healthcare waste management situation in Pakistan remains as serious as elsewhere. Studies from Karachi demonstrate that healthcare facilities produce 100 tons of medical waste each day of which 39% contains infectious elements [44].

The current implementation rates of national guidelines for HCWM fall short of desired results. Healthcare staff noncompliance stems from limited funds alongside poor system management and insufficient awareness. Unregulated incineration facilities along with open dumping create major problems for both public health as well as the environment. Smaller cities and rural areas face heightened challenges for healthcare waste management because their facilities typically lack suitable infrastructure together with essential resources for proper waste disposal [45].

The healthcare delivery functions between primary and secondary hospitals differ making their waste management practices different from each other. The waste generated by primary hospitals serving localized populations consists of small quantities for more manageable management [46].

These establishments usually do not possess advanced waste treatment systems and use only naïve waste sorting protocols. Secondary hospitals produce bigger and more

complicated waste streams consisting of chemical and pathological waste because they deliver a wide variety of medical services. These treatment facilities confront additional problems from logistical hurdles and increased patient volumes alongside obsolete treatment methods [47].

The Pakistan-based studies demonstrate that primary hospitals demonstrate stronger compliance patterns because they operate at a smaller scale with manageable operational parameters. Mianwali-based research demonstrates primary hospitals manage waste segregation through color-coded bins at an 80% rate exceeding secondary hospitals at 70%. Secondary facilities demonstrate better performance regarding dedicated waste management staff members and training initiatives yet score lower than primary facilities at waste management segregation [48].

Specific interventions must be designed to overcome distinct challenges which each facility type encounters. Healthcare waste management deficiencies generate considerable direct threats to ecosystems and a range of health risks affecting nearby communities. Handling defective medical equipment such as needles and scalpels presents medical workers and waste handling staff with their main occupational infection threat. Research shows that contaminated sharps injuries lead to 0.4 to 1 million deaths every year because they spread bloodborne diseases that attack the body with HIV and both types of Hepatitis B and C[49].

In rural and semi-urban areas like Mianwali, the lack of formal waste management systems exacerbates these risks. Healthcare waste disposal in municipal regions and open fields of several countries leads to major sanitation hazards which threaten both human populations and scavenger communities [50].

Hazardless chemicals permeate soil and water systems until they cause permanent environmental harm. Medical research focuses on how hospitals need sustainable waste management systems to safeguard environment ecosystems along with ensuring patient safety. System failures in hazardous waste management are mostly caused by staff members lacking proper training and insufficient awareness about right waste management methods. South Asian research shows dangerous waste compounds mix with appropriate medical waste because workers remain deficient in waste sorting techniques. Secondary hospitals within Pakistan experience recurring challenges in obtaining standard training because their educational structure spreads across different locations while overlapping courses and retaining staff remains limited [51]. Primary

hospitals organize regular training sessions which address gaps but their geographical area remains somewhat restricted. Education programs stand as vital elements for enhancing Hospital Routine Waste Management achievements. Technical training provided monthly shows remarkable progress because facilities record a 20% to 30% improvement in their segregation practices [52].

These activities improve workers' ability to tackle operational inefficiencies in hazardous chemical waste management thereby promoting safer and longer-lasting waste handling methods. The appropriate healthcare waste management in developing countries represents an ongoing challenging problem. The creation of successful HCWM networks faces barriers from financial restraints along with operational boundaries and systemic operational deficiencies [53].

Economically deprived locations encounter severe funding shortages which hampers their ability to create effective waste segregation systems together with suitable removal processes and required administrative frameworks essential for ongoing waste management sustainability. Financial constraints limit operational readiness because healthcare facilities need funding to procure advanced waste processing equipment while they lack the capability to train and recruit specialized waste management staff [54].

Research findings in both Nepal and Bangladesh confirm more than sixty percent of hospitals do not have adequate waste management facilities so they must burn their hospital waste while abandoning waste outside through improper disposal methods. Hospital waste management difficulties within Pakistan cause the same operational impediments which neighboring countries face. The study conducted in Karachi and Lahore plus rural Mianwali areas showed health facilities used outdated waste treatment processes and banned incineration methods [55].

Through improper waste management practices hazardous waste neutralization remains ineffective while causing simultaneous air and soil contamination. The deficiency of central waste treatment facilities for medical institutions in most districts requires them to handle waste by themselves which exhausts their limited capacities. Healthcare waste management inefficiencies emerge directly from various logistical challenges. Rural and semi-urban regions show poor management when transporting healthcare waste between its generation sites and the treatment facilities to which it

belongs [56].

Two primary challenges identified by hospitals in Mianwali include delayed picking up of waste from sites and the absence of appropriate vehicles for transportation. A lack of logistical options results in improper hazardous waste treatment strategies while creating dangerous working conditions for the personnel who process waste materials. Facilities managing healthcare waste encounter more difficulties through their inadequate waste storage infrastructure. Studies show that Pakistan's healthcare institutions which number about half of all hospitals fail to comply with global safe waste storage protocols and thus face higher potential for contamination while disease vectors like rodents and insects multiply [57].

The current inefficiencies in HCWM stem mainly from the inadequate enforcement of present regulations. National healthcare waste management guidelines exist at a national level in Pakistan but healthcare facilities show inconsistent compliance with these requirements. Although the Pakistan Environmental Protection Agency (EPA) established waste management standards in Pakistan studies confirm 60% of hospitals fail to comply [58].

Government dysfunction combined with insufficient monitoring procedures and corrupt activities generally disrupts regulatory enforcement. The problem is most severe for secondary hospitals because they manage bigger waste streams yet battle expensive logistics and insufficient resources. Most healthcare institutions struggle to uphold regulatory compliance because they lack adequate staff expertise combined with insufficient capabilities to meet the requirements. The healthcare institutions in Mianwali execute color-based waste allocation methods at primary hospitals but secondary hospitals face considerable difficulties implementing widespread adoption. Operating hurdles which uniquely face healthcare businesses create a clear need for customized and comprehensive legislation [59].

Health facilities located in developing countries face substantial damage when regulatory standards are put into effect. Multiple European Union states together with the United States have established strict healthcare waste requirements along with continuous compliance verification and fees for broken rules. Higher regulatory compliance together with noticeable waste management advancements results from these regulatory requirements [60]. Widely-reported non-compliance and unsafe waste practices affect Pakistan and other poor nations because they do not have established

institutions nor proper infrastructure to meet the regulatory requirements. Global sustainability faces difficulties because developing countries experience recurring healthcare waste disposal complications. Medical waste incineration through open burning and uncertified cremation practices at numerous hospitals produces environment-damaging pollutants including both dioxins and furans. Local residents experience major health threats because of these air-polluting substances. The open ground disposal system used for hospital waste management in Karachi has caused major contamination of soil and groundwater which damages environmental sustainability [61].

Mianwali's rural region faces major challenges because it lacks centralized waste disposal facilities. The combination of poor garbage management techniques such as open burning alongside burial practices generates major environmental degradation that proves these methods are not suitable options for sustainable waste management. The incorrect disposal of chemical and cytotoxic materials at hospitals in these areas leads to elevated water pollution [62]. Scientific studies indicate healthcare facilities maintain ongoing practices of releasing liquid waste toward sewer systems or adjacent water bodies which endanger public health and environmental aquatic systems.

Best environmental practices worldwide promote the adoption of waste management approaches that protect the environment. The nations of Sweden and Germany utilize waste-to-energy systems to create new usable electrical power from non-recyclable waste. These solutions have dual benefits: The systems deliver dual advantages through renewable local energy production while halting ecological destruction. The widespread adoption of these solutions remains limited in countries with financial constraints and technical requirements needed for operational implementation. Low- and middle-income regions require budget-friendly sustainable solutions which both account for their financial limitations and abide by their existing infrastructure systems [63].

