ORIGINAL ARTICLE

Environmental Impact of Polymer Based Waste in Dental Teaching Hospitals in Lahore, Pakistan; Should we be Concerned?

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OBJECTIVE: The widespread use of polymer-based materials (PBMs) in dental practices, including gloves, syringes, and suction tips, has raised environmental concerns, particularly in developing countries like Pakistan. Dental teaching hospitals in Lahore generate significant amounts of PBM waste, contributing to microplastic pollution, toxic emissions, and public health risks due to inadequate waste management systems.
METHODOLOGY: A cross-sectional study was conducted in five dental teaching hospitals in Lahore, selected from a total of 10 institutions based on patient volume. Data was collected using a structured questionnaire to quantify daily PBM waste production and analyze waste management practices. Descriptive statistics summarized the data, highlighting trends in PBM disposal.
RESULTS: The five hospitals collectively served 28,800 patients per month, generating 5,766 kg of waste monthly (0.2 kg/patient). Of 430,275 PBM disposables, 44% were polypropylene, 35% latex, 11% polyethylene, and 5% each polyvinyl chloride and polystyrene. Although all hospitals implemented basic waste collection protocols, none employed segregation systems for PBM disposables, raising concerns about improper disposal and environmental contamination.
DISCUSSION: Findings revealed significant reliance on polypropylene and latex, materials known for environmental persistence and toxicity. The absence of segregation protocols and limited accountability of waste disposal companies exacerbate ecological impacts. Interventions such as waste segregation, recycling, and biodegradable alternatives are urgently needed.
CONCLUSION: Dental teaching hospitals in Lahore contribute substantially to PBM waste. Improved compliance with waste management regulations, adoption of sustainable practices, and targeted awareness campaigns are critical to reducing their ecological footprint.
KEYWORDS: environmental, waste, toxic, latex
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INTRODUCTION

The increasing use of polymer-based materials (PBM) in dental practices has raised significant environmental concerns, particularly in developing countries like Pakistan. Dental teaching hospitals in Lahore, as centres of both education and clinical practice, generate substantial amounts of polymer waste, including disposable gloves, syringes, suction tips, and packaging materials. Improper disposal of these materials contributes to environmental pollution, including the release of microplastics and toxic substances into ecosystems.[1]

Studies have highlighted that healthcare facilities in Pakistan often lack adequate waste management systems, leading to the open dumping or incineration of plastic waste, which exacerbates air and soil pollution.[2,3] Furthermore, the degradation of polymer-based materials can release harmful chemicals, including volatile organic compounds (VOCs), leachates, and microplastics, posing risks to both human health and the environment.[4] Despite

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the existence of waste management regulations, compliance remains a challenge due to limited resources and awareness.

This study aims to explore the environmental impact of polymer-based materials in dental teaching hospitals in Lahore, focusing on waste generation, disposal practices, and potential mitigation strategies. By addressing these issues, the study seeks to collect evidence and contribute towards awareness of sustainable waste management practices and reduce the ecological footprint of dental healthcare facilities in Pakistan.

METHODOLOGY

Study Area and Population

This study was conducted in Lahore, the capital city of the Punjab province, located in the northeast of Pakistan. Lahore is the second most populous city in the country, has one government and nine private dental teaching hospitals. All institutions in the city, with a minimum OPD attendance of 100 per working day were invited to join the study.

DATA COLLECTION

Questionnaire Development

A self-designed questionnaire was developed to collect data on the daily consumption of PBM disposables in dental teaching hospitals. The questionnaire was structured into two sets:

1. *Quantitative Data Collection:* This set gathered quantitative data on the number of dental students and practitioners, as well as their practices regarding disposable waste management during daily dental procedures.
2. *PBM Waste Production Data:* This set required detailed quantitative information about the production of PBM dental disposable waste.

