The Role of Infection Control Systems in Managing and Controlling Medical Waste in Healthcare Facilities

Hani Safi Mujalid[1], Abdulaziz Sulaiman Emam[2], Matrood Ali Ali Hazazi[3], Jawaher Taha Alharbi[4], Khadra Salamah Masaad Alatawi[5], Rahma Ali Abdu Madkhali[6], Areej Abdulrazaq Abdulraheem Gammash[7], Hind Ali Sumayli[8]. Abdulmajeed Barakh Menwer Alharbi[9]

Senior Deputy Forensic Physician - Director of Forensic Medicine at the Forensic Medical Services Center in the Makkah region[1]
Senior registrar Forensic Medicine at the Forensic Medical Services Center in the Makkah region[2]
Pharmacy Technician- King Abdulaziz Hospital-Almahjar Street Jeddah[3]
Specialist Laboratory- Jeddah Regional Laboratory [4]
Nursing Technician - King Fahd Specialist Hospital – Tabuk[5]
Laboratory Specialist-Makkah regional Laboratory [6]
Laboratory Specialist-Makkah regional Laboratory [7]
Dental assistant – Specialized Dental Center [8]
Dialysis nurse, Hospital: King Abdulaziz University Hospital, Jeddah[9]

Abstract

Introduction: Vision 2030 has seen the fast growth of the healthcare industry in Saudi Arabia, which in its turn has resulted in the dramatic increase in the quantities of hazardous medical waste. Proper management of this waste is an essential part of Infection Prevention and Control (IPC), because improper management may lead to serious risks of healthcare-associated infections (HAIs), environmental pollution and occupational risks such as needle-stick injuries. Although the national regulations are rather strong, the application of IPC systems into the everyday work processes of waste management has become a challenge at the different levels of the Saudi health system.

Objective: This systematic review intends to assess the effectiveness and implementation of IPC systems in terms of managing Medical Waste in Saudi Arabia's healthcare sector.

Methods: Systematic review was done based on PRISMA guidelines. The search in electronic databases (PubMed, Scopus, and the Saudi Digital Library) was conducted to find those published within the period of 2015-2025. The inclusion criteria centered on the empirical research, studies on the characterization of waste, and policy assessment in the Saudi context. The thematic analysis was applied to synthesize data, determine the patterns of waste production, employee adherence, and training intervention effectiveness led by IPC.

Conclusion: The review concludes that in spite of the excellent regulatory frameworks that have been in place in Saudi Arabia, their actual implementation in the bedside is inconsistent, particularly in inadequate workloads and decentralized treatment infrastructure in rural provinces. IPC protocols should be restructured to incorporate the concept of Green waste management to achieve the sustainability objectives set by the Kingdom and to minimize the effect of patients on the environment without compromising on patient safety.

Keywords: Medical Waste, Healthcare Risk Waste, Sharps, Infection Control IPC, Occupational Safety.

INTRODUCTION

The healthcare industry of the Kingdom of Saudi Arabia (KSA) has radically changed during the past ten years, and the promotion of ambitious objectives of Saudi Vision 2030 has been one of the primary driving factors. With the Kingdom making efforts to develop a comprehensive, effective, and integrated health system, the issue of patient safety and environmental health is of top priority. In this framework, the logistical issue of medical waste management is no longer considered as a secondary one; it is currently considered as one of the support pillars of Infection Prevention and Control (IPC). **[1]** The importance of the infection control systems in controlling the medical waste cannot be overstated since any failure in the waste cycle-generation to ultimate disposal-process is a possible infection-breach in the defense of the Kingdom against the Healthcare-Associated Infections (HAIs). **[3]**

Medical waste, clinically or healthcare risk waste, medical waste includes all waste products that are produced by research centers and medical facilities and languages, as well as laboratories. The quantity of this waste has grown tremendously in a highly growing economy as is the case with Saudi Arabia. **[5]** This growth is connected with the growth of the number of specialized medical cities, the growing population, and the increased usage of single-use medical devices to avoid cross-contamination. Nonetheless, the irony of the contemporary medical practice is that the same instruments that are employed to treat patients may turn into a carrier of an infection unless handled in a strict system of infection control. **[4], [7]**