Healthcare waste management depends heavily on the competency and skills of its personnel. The personnel who handle healthcare activities along with trash handlers need proper training to perform safe waste management practices [64]. Hazardous waste management efforts in South Asia experience failure mainly because of inadequacies in workforce training according to published research. Half of the healthcare professionals from both India and Bangladesh studies demonstrated

insufficient understanding of basic waste types that resulted in combined disposal of hazardous and non-hazardous materials. The lack of waste management knowledge creates both occupational dangers and implementation challenges for entire waste management systems [65].

Healthcare waste management in Pakistan faces multiple operational challenges. Public hospitals in Mianwali operate training programs but hospitals of secondary importance fail to train their staff because of workforce instability and budgetary constraints. Variations in facilities' hazardous waste management capabilities stem directly from the differences between their training systems [66]. Lack of instruction about waste handling exposes workers to job hazards which continues to create safety issues.

Research data establishes that concentrated training activities produce substantial improvements in hazardous waste management operations. Healthcare organizations derive better compliance levels with waste management rules through ongoing training initiatives. Nepal-based research proved monthly training courses boosted trash segregation compliance through a 30% improvement [67].

Healthcare waste management systems must have ongoing capacity-building activities combined with educational strategies because research underlines their importance for system enhancement and safety improvement. Research confirms the essential nature of training and capacity building in waste management policies according to the findings hospitals with limited resources must develop dedicated training programs [68].

Modern solutions for HCWM problems enable financially constrained locations to explore cost-effective management alternatives. Healthcare waste treatment now achieves better efficiency under safety standards with inserted tech investments including autoclaves and microwave systems together with plasma pyrolysis units [69]. Tunisian hazardous waste management utilizes plasma pyrolysis technology which transforms dangerous waste into non-toxic products while fulfilling environmental objectives. Microwave disinfection systems offer an alternative treatment solution that combines ethical environmental performance and financial efficiency to replace conventional incineration [70].

The adoption of new technological solutions in Pakistan is blocked both by budgetary

constraints and issues related to system implementation. Despite inadequate pollution control systems rural hospitals across various areas continue to rely on outdated incinerators [71].

More countries are investigating ways to find both affordable and adaptable technologies which suit their distinct healthcare requirements. Decentralized waste treatment systems function as practical solutions for healthcare facilities because they let them handle waste right at their facilities thereby resolving infrastructure issues regarding waste transportation to centralized facilities [72].

Chapter 3

METHODOLOGY

3.1. Research Design

A cross-sectional design enabled this research to analyze how healthcare waste management practices operate throughout various hospital settings. Studies with a cross-sectional design enabled the acquisition of time-based data which allowed researchers to perform holistic assessments regarding HCWM practices' actual implementation levels and operational difficulties.

3.2. Clinical Settings

The researchers evaluated public sector primary and secondary hospitals within Mianwali district.

- **Primary Hospitals:** Medical waste management in these hospitals centers on furnishing limited healthcare services to nearby residents as they generate lower volumes of hospital waste.
- **Secondary Hospitals:** The specialized medical services delivered at these facilities produce substantial waste streams which contain both pathological and chemical waste.

The selected clinical settings offered representation across operational sizes and waste management difficulties within Mianwali's healthcare system.

3.3. Sample Size

Specific number of participants were selected to maintain statistical validity while ensuring sufficient representation of relevant groups. Research data was collected from 120 participants who split evenly among primary hospitals with 60 participants and their counterparts at secondary hospitals totaled 60. Nurses together with Laboratory technicians and technologists, Sanitary workers along with Waste handlers and administrative staff who actively manage waste constituted the study participants. A sample size determination considered the total number of staff eligible for selection from the hospitals together with findings from previous studies in similar HCWM

facilities.

3.4. Sampling Technique

A simple random selection process operated to promote unbiased selection without discrimination. Each individual participant received a unique identifier which the researchers used to generate random selections through computerized randomization. The method improved sample representativeness while guaranteeing participation from various job roles within healthcare facilities.

3.5. Duration of Study

The study was conducted over a period of six months, from June 2024 to December 2024.

- Phase 1 (June - July 2024): Phase 1 (June - July 2024): Development of research instruments, which includes a questionnaire and an observational checklist.
- Phase 2 (August - October 2024): Data collection through surveys and field observations in primary and secondary hospitals.

Phase 3 (November - December 2024): Data analysis, interpretation and preparation of results.

3.6. Selection Criteria

3.6.1. Inclusion Criteria

Operation theatre Staff, intensive care staff and labour room staff and laboratory room staff were included. Doctors, Nurses, Nursing assistants, OT Technician, Maid's helpers, and sanitary workers were included.

3.6.2. Exclusion Criteria

Management staff were excluded.

3.7. Ethical Consideration

Ethical approval was obtained from the research review board of Superior University Lahore before the study. A written informed consent was obtained from all participants after the purpose, methodology and potential benefits of the study were explained. The participant's anonymity was maintained by coding the responses and providing recorded personal identification information. Compliance with ethical standards: The study adhered to the statement of Helsinki and local ethical instructions and ensured the protection of the rights and dignity of the participants during the research process. Participants were informed of their right to withdraw from the study at any time without a fine or negative consequences.

3.8. Data Collection Procedure

Data collection included two basic methods:

- **Structured Questionnaire:** For the collection of quantitative and qualitative data, a pre -structured questionnaire was used. The questionnaire contained components:
- **Sorting of waste:** Methods used (e.g. Colour coated garbage baskets, marked containers).
- **Storage procedures:** Availability and storage status.
- **Transport:** Procedures and frequency of waste transport in the hospital.
- **Settings and disposal:** Methods used (e.g. combustion, autoclave, landfill).
- **Compliance:** Awareness and compliance with National and International Regulations HCWM.
- **Challenges:** Obstacles to introduce effective HCWM procedures.

The questionnaire was distributed to participants during their shifts and the answers were collected anonymously.

Observational Checklist: On -site observation was made to evaluate HCWM procedures in real time and a consistency between reported and observed procedures.

The main aspects were:

- Correct use of colored containers for segregation.
- Status and location of the waste storage space.

- Availability and use of personal protective equipment (PPE) employees.
- Frequency and method of waste collection and transport.

Data collectors received previous training to ensure standardized and unparted observations.

3.9. Data Analysis

Data were analyzed using SPSS (Statistical Package for the Social Sciences), version 26. Frequencies and percentages were calculated for categorical variables (e.g. levels of agreement, types of waste produced). For continuous variables, there were means and standard deviations. Chi-square tests: Used to determine the context between variables such as hospital type (primary vs. secondary) and adherence to waste separation practices. T-tests: Used to compare mean differences in harmony and problems between primary and secondary hospitals. Significance threshold: P-value <0.05 was considered statistically significant. Themes were analyzed using qualitative data from open-ended survey questions and observation notes. Key themes such as challenges, compliance and resource gaps were identified and synthesized to complement the quantitative findings.

Chapter 4

RESULTS

4.1: Demographic Variables:

One hundred twelve healthcare professionals participated in this study chosen from both primary and secondary medical facilities in Mianwali. The 112 healthcare professionals included 59 primary hospital workers representing 52.7% and 53 secondary hospital employees representing 47.3% of the total. Most of the collected demographic information focused on measuring professional positions and years of work experience for respondents. Respondents from primary and secondary hospitals consistently reported that their working experience was below ten years. The research showed primary hospital staff with lower experience levels (74.6%) matched similar percentages (77.4%) found in secondary hospital staff. The data demonstrated that healthcare staff members make up a considerable percentage who just recently entered their roles. Analysis of years of experience produced a p-value tallying 0.731 which exceeds the typical p-value threshold of 0.05 at significance. The analysis showed that primary hospital staff and secondary hospital staff had equivalent experience levels across both institutions. Laboratory technicians and sanitation workers made up the second-largest responding roles after nurses in basic hospitals (37.1%) and secondary facilities (28.5%). A p-value of 0.437 showed that hospital categories did not affect the professional balance within the workforce. This value proved substantially greater than the accepted 0.05 threshold. The professional experience levels of respondents did not cause major differences in waste management techniques between primary and secondary hospitals.