The questionnaire was reviewed by three Medical Superintendents of teaching dental hospitals (experts in dental waste management) to ensure content validity and reliability in line with the recommendations of McMillan & Schumacher, 2010.[5]

DATA ANALYSIS

The collected data from the questionnaires were numerically coded and entered into Microsoft Excel 2010 for analysis. Frequency and percentage analyses were conducted to quantify the data. Descriptive statistics were used to summarize the data, highlighting the patterns and trends in PBM disposable waste production.

RESULTS

- Study Duration and Participation

The study was conducted over a period of five months, from March to July 2024, to assess the consumption and disposal of polymer-based material (PBM) disposables in dental teaching hospitals in Lahore. There are ten dental colleges in Lahore, contacts were established with the administrative offices of all ten dental teaching hospitals. Three private dental teaching hospitals declined to participate in the study, and data from two others were excluded due to lower patient pools. Consequently, five dental teaching hospitals (four from the private sector and one public sector institution) agreed to participate.

- Demographics and Participants

Among the 1,354 PBM single disposal waste producers (dental functionaries), the distribution was as follows:

- Undergraduate Students: 63% (n=853)
- House Officers: 18.5% (n=250)
- Postgraduate Students: 3.5% (n=48)
- Clinical Demonstrators: 8.7% (n=118)
- Clinical Faculty: 6.3% (n=85)

This distribution highlights the diverse range of individuals contributing to PBM waste within dental teaching hospitals.

- Patient and Waste Statistics

The five participating dental teaching hospitals collectively served approximately 28,800 patients per month and produced a total of 5,766 kg of solid waste monthly. This corresponds to an average of 0.2 kg of waste per patient and 1,153.2 kg of waste per institution per month.

- Types and Quantities of PBM Disposables

The study revealed that 90% of PBM disposables were used as protective barriers. Among the total 430,275 PBM disposables, the composition was as follows:

- Polypropylene: 44% (n=188,954)
- Latex: 35% (n=152,022)
- Polyethylene: 11% (n=49,424)
- Polyvinyl Chloride: 5% (n=20,160)
- Polystyrene: 5% (n=19,715)

These findings indicate a significant reliance on polypropylene and latex materials in dental practices, contributing to the overall environmental burden due to their persistence and potential toxicity.

- Hospital Waste Management Practices

All participating dental teaching hospitals had established their own waste management strategies and had trained staff to manage waste effectively. The majority demonstrated satisfactory practices regarding the collection of waste, adhering to prescribed protocols. However, none of the teaching hospitals had segregation protocols in place for

polymer-based materials. Proper and timely waste collection was observed in all institutions except one, which exhibited some deficiencies in this regard.

Digital X-ray technology was predominantly used for imaging, reducing the reliance on traditional X-ray films, which also contribute to waste. All hospital waste was managed and disposed of by their respective waste management companies. However, the hospitals were unaware of how this waste was ultimately disposed of by these companies.

DISCUSSION

While commendable efforts have been made in waste collection, the lack of segregation and unclear disposal pathways are critical issues that require immediate attention. By prioritizing sustainable waste management practices and fostering a culture of environmental accountability, dental teaching hospitals can significantly reduce their ecological footprint and set an example for other healthcare institutions in Pakistan.

Improved access to dental care has led to a rise in waste production, emerging as a significant concern for both national and international authorities due to its environmental and public health implications.[6] A study in 2009, identified healthcare waste as a growing challenge in numerous major cities and rapidly urbanizing areas across Africa, Asia, and the Middle East. Pakistan was one of the countries included in this study. The concerns stemmed not only from the increasing volumes of waste but also from the complexities associated with its effective management.[7]

The average waste generation of 0.2 kg per patient reported in this study is comparable with the figures quoted by WHO for developing countries[8], and it underscores the scale of the issue, which is further exacerbated by the lack of proper segregation protocols.