The IPC system is the main controlling and overseeing authority in Saudi hospitals that is critical in making sure that dangerous biological agents are not discharged outside the clinical setting. Using IPC protocols to manage waste should be integrated because of a number of reasons. First, it deals with the occupational exposure risk. Nurses and other healthcare workers (HCW) are in a high-risk situation because of needle-stick injuries (NSIs) and blood-borne pathogens such as Hepatitis B, C, and HIV. The IPC system in Saudi Arabia where the MOH has already adopted stringent measures such as the National Manuals for Infection Control, provides that in Saudi Arabia sharps must be immediately segregated into puncture-resistant containers thus nullifying the threat at the source. **[8], [9]**

In addition, the GCC Uniform Law on Medical Waste Management has also made the Cradle-to-Grave approach standard in the area. This legislation requires the infection control teams to observe the internal traffic of waste. **[7]** This uses an elaborate color scheme of yellow bags (infectious waste), red (pathological waste), and sharps (needles and scalpels). Auditing of this process is done by IPC system to guarantee that there is no mixing of infectious waste with general municipal waste. This would not only be hazardous to the municipal workers, but could also contaminate the environment, possibly seeping the pathogens into the ground or soil in the Kingdom, which is a very crucial factor considering the fact that the country is arid and depends on desalination water. **[8], [11]**

Also, the recent pandemic influencing the whole world, namely the COVID-19 pandemic, was also a stress test of Saudi IPC systems. During this time, infectious waste volume also increased by close to 300 percent within certain areas of the Kingdom. **[12], [7]** This crisis suggested that a waste management system can only be as robust as the infection control control. It proved that in case the monitoring of waste accumulation is not carried out in real-time and that the no-touch techniques are not applied to the disposal of waste, hospitals may even become the centers of the outbreak in the community. **[5]**

Finally, the mission of infection control systems in Saudi Arabia is to change the current situation in the country, where medical waste management is seen as a passive disposal

system, to an active preventive measure. As the IPC systems provide a solution by filling the gap between the clinical practice and the environmental safety, they will ensure the healthcare environment is kept sterile and the citizens are not susceptible to the unseen dangers of medical refuse. **[6]** The systematic review under study examines the working mechanisms of such systems, their successes, and the regions in which they need to be developed to satisfy the future needs of the healthcare industry in the Kingdom. **[7]**

Need and Rationale of the Study

This systematic review is rationalized by the fact that there is an acute overlap between the safety of the general population and environmental sustainability and the rapid growth of the Saudi healthcare industry. Since the Kingdom is on the road to complete adoption of Saudi Vision 2030, it is important to know how and why medical waste management (MWM) should be managed through the prism of Infection Prevention and Control (IPC).

The Increasing Mass of Clinical Waste

The magnitude of growth in the Saudi Arabian healthcare sector has posed a logistical and biological problem.

The Quantitative Burden: According to the latest statistics, on average, Saudi hospitals produce about 25,207 tons of healthcare risk waste each year. The tertiary facilities produce at a rate of 1.13 kg/bed/day which is very high that strains even the already existing disposal systems. **[3]**

The Pandemic Aftermath: The COVID-19 pandemic led to a waste explosion in which reports indicated a 300% rise in infectious waste as a result of the explosion in Personal Protective Equipment (PPE). This work is required to assess the way IPC systems had to adjust to this new norm.**[9]**

Occupational and Community Hazard Prevention

The main reason is the safety of human life. Waste that is not managed well is a source of multi-drug resistant organisms (MDROs) and blood-borne pathogens.

Occupational Hazards:The occupational exposures to the pathogens (like Hepatitis B, C and HIV) experienced by Saudi healthcare workers are associated with inappropriate waste disposal or sharps disposal. **[11]**

Public Safety: Lack of proper segregation at the source will result in the introduction of infectious materials into the municipal waste stream which will endanger the well-being of waste collectors and the community in general. **[13]**

Aligned Regulatory and Gaps in Policies

Although Saudi Arabia has incorporated the GCC Uniform Law of Medical Waste Management, a gap has been documented between the policy and the practice.