Table 4.1: Demographic Variables

Parameters		Hospital Categories				Total		p-value
		Primary Hospitals		Secondary Hospitals				
		n	%	n	%	n	%	
How many		5	52.7%	5	47.3	11	100%	
		9		3	%	2		

years of experience ?	<=10 YEARS	4	74.6%	4	77.4	85	75.9	0.73
		4		1	%		%	
	>10 YEARS	1	25.4.	1	22.6	27	24.1	
		5	%	2	%		%	
Profession	LAB Tech/ LAB TECHNOLOGIST/O T Tech	1	25.4%	2	39.6	36	32.1	0.43
		5		1	%		%	
	Sanitary worker	6	10.2%	4	7.5%	10	8.9%	
	Nurses/LHVs	2	37.1%	1	28.5	37	33.0	
	2		5	%		%		
	Doctor	1	27.1%	1	24.5	29	25.9	
		6		3	%			

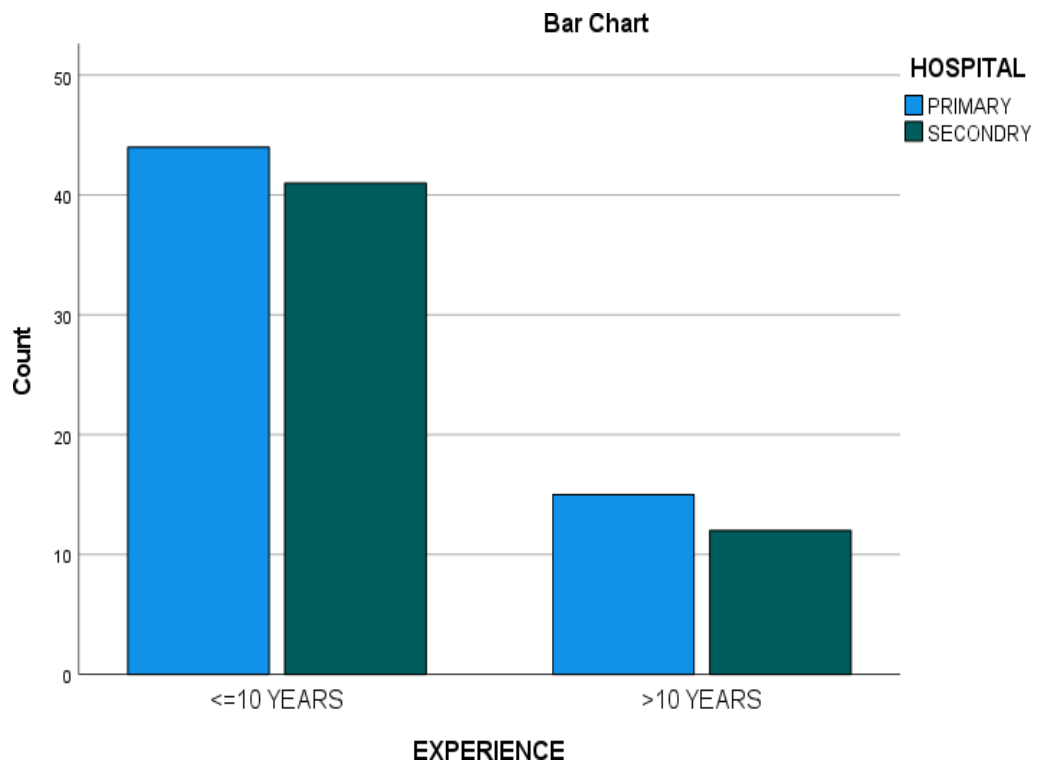


Figure 4.1: Profession

4.2: Current Waste Management Practices

The results revealed main hospitals used color-coded bins at a rate of 81.4% while secondary hospitals achieved 67.9% usage for trash segregation. The extremely significant comparison received a p-value below 0.001. The analysis showed that

primary hospitals followed standard waste segregation techniques at higher rates than secondary hospitals. Secondary hospital staff employed labeled waste containers for segregation according to 26.4% of respondents but primary hospital staff did not use this practice. Secondary facilities demonstrate significantly higher adoption of labeled waste holding containers according to a p-value lower than 0.001. Secondary hospitals seem to adopt different waste segregation methods because their widespread application of color-coded bins meets practical resistance. Statistical tests confirm the connection between hospital categorization and waste segregation methods by producing p-values that remained under 0.05 in all cases.

Medical waste collection coupled with transportation practices serve as essential elements for protecting hospital environment hygiene and controlling contamination spread. Results indicate that primary healthcare facilities maintain robust processes for waste handling regarding collection and transportation. Main hospital professionals had dedicated waste management staff utilized for waste collection while secondary hospitals used essentially the same arrangement at 86.8%. No statistical significance could be established about trash collection method discrepancies between primary and secondary hospitals because the comparison p-value of 0.302 indicated no meaningful statistical difference existed. Respondents from primary hospitals reported waste collection multiple times per day through 69.5% of the sample compared to 77.4% from secondary hospitals. Results showed a p-value of 0.348 indicating no substantial difference occurs in trash collection frequency between primary and secondary hospital institutions. The results show that both primary and secondary hospitals follow comparable waste-collection approaches yet secondary facilities perform scheduled waste collection more frequently than primary facilities do.

Survey participants from 18.6% of primary hospitals and 9.4% of secondary facilities confirmed they employed both dedicated waste management staff and department-based personal to handle waste collection and transportation initiatives. Hospital category proved not relevant to staff allocation for waste management tasks since the recorded p-value equaled 0.302.

The correct disposal and treatment of healthcare waste stands as a vital healthcare waste management practice because improper waste handling tools result in severe environmental and public health risks. Results from the survey establish that a major percentage of basic hospitals together with secondary hospitals select incineration as their main healthcare waste system. Experimental results showed incineration use by 61% of main hospitals and by 83% of secondary hospitals. Incineration utilization between primary hospitals stood significantly different from secondary facilities at a p-value level below 0.001. The data indicate secondary hospitals adopt incineration as their primary waste disposal method because they generate larger waste quantities or possess superior facilities for burning waste.

Table 4.2: Current Waste Management Practices

Parameters		Hospital Categories						p-value
		Primary Hospitals		Secondary Hospitals		n	%	
How does your hospital segregate healthcare waste?	Color Coded Bins	48	81.4%	36	67.9%	84	75	<0.001
	Labelled Containers	0	0.0%	14	26.4%	14	12.5	
	All	11	18.6.0%	3	5.7%	14	12.5	
What types of healthcare waste are generated at your department?	Infections and sharp	15	25.4%	0	0.0%	15	13.4	<0.001
	Infectious waste	3	5.1%	14	26.4%	17	15.2	
	Chemical Waste	0	0.0%	1	1.9%	01	0.9	
	All	41	69.5%	38	71.7%	79	70.5	
Does the facility	Yes	57	96.6%	50	94.3%	107	95.5	