The absence of segregation protocols in the participating hospitals is consistent with findings from other developing countries, where healthcare facilities often struggle with inadequate resources and limited awareness regarding effective waste management. WHO reports that between 20% and 60% of healthcare facilities in 22 developing countries lack proper waste management systems, including segregation at the source, appropriate storage, collection, transportation, treatment, and disposal.[8,9]

Additionally, research highlights that clinical waste mismanagement is a serious environmental concern in developing nations, particularly due to rapid urbanization and the expansion of private healthcare facilities. A lack of knowledge and awareness among healthcare workers has been identified as a major barrier to implementing effective waste segregation practices.[3]

The World Health Organization (WHO) has also emphasized that improper healthcare waste management poses significant risks to both human health and the environment, particularly in low-income countries where hazardous waste disposal remains a challenge.[10]

The present study provides insights into the environmental impact of PBM disposables in dental teaching hospitals in Lahore. The findings highlight the environmental burden posed by polymer-based material (PBM) disposables in dental teaching hospitals in Lahore. With 90% of disposables used as protective barriers; and polypropylene and latex accounting for 79% of the total disposables, these institutions are substantial contributors to polymer waste. The ever-increasing dependence of these materials in healthcare industry is well documented.[11]

The World Health Organization (WHO) has emphasized the need for proper segregation and disposal of PBM waste to minimize its environmental impact.[11] These materials are known for their persistence in the environment. Most PBM can take decades to degrade, contributing to microplastic pollution in ecosystems.[12] The incineration of these materials produces toxic emissions, including dioxins and furans, which pose serious health and environmental risks.[13] Despite these concerns, healthcare facilities in many low-resource settings, including Pakistan, continue to rely on incineration as a primary disposal method, often without adequate emission control measures.[14]

The absence of segregation protocols in the participating hospitals aligns with findings from other developing countries, where healthcare facilities often lack resources and awareness for effective waste management.[6,15] A policy brief from the Asian Development Bank Institute highlights the importance of waste separation in developing Asian countries, emphasizing that structured segregation practices improve recycling rates and reduce overall waste.[16] Similarly, The United Nations Environment Programme published a guide on improving waste management and addressing plastic pollution in Southeast Asia, detailing proven practices for waste segregation and reduction.[17] Proper segregation is critical for recycling and reducing environmental harm, yet none of the hospitals in this study had such systems in place.

The reliance on external waste management companies without transparency regarding final disposal raises concerns about the ultimate fate of PBM waste. Studies have shown that in Pakistan, healthcare waste is often subjected to open dumping or unsanitary landfilling, contributing to soil and water contamination.[14,18] This lack of accountability limits the effectiveness of existing waste management systems.

The study finally highlights a disconnect between existing waste management regulations[19] and their enforcement.

Strengthening compliance with these regulations is essential for ensuring that dental teaching hospitals adhere to environmentally responsible practices. Collaborations with regulatory bodies can further support the implementation of sustainable waste management systems. Enhancing awareness among dental students and faculty through targeted training programs is also essential for fostering sustainable practices. Educational initiatives can help bridge the gap between existing regulations and their implementation.

The management of healthcare polymer-based solid wastes in Pakistan, as in many other developing countries, has not received the necessary attention and concern. A significant lack of knowledge and awareness exists regarding polymer-based healthcare waste management. Notably, no interventional studies have been conducted to address this critical issue, and existing literature offers limited insight into the practices of health workers in government sector hospitals, private hospitals, teaching hospitals, or clinical settings.

The findings of this study underscore the urgent need for sustainable waste management practices in dental teaching hospitals. Implementing segregation protocols, promoting recycling, and adopting biodegradable alternatives can significantly mitigate the environmental impact of PBM disposables. These findings align with global calls for reducing plastic waste in healthcare and transitioning to more sustainable materials.[20] Polymer-based materials, commonly used in dental practices, pose a substantial environmental threat. These materials not only harm human health but also contribute to climate change on a global scale.

CONFLICT OF INTEREST

None to declare

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