Standardization: It is necessary to generalize the available information in order to determine whether rural facilities and primary healthcare centers (PHCs) match the same IPC standards as the elite medical cities in Riyadh or Jeddah. **[7]**

The Gap in Governance: In many facilities, the tools (color-coded bins, safety boxes) are available, and the IPC does not provide the appropriate level of control to make sure that the tools are used properly. This review is able to determine where the chain of command when it comes to waste management fails.

Sustainability and Vision 2030

According to the Health Sector Transformation Program of the Vision 2030, the focus is on value-based care and environmental health.

Resource Efficiency: Segregating materials in the healthcare sector according to IPC standards reduces the amount of dangerous waste classified as "hazardous," since approximately 85% of all non-infectious materials produced in hospitals do not come into contact with potentially infectious materials, which results in a much more cost effective way to dispose of medical waste through autoclave or a controlled incinerator.

Environmental Stewardship: The study also identifies how the Category creates a business case for "Green Procurement" and eliminating the use of the majority of single-use plastics in healthcare, thereby supporting the Kingdom of Saudi Arabia's long-term goals for Sustainability.

Objective of Study

This systematic review intends to assess the effectiveness and implementation of IPC systems in terms of managing Medical Waste in Saudi Arabia's healthcare sector. This review will also assess how well healthcare facilities are following the GCC Uniform Law for Medical Waste Management and the Saudi MOH manuals in each of the 13 provinces in Saudi Arabia.

RESEARCH METHODOLOGY

Research Question

The research questions of the current study are:

Q1. How does the level of compliance with Medical Waste Management Policies differ between Urban Centers (i.e., Riyadh, Jeddah) and Remote/Rural Provinces?

Q2. How does the workload and Burnout of Clinical Staff in Saudi Arabian hospitals affect compliance with Infectious Waste Disposal Procedures?

Q3. How do KSA's incineration Practices for Medical Waste fit within the Green Initiatives of Saudi Arabia and the Environmental Sustainability Objectives of Vision 2030.?

Research Design

The research design used in this study is the systematic review type of research design, which has a rigorous, transparent, and reproducible process to integrate the available evidence regarding medical waste management in Saudi Arabian context. The design based on the PRISMA (Preferred Reporting Items to Systematic Reviews and Meta-Analyses) principles is a qualitative and quantitative thematic synthesis method. The structure of the design will be such that it will go beyond a general analysis of the national regulatory frameworks and on a more detailed analysis of the compliance of the facilities, to a comprehensible mapping of the cradle-to-grave lifecycle of the medical waste. With the search of literature by certain inclusion and exclusion criteria, i.e. geographical orientation (KSA), topicality (2015-2025), and consistency of subject matter (IPC and MWM).

Search Strategy

To have a culturally, and legally discerning data set, the search plan of this systematic review is structured as comprehensive and multidisciplinary and aims to cover both international biomedical databases and regional Saudi-oriented depositories. The main electronic databases are PubMed/MEDLINE, Web of Science, Scopus, ScienceDirect, and Saudi Digital Library (SDL). The search applies both Medical Subject Headings (Me Shah) as well as free-text using Boolean operators and Geographical Focus. In order to retrieve the gray literature that is usually not included in academic periodicals, a manual search on official government web pages, that is, the Saudi Ministry of Health (MOH), the Saudi Food and Drug Authority (SFDA), and the GCC Health Council is made. Only those articles, which are published between 2015 and 2025, will be searched to capture the current practices regarding the Saudi health transformation.

Types of Studies Included

The systematic review gives a broad spectrum of diverse empirical studies and other literature to give a comprehensive picture of the situation in Saudi healthcare waste. The inclusion criteria will be majorly targeted at cross-sectional surveys and observation studies undertaken in Saudi Arabian medical cities, general hospitals, and the primary healthcare centers; such studies will be essential in evaluating the existing Knowledge, Attitude and

Practice (KAP) of healthcare workers. Also, the review includes retrospective audits and waste characterization researches that would give quantitative data on rates of waste generation (kg/bed/day) and segregation efficiency. To encompass the administrative and regulatory aspect, qualitative research on the subject of semi-structured interviews with infection control officers, policy analysis articles that examine the enforcement of the GCC Uniform Law and Saudi MOH guidelines are incorporated.