have a separate area and separate storage areas for HCW?	No	2	3.4%	3	5.7%	05	4.5	.666
Does the facility have a separate container for Hazardous waste and non-hazardous waste?	Yes	59	100.0%	53	100.0%	112	100	---
	No	0	0.0%	0	0.0%	0	0	
Are all types of Containers are clearly marked and labelled?	Yes	59	100.0%	53	100.0%	112	100	---
	No	0	0.0%	0	0.0%	0	0	
Are all type of containers located in appropriate area where might be needed?	Yes	59	100.0%	53	100.0%	112	100	---
	No	0	0.0%	0	0.0%	0	0	
Does all waste handler wear heavy duty gloves and sturdy shoes when handling medical waste?	Yes	58	98.3%	53	100.0%	112	100	1.000
	No	1	1.7%	0	0.0%	0	0	
Does any formal and informal segregation of waste take place?	Yes	58	98.3%	50	94.3%	111	99.1	0.343
	No	1	1.7%	3	5.7%	01	0.9	
Area containers	Yes	59	100.0%	51	98.2%	108	96.4	

made up of leak proof material (plastic) for disposal of HCW?	No	0	0.0%	2	3.8%	04	3.6	0.222
Does the establishment generate Cytotoxic waste at special concern?	Yes	27	45.8%	20	37.7%	110	98.2	0.390
	No	32	54.2%	33	62.3%	2	1.8	
Does the establishment generate Pathological waste at special concern?	Yes	55	93.2%	42	79.2%	47	42	0.030
	No	4	6.8%	11	20.8.0%	65	58	
	Yes	26	41.1%	9	17.0%	35	31.3	.002

Does the establishment generate Reagent waste at special concern?	No	33	55.9%	44	83.0%	77	68	
Does the establishment generate Out dated pharmaceuticals waste at special concern?	Yes	21	35.6%	11	20.8%	32	28.6	.083
	No	38	64.4%	42	79.2%	80	71.4	
Does the establishment generate Radioactive waste at special concern?	Yes	16	27.1%	8	15.1%	24	21.4	.122
	No	43	72.9%	45	84.9%	88	78.6	
How is Liquid waste disposal?	Sinks	43	72.9%	49	92.5%	92	82.1	0.007
	Sewers	16	27.1%	4	7.5%	20	17.9	
How is the healthcare waste management staff	Dedicated	44	74.6%	46	86.8%	90	80.4	0.302

collected and transported within the hospital?	Department staff	4	6.8%	2	3.8%	06	5.4	
	Both	11	18.6%	5	9.4%	16	14.3	
How often is healthcare waste collected from various departments?	Multiple times a day	41	69.5%	41	77.4%	82	73.2	0.348
	Daily	18	30.5%	12	22.6%	30	26.8	
What methods are used for the Treatment and disposal of healthcare waste?	Land filling	16	27.1%	0	0.0%	16	14.3	<0.001
	Incineration	36	61.0%	44	83.0%	80	71.4	
	Autoclaving	3	6.8%	4	7.5%	7	6.3	
	Landfilling	4	6.8%	5	9.4%	9	8.0	
Are there any recycling practices in place for certain types of healthcare waste?	Yes	9	15.0%	13	24.5	22	19.6	.217
	No	50	84.7%	40	75.5	90	80.4	

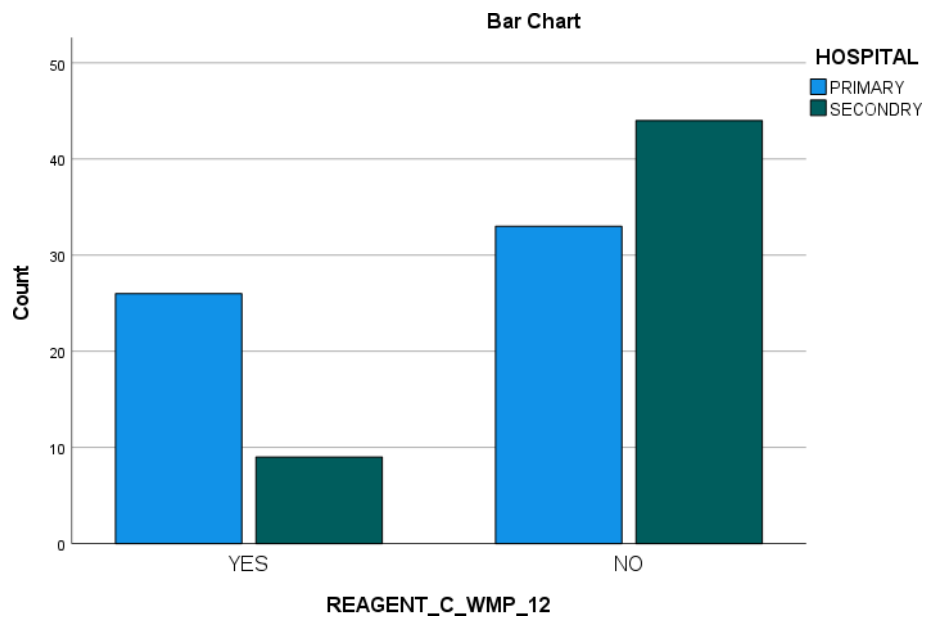


Figure 4.2: Reagent

Table 4.3 shows wide differences in medical laboratory waste management practices between primary and secondary hospitals. A dominant 79.7% of primary hospitals reported the generation of needles and biological waste, compared to only 15.1% of secondary hospitals, with a statistically significant p-value of <0.001 . Secondary hospitals, on the other hand, had a higher proportion (34.0%) of garbage consisting solely of needles and sharps compared to main hospitals (8.5%). Training in waste segregation methods was vastly higher in secondary hospitals (94.3%) compared to main hospitals (78.3%) with a p-value of 0.013, indicating that it was statistically significant.

Knowledge of disposing of medical wastes was significantly very high in the two categories of hospitals, as secondary hospitals presented a higher figure (90.6%) against main hospitals (81.4%), though their p-value was 0.133 and did not show statistically significant results. Secondary hospital personnel possessed a better understanding of chemical waste disposal (58.5%) compared to primary hospital workers (6.8%) regarding awareness of particular types of laboratory waste disposal. Primary hospitals possessed a significantly higher level of understanding of biological waste disposal (49.2%) compared to secondary hospitals (34.0%). The p-value in this case was less than 0.001, indicating a strong statistical association. Regarding the disposal of chemical waste, the two groups of hospitals predominantly dumped waste into the sewage system (75.0%), but lower percentages disclosed improper disposal procedures, like dumping it outside the building or in wells. Biological waste disposal complied with the rules of medical waste companies in most instances (94.6%), with no considerable differences among types of hospitals ($p = 0.369$). These findings suggest significant differences in the generation, awareness of disposal, and levels of training regarding laboratory waste among primary and secondary hospitals, indicating a necessity for improved training and standardized waste disposal practices.

Only 6.8% of primary hospitals used autoclaving and 7.5% of secondary hospitals utilized this method yet evidence reveals no meaningful difference between the two hospital types. The p-value measurement at 0.972 reveals that both hospital types maintain comparable rates of autoclaving adoption. Primary and secondary hospital respondents reported landfilling as a waste disposal method at rates of 6.8% and 9.4% respectively. The p-value of 0.637 confirmed that primary and secondary hospitals demonstrate equal levels of landfill waste disposal practices. The evaluative research examined recycling practices within healthcare waste management operations. The

data indicates that among primary hospitals 15% practiced waste recycling yet secondary hospitals achieved 24.5% implementation levels according to respondent feedback. The statistical analysis through p-value equals 0.217 indicating both types of hospitals present similar recycling protocols. Both hospitals show limited recycling practices making current waste management strategies susceptible to sustainability issues.

Many important findings about hospital classification effects on healthcare waste management strategies emerge from the p-values in this study. Statistically significant results with p-values below 0.05 appeared across multiple areas including both waste segregation approaches that used color-coded bins and labeled containers. The study reveals that main hospitals follow best practices in waste separation better than secondary hospitals do.