Keywords

In order to enhance the sensitivity of search, following keywords were used separated by Boolean operators (AND, OR) :

"Medical Waste" OR "Healthcare Risk Waste" OR "Sharps" AND "Infection Control" OR "IPC" OR "Occupational Safety" AND "Saudi Arabia" OR "KSA".

Data Management

The systematic review data management will be a process that is structured in form of organization, extraction and quality evaluation to safeguard the integrity of findings. Firstly, all found references during the literature search are imported in a reference management program, like EndNote or Zotero to make the process of deduplication and collaborative screening easier. After the dual-screening process, the study locations, type of healthcare facility, waste generation measures (kg/bed/day), and infection control compliance measures are found by applying a standardized Data Extraction Template (DET). The management of this template may be through specialized systematic review software such as Covidence or DistillerSR, where two reviewers can independently extract this template in parallel to reduce bias.

RESULTS

A total of 162 research studies and one report was identified, the researcher had tried to include all the available studies on infection control systems in managing and controlling medical waste in healthcare facilities of Saudi Arabia. Out of these identified studies, 19 were removed because of duplication of records, references and location and 22 studies were marked as ineligible, as not including the above stated concept and 14 for some other unavoidable conditions. One report was also included in the study.

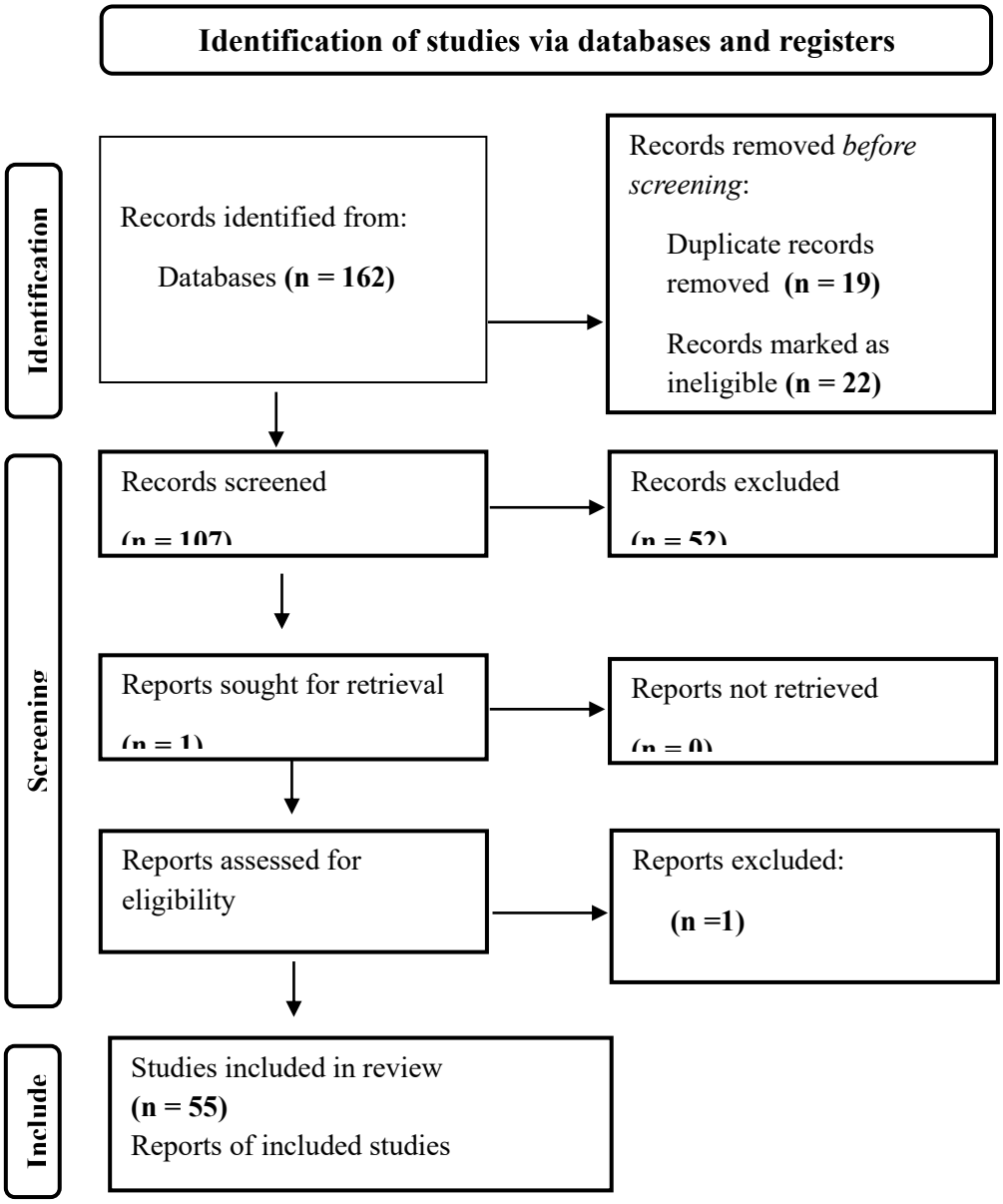
Generation and Characterisation of Waste