Statistical analysis revealed no significant differences between primary and secondary hospitals regarding their trash collection methods and treatment and disposal processes and recycling operations. The p-values from these analyses fell above 0.05, indicating that both types of hospitals hold identical performance levels in these healthcare waste management domains. Analysis of p-values shows healthcare waste management practices like segregation depend on hospital type but trash collecting methods and treatment processes appear unaffected by this distinction. The conclusions obtained through this research are fundamental to comprehend what makes hospital waste management successful along with identifying improvement opportunities. Proper adoption of healthcare waste management practices depends fundamentally on staff training which must be accompanied by outreach initiatives. The study investigated training involvement levels together with their effects on waste management approaches in both primary and secondary hospitals. The recorded training participation rates between main and secondary hospitals show substantial differences.

Table 4.3: Medical Laboratory Waste Management practices

Parameters		Hospital Categories				n	%	p-value
		Primary Hospitals		Secondary Hospitals				
What types of waste Does your laboratory generates?	Needles and biological waste	47	79.7%	8	15.1%	55	49.1	<0.001
	Needles and sharps	5	8.5%	18	34.0%	23	20.5	
	Biological (Patient sample)	0	0.0%	1	1.9%	1	.9	
	Bactria culture media	0	0.0%	1	1.9%	1	.9	
	All	7	11.9%	25	47.2%	32	28.6	
Are laboratory personnel trained in waste segregation procedures?	Yes	46	78.3%	50	94.3%	96	85.7	0.013
	Not sure	13	22.0%	3	5.7%	16	14.3	
Do you have awareness of medical waste disposal of laboratory?	Yes	48	81.4%	48	90.6%	96	85.7	0.133
	No	1	1.7%	2	3.8%	03	2.7	
	Not sure	10	16.9%	3	5.7%	13	11.6	
Which type of laboratory medical waste do you have better awareness of disposal?	Chemical and biological	19	32.0%	0	0.0%	19	17.0	<0.001
	Chemical	4	6.8%	31	58.5%	35	31.3	
	Biological	29	49.2%	18	34.0%	47	42.0	
	Culture media	3	5.1%	2	3.8%	5	4.5	
	Radioactive	4	6.8%	2	3.8%	6	5.4	

What is your hospital's protocol for disposing of laboratory chemical waste?	Sewage	44	74.6%	40	75.5%	84	75.0	0.371
	Pour it in street	0	0.0%	0	0.0%	9	8.0	
	Pour it far away from building	3	5.1%	6	11.3%	18	16.0	
	Pour to in well	12	20.3%	7	13.2%	01	0.9	
What is your hospital's protocol for disposing of laboratory biological waste?	Medical waste e company protocol	54	91.5%	52	98.1%	106	94.6	0.369
	Ordinary waste company	2	3.4%	0	0.0%	2	1.8	
	Landfilling and burning	3	5.1%	1	1.9%	4	3.6	

Table 4.4 The study of healthcare waste management training identified a stark difference between main and secondary hospitals. Whereas 93.3% of staff members in main hospitals had undergone training for waste management processes, only 58.3% of experts in secondary hospitals had done so. This difference, with a statistically significant p-value of <0.001 , demonstrates the value that is given to waste management training in primary hospitals, which translates into greater security and efficiency in waste removal.

Training sessions in primary hospitals were carried out more frequently, usually on a monthly or quarterly basis, while secondary hospitals had sporadic and irregular training timings. The lack of frequent training in secondary hospitals has led to ineffective compliance with waste segregation guidelines and improper disposal measures. Moreover, 30% of workers in secondary hospitals reported receiving zero training, giving rise to concern regarding their exposure to occupational risks like needle-stick injuries and contact with infectious waste. The significant gap in the rates of participation in training underscores the urgent need for organized and standardized training programs in secondary hospitals to ensure compliance and reduce health risks.

Table 4.4: Compliance and Training

Parameters		Hospital Categories						p-value
		Primary Hospitals		Secondary Hospitals		n	%	
Are the healthcare waste management practices at your hospital compliant with national or international regulations?	Yes	54	91.5%	42	79.2%	96	85.7	0.053
	No	0	0.0%	4	7.5%	4	3.6	
	Not sure	5	8.5%	7	13.2%	12	10.7	
How often do you conduct training programs for staff on healthcare waste management?	Monthly	56	93.3%	30	56.6%	86	76.8	<0.001
	Quarterly	3	5.1%	19	35.8%	22	19.6	
	Annually	0	0.0%	4	7.5%	4	3.6	
What topics are covered in the training programs?	Never	0	0.0%	2	3.3%	0	0	<0.001
Waste Segregation	6	10.2%	22	41.5%	28	25.0		
Safe Handling and Disposable Methods	12	20.3%	2	3.8%	14	12.5		
PPE Usage	2	3.4%	2	3.8%	4	3.6		
Spill Management	3	5.1%	1	1.9%	4	3.6		
Others	36	61.0%	26	49.1%	62	55.4		

Table 4.5 In terms of healthcare waste management problems, primary and secondary hospitals both indicated similar challenges, the most cited of which was the restriction of resources, affecting 71.4% of the facilities. Financial limitations, inadequate infrastructure, and lack of enforcement of waste management regulations were other major challenges. Challenges in transportation were more prevalent among secondary hospitals, with 20.8% of employees finding it challenging compared to 13.6% in primary hospitals. Moreover, 8.5% of primary and 5.7% of secondary hospitals faced problems with current disposal and treatment processes, primarily due to dependence on outdated cremation systems. Lack of recycling facilities also compounded waste management issues, with only 15% of primary hospitals and 24.5% of secondary hospitals incorporating recycling into their waste disposal systems. Statistical comparison ($p = 0.217$) revealed there were no meaningful differences in recycling practices between the two types of hospitals, proving that sustainable waste management was still a challenge in all institutions. The research emphasizes the necessity of investments in modern waste disposal technology and stronger regulatory enforcement in order to avoid risks and promote healthcare waste management in both primary and secondary hospitals.

Table 4.5: Challenges and Problems

Parameters		Hospital Categories				n	%	p-value
		Primary Hospitals		Secondary Hospitals				
What are the main challenges your hospital Faces in managing healthcare waste?(Select all that apply)	Lack of resources	42	71.2%	38	71.7%	80	71.4	0.504
	Insufficient training	2	3.4%	4	7.5%	6	5.4	
	Inadequate Infrastructure	8	13.6%	3	5.7%	11	9.8	
	Financial Constrains	4	6.8%	3	5.7%	7	6.3	
	Lack of enforcement	3	5.1%	5	9.4%	8	7.1	
	Yes	8	13.6%	11	20.8%	19	17.0	

Have you experienced any issues with the transportation of healthcare waste?	No	51	86.4%	42	79.2%	93	83.0	
Are there any problems with the treatment And disposal methods currently used?	Yes	5	8.5%	3	5.7%	22	19.6	0.720
	No	54	91.5%	50	94.3%	90	80.4	
How do you handle any Hazardous or	Dedicated spill response team	33	55.9%	30	56.6%	63	56.3	0.439
infectious waste spillages or accidents?	General staff response	20	33.9%	21	39.6%	41	36.6	
	Out sourced service	6	10.2%	2	3.8%	8	7.1	