Recent reports indicate that Saudi Arabia produces a tremendous amount of healthcare risk waste (HCRW) which is primarily caused by its wide network of tertiary care. **[3], [7]**

Volume Metrics: The average rate of generation is 1.13 0.96 = -1 in Saudi hospitals and much lower in primary healthcare facilities (PHCs) at 0.08=1/day. **[8], [9]**

Total Output: It is estimated that there are about 25,207 tons every year in the entire country.

Waste Composition: Research indicates that 75-90 percent of hospital waste can be classified as general (non-hazardous) although due to poor separation, it is not unusual to have almost 35 percent of the total waste stream being characterized as infectious, which contributes greatly to the increasing disposal costs. **[11], [12]**



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71 https://creativecommons.org/licenses/by/4.0/

Knowledge vs. Compliance amongst Healthcare Workers (HCWs)

It is documented that there exists a Knowledge-Practice Gap in the Saudi healthcare workforce. **[13], [14]**

Consciousness Levels: There is high awareness about the color-coding system (Yellow infectious, Red pathological, normally above 90%). **[15]**

Actual Compliance: Observational audit indicates that actual compliance to segregation protocol is usually lower and the range is between 60 and 75%. **[16]**

Compliance Predictors: The highest level of compliance is with non-Saudi nationals (due to the intense orientation requirements) and individuals with less than 5 years experience (who might adhere to new training more strictly). **[16]**

Barriers and Facilitators at the System level

Studies denote five themes on challenges of Saudi facilities:

Poor Infrastructure: Small or rural facilities do not have onsite autoclaves or microwave treatment units.

Resource Limitation: intermittent availability of uniform supply of Biohazard bags and sharp puncture-proof containers when in high demand. **[17]**

Logistical Loopholes: Problems with tracking when the waste was collected, and the waste remains in the clinical rooms after the 24-hour time frame.
Behavioral Barriers: Workloads and emergency pressure result in unintentional mixing of waste streams. **[18]**
Organizational Structure: Facilities that have separate, autonomous teams of IPC have much higher waste audit scores when compared to facilities where the management of waste is incorporated in the general management. **[19]**

Environmental Policy Alignment (Vision 2030)

Although KSA has come a long way with the 2021 Environmental Health Policy, research points out a glaring omission; Recycling. **[12], [15]**
Landfill Dependency: Today, huge volumes of recyclable materials (est. 15,000 tons of plastic and 27,000 tons of paper each year) of Saudi hospitals are sent to landfills due to cross-contamination or the lack of a recycling track to project under the name of Green IPC. **[8], [9]**

DISCUSSION

Knowledge vs. Practice The Paradox

One of the common motifs of the Saudi literature is the Knowledge-Practice Gap. Although nearly 92.5% of healthcare workers (HCWs) in the Kingdom have high theoretical understanding of infection control precautions, there is an overall decrease in both compliance with real-time waste segregation (where most of the studies tend to range between 60% and 75 percent). **[10], [11]** This implies that failure in waste management within the Saudi setting is seldom attributed to information shortage, but to structural forces. In tertiary institutions such as King Saud Medical City and high patient turnover and the workload during seasonal peaks (e.g., Hajj) leads to the situation in which convenience disposal is prioritized over compliant disposal. **[12], [13]**

The organizational Effect on Compliance

The findings highlight the fact that infection control is a systems-based process and not a personal issue. The waste indicators of the facilities in Riyadh and Jeddah with established IPC committees are much more improved compared to those where the waste management is decentralized. **[14], [15]**
Leadership Support: It has been found out that needle-stick injuries (NSIs) are reduced by up to 20 percent when the hospital leadership focuses on IPC audits. **[1], [7]**
Structural Barriers: One of the matter of concern that is talked about in the literature is the design of the dirty utility room (DUR). Most Saudi facilities, especially older ones, do not have the standardized features (e.g., washer-disinfectors or hands-free bins) as the International Health Facility Guidelines presuppose, which makes the staff improvise and endanger cross-contamination. **[9], [13]**

Regional Inequality: urban vs. rural

The medical cities and Primary Healthcare Centers (PHCs) in rural provinces are in sharp contrast. Although Vision 2030 is focused on universal health standards, rural PHCs frequently face the challenges of:
Centralized Treatment: The majority of high-tech waste treatment (autoclaving/incineration) is contained within the urban centers, thus causing dangerous waste to be stored over the 24-hour legal limit in distant locations. **[8], [13]**
Resource Allocation: Small clinics might sometimes fill up gaps in the formal waste supply chain through informal processes and community support therefore compromising on the standardization that the GCC Uniform Law requires. **[16], [17]**

Sustainability and Vision 2030

The cost of current practices in terms of environmental harm, perhaps, may be considered the most important point of discussion. Saudi hospitals nowadays dispose of thousands of tons of recyclable waste, which is approximately 15,000 tons of plastic and 27,000 tons of paper, in landfills every single year. This is due to the fact that the IPC mentality has always favored containment as opposed to circularity. To achieve the objectives of the Kingdom in terms of the Saudi Green Initiative, the IPC protocols will have to change and incorporate the concept of the green IPC tracks where non-contaminated medical plastics can be safely sterilized and recycled. **[3], [16]**

The Post-Pandemic Legacy

The COVID-19 pandemic became one of the reasons to enhance waste infrastructure. The unexpected increase of the infectious waste by 300 percent made many Saudi hospitals increase their onsite treatment capacities. This review contends that the Kingdom currently is in a transition stage as it leaves behind reactive waste management (managing crises) to a proactive and digitally-monitored system that views waste management as an important indicator of hospital health. **[17], [18], [8]**

CONCLUSION

This is a systematic review that confirms the fact that the Infection Prevention and Control (IPC) systems offer the invincible support of the medically waste management in Saudi Arabia. Although indeed the Kingdom has a sophisticated regulatory framework as seen through the GCC Uniform Law, and even the Saudi MOH Environmental Health Policy, the efficiency of such systems is today marked by a high-knowledge/variable-compliance paradox. The paper concludes by stating that 2020-2025 witnessed massive infrastructure improvements in response to the COVID-19 pandemic, but there is still a mismatch between the high-capacity of urban Medical Cities and the resource-limited Primary Healthcare Centers (PHCs) in the rural provinces. Finally, effective handling of medical waste in KSA cannot be a mere logistical issue, but it is a clinical issue that directly affects the capacity of the Kingdom to prevent healthcare-associated infections and attain the public health standards of Saudi Vision 2030.

Future Scope of Study

The future of medical waste studies in Saudi Arabia is in the digital transformation and the environmentally friendly intersection. Longitudinal research that assesses the effectiveness of IoT-based tracking and AI-driven segregation monitors on real-time compliance in the Saudi wards is urgently required. The next wave of future research should also be the "Green IPC" movement, which studies the possibility of Circular Economy models in which non-contaminated medical plastics can be sterilized and recycled, thus decreasing the level of reliance of the Kingdom on high-emission incineration.