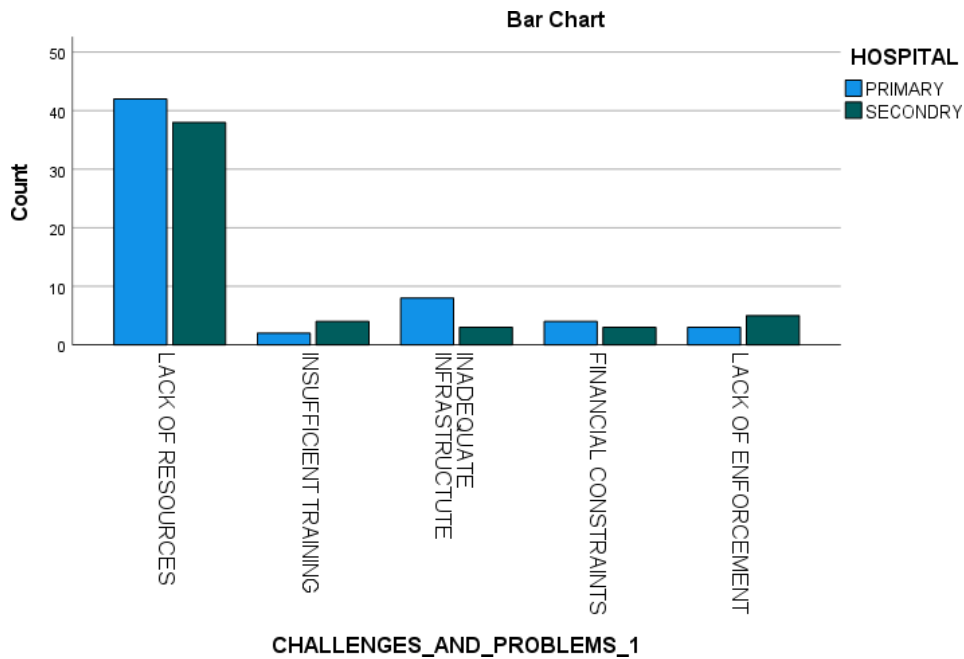


Figure 4.3: Challenges and Problems

Primary hospitals maintain waste disposal balance through incineration and employ autoclaving and landfilling procedures alongside their disposal methods. The comparison test produced a p-value of 0.972 for autoclaving evaluations between primary and secondary hospitals which shows that this procedure occurs identically across both facility types. Most hospitals use autoclaving on a small scale due to insufficient investment in eco-friendly procedures for waste management. Both basic and secondary hospitals lack appropriate recycling systems which creates pressing concerns. The survey revealed recycling processes were established by 15% of primary hospitals together with 24.5% of secondary hospitals. Statistical tests using a p-value of 0.217 indicate that recycling habits in both institutions do not show differences that warrant statistical significance. The low recycling frequency proves that hospitals need to find sustainable waste disposal solutions which reduce their healthcare behaviors' environmental impact.

Chapter 5

DISCUSSION

This research's findings provided critical insights into healthcare waste management practices within basic and secondary hospitals in Mianwali. The findings highlighted clear differences among these hospitals with respect to their waste management practices, compliance rates, and challenges faced. The analysis comparatively compared these results against existing literature, explaining apparent trends and suggesting improvements for HCWM effectiveness.

Waste segregation is also an essential element of healthcare waste management, which ensures safe management and disposal of hazardous waste and reduces risks for healthcare workers, patients, and the environment. The research findings indicated that there was better adherence to segregation technique in main hospitals, where 81.4% of workers used color-coded bins compared with 67.9% for secondary hospitals ($p < 0.001$). The higher compliance of primary hospitals can be attributed to their relatively smaller operating size, making it easier to enact and monitor waste segregation requirements. On the other hand, secondary hospitals generating more waste face operational challenges in upholding stringent compliance with segregation regulations. This finding is consistent with findings from other studies, which report poor waste segregation compliance in large hospitals due to operation challenges and inadequate monitoring (Caniato et al., 2015)[73]. Significantly, secondary hospitals were more likely to use labeled containers for waste segregation, as 26.4% used this method, while no first hospital used labeled containers. This difference shows that primary hospitals use traditional color-coded bins as the main system, but secondary hospitals attempt to upgrade this system with additional labeling. Yet overall compliance with proper segregation protocols in both hospital settings is still inadequate, highlighting the necessity for increased staff training and stricter enforcement of waste management regulations.

Another significant result was the difference in waste types produced by primary and secondary hospitals. Primary hospitals indicated that they produced more infectious and sharp waste (25.4%) than secondary hospitals (0%), whereas

secondary hospitals produced more chemical waste (1.9%) than primary hospitals (0%). But when all waste types were compared together, hospital groups of both types reported nearly the same ratios, with 69.5% of the primary hospitals and 71.7% of the secondary hospitals producing multiple types of trash. The wide disparity in the generation of infectious and sharp wastes reveals that primary hospitals, which deal with more simple medical care, might not have adequate disposal means for harmful wastes, so they accumulate. Conversely, secondary hospitals, which perform more specialized procedures, would most likely have more formalized protocols for dealing with such waste. This is consistent with the findings of earlier studies that tertiary care hospitals produce more chemical and pharmaceutical waste, while primary care centers generate more general medical waste (Al-Khatib et al., 2010)[74].

Storage of medical waste is another important element of HCWM, since improper storage can result in environmental contamination and occupational risks. This survey revealed that 96.6% of primary hospitals and 94.3% of secondary hospitals have specific storage areas for medical waste, indicating a high level of compliance in this regard. Nevertheless, while there were ubiquitous arrangements by all hospitals for having separate containers for hazardous and non-hazardous waste, there were small variations in the quality and location of the containers. In particular, while 100% of hospitals had designated containers, only 98.2% of secondary hospitals used leak-proof materials to dispose of waste, compared to 100% of primary hospitals. This small difference may be due to infrastructure limitations in secondary hospitals, where larger volumes of waste enhance the likelihood of container breakage or leakage. The availability of separate waste storage areas in both hospital settings is in accordance with global HCWM standards, which emphasize the importance of separate storage areas to reduce cross-contamination and unauthorized access (WHO, 2018)[75].

The questionnaire also analyzed the use of protection by the waste handlers, with 98.3% of primary hospital employees and 100% of secondary hospital staff reporting the use of heavy gloves and strong footwear in handling medical waste. High rate of compliance attests to proper knowledge on occupational safety from healthcare workers, which is positive due to dangers associated with direct exposure to risky waste. Yet, informal waste segregation methods were slightly

more prevalent in primary hospitals (98.3%) compared to secondary hospitals (94.3%), indicating that some level of informal handling still exists. This finding emphasizes the need for ongoing training and strict monitoring to ensure that waste segregation is according to laid-down guidelines and not on an ad-hoc basis.

Among the most concerning findings was the significant difference in waste management methods between primary and secondary hospitals. Incineration was the predominant disposal method in both hospital types, with 61% of primary and 83% of secondary hospitals relying on it ($p < 0.001$). This preference for burning is in concurrence with previous studies that ranked incineration as the most frequently used but environmentally risky mode of medical waste disposal in less developed nations (Patwary et al., 2011)[76]. The over-reliance on incineration, especially in secondary hospitals, results in environmental problems, as open and uncontrolled burning can release harmful pollutants like dioxins and furans. Conversely, autoclaving was utilized by only 6.8% of primary hospitals and 7.5% of secondary hospitals, which reflects a lack of up-to-date, environmentally friendly waste treatment technologies. The lack of acceptance of autoclaving can be attributed to economic constraints and the lack of appropriate infrastructure for its implementation. Landfilling was also noted as a treatment choice, having been used by 6.8% of primary hospitals and 9.4% of secondary hospitals. Nonetheless, landfilling is not a recommended disposal method for hazardous medical waste, as it presents risks of soil and groundwater pollution (Ogbonna, 2011)[77].

Medical waste recycling was limited in both hospital types, as only 15% of principal hospitals and 24.5% of secondary hospitals utilized it. The low recycling rate unveils a glaring lacuna in HCWM since items such as plastics, metals, and glass that are recyclable can be recycled rather than being incinerated or landfilled. A number of studies have shown that integrating recycling into HCWM can significantly decrease waste volume and environmental impact while providing economic returns (Nemathaga et al., 2008)[78]. Still, in Pakistan, the lack of structured recycling efforts and garbage sorting infrastructure are key hindrances to sustainable waste disposal practices.