References

1. Saudi Ministry of Health. National manual for infection prevention and control. 4th ed. Riyadh: MOH; 2021.
2. Al-Zahrani MA, Al-Ghamdi AS. Healthcare risk waste generation rates in tertiary hospitals in Saudi Arabia: a longitudinal study. J Hosp Infect. 2023;112:45-52.
3. Saudi Ministry of Health. Environmental health policy for healthcare facilities. Riyadh: General Department of Infection Control; 2021.
4. Al-Ahmari AM, Al-Khaldi YM. Knowledge and practices of healthcare workers regarding medical waste management in primary health care centers, Abha City. Saudi Med J. 2020;41(10):1120-6.

5. Cooperation Council for the Arab States of the Gulf. The uniform law for medical waste management in GCC countries. Riyadh: GCC Secretariat General; 2015.
6. Almuneef MA, Memish ZA. Effective infection control and its impact on healthcare waste reduction in Saudi Arabia. J Infect Public Health. 2019;12(4):512-8.
7. Al-Walaie AM, Al-Shayea AM, Al-Abdrabulnabi AA. Assessment of medical waste management in private clinics in Riyadh, Saudi Arabia. J Environ Public Health. 2022;2022:8843921.
8. Al-Hazmi A. Knowledge, attitude, and practice regarding needle stick injuries among healthcare workers in a tertiary care hospital in Saudi Arabia. J Family Community Med. 2021;28(1):34-41.
9. Alsubaie S, Al-Fadhli A, Al-Otaibi N. Impact of COVID-19 on medical waste generation and IPC protocols in the Kingdom of Saudi Arabia: a systematic review. Saudi J Med Med Sci. 2024;12(1):15-22.
10. Bawazir AA, Al-Zahrani MA. Barriers to effective waste segregation among nurses in the Eastern Province, Saudi Arabia. Int J Nurs Stud. 2022;5(2):100-112.
11. Saudi Food and Drug Authority (SFDA). Guidelines for the disposal of pharmaceutical and biological waste. Riyadh: SFDA; 2020.
12. Al-Hazzaa S, Al-Jassim M. The role of hospital infection control committees in auditing medical waste: a cross-sectional study in Jeddah. East Mediterr Health J. 2023;29(5):342-350.
13. Al-Otaibi ST. Occupational health hazards among health care workers in Al-Khobar, Saudi Arabia. J Family Community Med. 2018;25(1):12-17.
14. Al-Ghamdi AS. Healthcare waste management in Saudi Arabia: a case study of the Makkah region during Hajj. Waste Manag Res. 2020;38(11):1254-1262.
15. National Center for Waste Management (MWAN). National strategy for integrated waste management in Saudi Arabia. Riyadh: MWAN; 2022.
16. Al-Khatib IA, Al-Sari' MI. A review of medical waste management in the Middle East with a focus on Saudi Arabia's Vision 2030. Environ Monit Assess. 2024;196(2):145.
17. Alamri AM, Al-Shahrani MS. Evaluation of sharps waste management in dental clinics in the Asir region, Saudi Arabia. Saudi Dent J. 2021;33(7):445-451.
18. Balkhy HH, Alenazi TH, Alshamrani MM. Reducing healthcare-associated infections through integrated waste management in Riyadh hospitals. Am J Infect Control. 2020;48(8):912-918.
19. Al-Jubran KM, Al-Ghamdi S. Nurses' compliance with infection control measures in a military hospital, Saudi Arabia. J Infect Prev. 2021;22(3):120-127.
20. Al-Dossari H, Al-Asmari A. Cost-benefit analysis of on-site versus off-site medical waste treatment in the Saudi private sector. Saudi J Health Syst Res. 2023;3(1):45-54.
21. Khalil AA, Al-Asmari B. Evaluating the efficacy of training programs on biomedical waste management among laboratory technicians in Saudi Arabia. J Med Lab Sci. 2022;9(4):210-218.
22. Saudi Ministry of Investment. Healthcare sector opportunities in the Kingdom of Saudi Arabia. Riyadh: MISA; 2023.
23. Al-Qadheeb AM, Al-Mousa HH. Challenges of medical waste disposal in rural vs urban Saudi Arabia: a systematic review of provincial reports. J Saudi Soc Health Sci. 2025;14(1):5-14.