Waste management within laboratories was a key aspect of this study. The findings collected indicated that principal hospitals generated a significantly higher level of biological and sharp waste (79.7%) compared to secondary

hospitals (15.1%), while secondary hospitals generated chemical waste and used a greater variety of waste removal techniques. This could be caused by differences in the level of laboratory testing and the availability of specialist diagnostic facilities in secondary hospitals. Moreover, although laboratory personnel knowledge of disposal of medical wastes was satisfactory for both types of hospitals, chemical waste disposal guidelines had gaps. In particular, 74.6% of primary and 75.5% of secondary hospitals released laboratory chemicals through sewage systems, which is a serious threat to environmental and human health. Research has shown that improper disposal of chemical waste in hospitals can result in contamination of water sources and long-term environmental damage (Raghab et al., 2011)[79]. To solve this problem requires strict enforcement of chemical waste disposal regulations and capital spending on waste treatment technology that deactivates harmful substances prior to disposal.

Conformity with HCWM legislation was also an issue, where major hospitals had better compliance (91.5%) than secondary hospitals (79.2%) ($p = 0.053$). The comparison reveals that secondary hospitals experience more regulatory compliance problems, possibly because they are larger in operational size and have more complex waste disposal needs. Earlier research has also found such compliance deficiencies in other developing countries, where hospitals are not meeting regulatory norms because of financial limitations and lack of institutional resources (Tudor et al., 2005)[80]. Compliance can be enhanced with higher government oversight, regular audits, and capacity-building measures among hospital personnel.

The results on HCWM training also highlight the necessity for improvement in secondary hospitals. Whereas 93.3% of primary hospitals gave monthly training, just 56.6% of secondary hospitals offered monthly training ($p < 0.001$). The lack of frequent training at secondary hospitals certainly accounts for worse compliance rates and inefficient waste management protocols. Research has consistently shown that regular training significantly enhances waste segregation and disposal practices through enhanced staff knowledge and responsibility (Debere et al., 2013)[81]. Secondary hospitals ought to engage in required, structured training programs to enhance HCWM effectiveness and remove environmental and occupational health issues.

Identifying solutions to the challenges experienced by hospitals in the application of HCWM concepts is important in establishing a gap in waste management effectiveness. The survey determined that shortage of resources was the most widely given challenge (71.2% in basic and 71.7% in secondary hospitals, $p = 0.504$). This result aligns with global research that emphasizes economic and infrastructural constraints as key impediments to effective HCWM among underdeveloped countries (Manyele & Anicetus, 2006)[82]. Restrictions on financing do not allow hospitals to invest in significant waste management infrastructure, like specialized waste disposal units and new treatment technology. Poor training (3.4% in primary hospitals compared to 7.5% in secondary hospitals) and poor infrastructure (13.6% in primary hospitals compared to 5.7% in secondary hospitals) were also identified as significant issues. While primary hospitals seemed to have marginally better infrastructure for HCWM, secondary hospitals faced more problems owing to the massive quantity and nature of waste generated.

Another significant issue observed was transportation issues, with 20.8% of secondary hospital staff facing delayed garbage collection versus 13.6% in primary hospitals ($p = 0.311$). This problem could stem from inefficient logistics, absence of specific waste management staff, and poor transport facilities. Research conducted in other low-resource facilities has found these same issues, where garbage pickup delays result in waste accumulation with a higher possibility of disease and contamination (Oweis et al., 2005) [83]. The hospitals need to adopt a planned approach to rubbish transport, arranging timely and proper garbage collection so that risks may be minimized.

Disposal and management of hospital waste are primary issues in both types of hospitals. While 91.5% of primary and 94.3% of secondary hospitals had no issues with their disposal practices, 8.5% of primary and 5.7% of secondary hospitals admitted challenges associated with inefficiencies in treatment. One of the main causes of this is the excessive dependence on incineration, which, as indicated earlier, poses extreme environmental hazards. Secondary hospitals, however, had a greater reliance on incineration, possibly because they have more waste and fewer alternative treatment options. Studies have shown that over-reliance on incineration coupled with inadequate emission controls contributes to air pollution

and increases the risk of respiratory illnesses in surrounding inhabitants (Windfeld & Brooks, 2015)[84]. To eliminate such risks, hospitals ought to switch to safer alternatives such as autoclaving and chemical disinfection that have been effectively implemented in various high-income countries.

Spillage and accident management were also explored under this study, and it was found that 55.9% of primary hospitals and 56.6% of secondary hospitals have spill response teams ($p = 0.439$). Nevertheless, a large percentage of hospitals were still using general staff response (33.9% in primary and 39.6% in secondary hospitals), which is a huge issue. management hazardous waste spills requires trained workers with appropriate protective gear, as poor management can cause occupational exposure to infectious pathogens and toxic substances. The results suggest a pressing requirement for hospitals to create specialized spill response teams and conduct regular training on emergency waste management methods.

The survey also revealed an alarming trend in reagent and pharmaceutical waste management, where 41.1% of primary hospitals and 17% of secondary hospitals reported reagent waste as a major issue ($p = 0.002$). The improper disposal of expired drugs and laboratory reagents has severe environmental impacts, such as contamination of water bodies and land. Research has shown that drug waste is usually disposed of via normal waste streams or dumped into sewerage systems, leading to the buildup of harmful substances in the environment (Abah & Ohimain, 2011)[85]. Secondary hospitals reported less concern for reagent waste, which may reflect poor awareness or inadequate disposal procedures. Policymakers and hospital managers should emphasize establishing clear policies regarding the safe disposal of pharmaceutical and reagent waste while complying with national and global environmental safety standards.

In addition, the research revealed significant differences in liquid waste disposal methods, with 72.9% of major hospitals and 92.5% of secondary hospitals disposing of liquid waste through sinks, while 27.1% of major hospitals and 7.5% of secondary hospitals utilized sewage systems ($p = 0.007$). Dumping of liquid waste through sewers and sinks is common in most hospitals but poses significant environmental and public health hazards if not properly addressed. Toxic substances, disease-causing pathogens, and drug residues are able to infuse water systems, causing long-term ecological and health implications. According to

studies, it has been established that having waste treatment plants within hospital premises can significantly reduce the environmental impact of liquid medical waste (Dasimah et al., 2012)[86]. Based on these findings, hospitals in Mianwali need to invest in liquid waste treatment plants to ensure safer disposal methods.

Finally, this research includes a comprehensive overview of HCWM practices within basic and secondary hospitals in Mianwali that unveil strengths and areas requiring urgent improvement. Though primary hospitals showed greater compliance with segregation policies and training schemes, secondary hospitals were facing serious problems in waste disposal, treatment, and infrastructure. The total reliance on incineration, weak recycling efforts, and inadequate appropriate chemical and pharmaceutical waste disposal methods are key challenges that should be addressed promptly. Overcoming these challenges requires a multi-dimensional approach, involving more staff training, investment in advanced waste treatment technology, more stringent regulatory enforcement, and better logistical support for rubbish transportation. Long-term treatments should be studied in future research to assess their impact on HCWM effectiveness and sustainability in comparable healthcare facilities.

CONCLUSIONS

Research in Mianwali assessed how primary and secondary hospitals manage their healthcare waste through separation protocols alongside storage facilities and transportation systems alongside treatment procedures and regulatory compliance checks. Although healthcare waste management advancements occurred in some areas the assessment confirmed major unmet needs at secondary hospitals due to their bigger size and complex waste flows. Primary hospitals achieved superior compliance rates in segregation protocols together with staff training that enabled 80% adherence to colored bins while also providing regular educational programs. Analysis indicated that 20% of the waste handling protocols at primary hospitals were inadequate and thus required improvement. Secondary hospitals struggled with inadequate processing lines alongside storage infrastructure flaws and depended upon obsolete medical treatment systems. One-third of secondary hospital incinerators did not have pollution control systems in place which created potential harm for both environmental safety standards and public health. Fluctuating waste management procedures caused both slowdowns in waste transport operations and inadequate training for waste handlers that include 22% unsafe and incorrectly mixed gambling materials. The research indicates different targeted measures including investments into modern waste treatment methods like autoclaves and combined stronger HCWM regulation enforcement along with compulsory education programs for medical and waste management personnel. The study reached its primary objective which was to establish key problems in HCWM practices through self-served data from Mianwali but future research should broaden hospital sampling beyond geographically cantered Mianwali and integrate longitudinal behavior analysis for progress tracking. This research demonstrates the essential role of better HCWM systems as a public health and safety requirement even though significant study constraints exist. Healthcare facilities throughout Mianwali and other comparable regions need to address recognized deficiencies to move toward sustainable healthcare waste management practices. The study establishes fundamental groundwork for upstream policy construction which allows healthcare managers to boost medical waste protocols in areas that suffer from limited resources.

Limitations

The analysis delivers useful information on healthcare waste management at Mianwali's primary and secondary facilities but contains specific constraints which need to be recognized. Participants served as the main source of data which could lead to biases from variations in how well regulations and procedures were followed. The research was geographically confined to Mianwali creating risks for reduced applicability of results to various regions having different sociological and infrastructure characteristics. The use of cross-sectional data led to HCWM practices being recorded only at one moment and did not represent seasonal or other time-of-year variations in waste production and treatment methods. The research team used observational techniques for procedure verification but lacked comprehensive evaluation capabilities for environmental pollutants emitted by incinerators because of resource and technical constraints. Although subject to certain limitations these findings provide strong foundations to explore HCWM practices in Mianwali as well as revealing important directions for future research and policy development.

Recommendations

This research provides multiple approaches to enhance healthcare waste management operations across all hospitals in Mianwali at both primary and secondary levels.

- A system of prolonged ongoing training should exist to deliver essential waste management education to healthcare personnel and waste handlers.
- International organizations and governments must fund contemporary medical waste treatment technology implementing autoclaves and microwave systems so natural waste incinerators can be permanently removed from healthcare facilities. Junctions of waste processing facilities reduce transportation costs and streamlines disposal standards thereby benefitting all secondary-level medical facilities.
- Improved compliance together with enhanced accountability can result from strengthened HCWM laws combined with steady audit check methods. From funding difficulties managers could gain advantage through implementing public-private partnership models.

- Local awareness campaigns that detail dangerous waste behavior would establish joint waste responsibility at the grassroots level while building better waste disposal practices.
- When used as a combined strategy these proposed solutions can boost HCWM operations and minimize public and environmental risks across Mianwali district and other underdeveloped regions.

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APPENDICES

ENGLISH CONSENT FORM

The study you are about to participate is a randomized control trial survey titled as;

“EVALUATION OF DIFFERENT HEALTHCARE WASTE MANAGEMENT PRACTICES AND PROBLEMS AMONG PRIMARY AND SECONDARY HOSPITALS IN MIANWALI”

The study has no potential harm to participants. All data collected from you will be coded in order to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

NAME _____

SIGNATURE _____

DATE _____

URDU CONSENT FORM

میں _____ تصدیق کرتا/ کرتی ہوں کہ محمد اسد بلال نے اپنی اس تحقیق

“Evaluation Of Different Healthcare Waste Management Practices And Problems Among Primary And Secondary Hospitals In Mianwali”

زیرنگرانی ڈاکٹر محمد عدنان حفیظ کے متعلق بنا دیا ہے۔ مجھے اس تحقیق کی نوعیت، مقاصد، احداث، توقعات، فوائد اور خطرات کے متعلق ، ساری معلومات فراہم کر دی گئی ہیں

اس تحقیق کے دوران ساری معلومات صیغہ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات صرف تحقیق کے لیے استعمال ہوں گی مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلقہ ہر قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص ک مفاد میں نہیں ہے بلکہ بحسنیت مجموعی انسانیت کا مفاد اس سے وابستہ ہے۔ تمام تفصیلات جاننے کے بعد میں تحقیق میں شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے پر مجھ پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمہ حوش و حواس اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں

دستخط محقق -----

دستخط شرکت کار -----

تاریخ -----

DEMOGRAPHICS FORM & QUESTIONNAIRES

Hospital						
Profession						
How many years of experience?						
Is your hospital a primary or secondary healthcare facility?	Primary			Secondary		
What is the size of your hospital (number of beds)?	Less than 50	50-100	101-200	More than 200		
Current Waste Management Practices						
How does your hospital segregate healthcare waste?	Color-coded bins		Labelled containers		Other	
What types of healthcare waste are generated at your facility?	Infectious waste	Sharp waste	Chemical waste	Pharmaceutical waste	General (non-hazardous) waste	All
How is the healthcare waste collected and transported within the hospital?	Dedicated waste collection staff	Department staff	Both		Other	

How often is healthcare waste collected from various departments?	Multiple times a day	Daily	Every other day	Weekly	Other	
What methods are used for the treatment and disposal of healthcare waste?	Incineration	Autoclaving	Land filling	Chemical disinfection	Microwave treatment	Others
Are there any recycling practices in place for certain types of healthcare waste?	Yes		No			
Compliance and Training						
Are the healthcare waste management practices at your hospital compliant with national or international regulations?	Yes		No		Not sure	
How often do you conduct training programs for staff on healthcare waste management?	Monthly	Quarterly	Annually	Never	Others	
What topics are covered in the training programs? (Select all that apply)	Waste segregation	Safe handling and disposal methods	Personal protective equipment (PPE) usage	Spill management	Others	
Challenges and Problems						
What are the main challenges your hospital faces in managing healthcare waste? (Select all that apply)	Lack of resources	Insufficient training	Inadequate infrastructure	Financial constraints	Lack of regulatory enforcement	
Have you experienced any issues with the	Yes			No		

transportation of healthcare waste?				
Are there any problems with the treatment and disposal methods currently used?	Yes		No	
How do you handle any hazardous or infectious waste spillages or accidents?	Dedicated spill response team	General staff response	Outsourced service	Others
Are there any specific issues related to the segregation of healthcare waste at your hospital?	Yes		No	

PERMISSION LETTER



OFFICE OF THE DEAN-FAHS

SUPERIOR UNIVERSITY

Ref: IRB /FAHS/Allied-HS/10/24/MS/RS-3527

Date: 29th October 2024

Name: Mohammad Asad Bilal (MS Allied Health Sciences)

Registration: SU91-MSAHW-S23-075

Subject: Ethical Approval Letter

The Research Ethical Committee convened on Dated: **17th October, 2024** to discuss your protocol titled **“Evaluation of different healthcare waste management practices and problems among primary and secondary hospitals Mianwali”**

No further corrections and recommendations were suggested. The above-mentioned protocol has been approved after considering various research issues including ethical concerns with condition that the researcher will submit completion report at the end of his/her research.

A handwritten signature in black ink, appearing to read 'Naveed Babur', written over a horizontal line.

Prof. Dr. Muhammad Naveed Babur
Dean/Convener REC
Faculty of Allied Health Sciences
Superior University, Lahore

ETHICS COMMITTEE LETTER

Synopsis entitled as “Evaluation of different healthcare waste management practices and problems among primary and secondary hospitals in Mianwali”. Submitted by Muhammad Asad Bilal Roll no SU91-MSAHW-S23-075 has been approved for research work.

<hr/> Dr. Hafiz Shehzad Muzammil Convener Research Review Board	
<hr/> Dr. Tahira Batool (Member)	<hr/> Dr. Adnan Hafeez (Member)

PLAGIARISM REPORT