Healthcare plastic waste: A global synthesis of estimates across scales and contexts

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Abstract: Healthcare plastics are essential for sterility and affordability but pose significant waste management challenges, exacerbated by the rise in single-use plastics, particularly during the COVID-19 pandemic. This study reviews 25 studies across 17 countries, analyzing healthcare plastic waste at the national, hospital, departmental, and procedural levels. Findings reveal substantial variations, with national estimates ranging from 15,000 to 1.7 million metric tons annually and hospital-level waste averaging 0.44 kg per patient per day. The results highlight the urgent need for improved circular economy solutions to reduce healthcare plastic waste.

Healthcare plastics are integral to modern medical practices due to their versatility, affordability, and compatibility with sterility requirements (1). However, these same properties pose challenges in managing healthcare plastic waste. With the healthcare supply chain being tightly regulated to prioritize patient safety (2), the widespread use of plastics has led to increased plastic waste generation. Since 2010, global concerns over plastic waste management have grown, particularly due to heightened awareness of its impact on marine pollution, driving research into healthcare plastic waste management (2). The COVID-19 pandemic further intensified the use of single-use (or disposable) plastics to mitigate virus transmission, leading to a surge in plastic waste and mismanaged personal protective equipment, underscoring the need for improved waste management strategies (3). This paper aims to classify the literature that quantifies healthcare plastic waste in terms of study scale, geographical scope, and year. We conducted a systematic literature review following the PRISMA guidelines, using the Web of Science database. We identified 25 studies involving 17 countries in different regions of the world, and extracted and synthesized data on

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quantities and compositions of healthcare plastic waste at the scales of procedure, department, hospital and country.

ESTIMATION OF THE QUANTITY AND PROPORTION OF HEALTHCARE PLASTIC WASTE

Twenty-five studies assessed healthcare plastic waste across 17 countries and four different scales, resulting in 31 distinct data sets. These data sets included estimates of plastic waste generation by mass and the proportion of plastics within the overall medical waste composition (%) (Table 1).

		Healthcare Plastics Waste (kg)				Proportion of Plastics in Healthcare Waste (%)			
Level	**Unit**	**n**	**Min**	**Max**	**Avg**	**n**	**Min**	**Max**	**Avg**
Country	kg/year	4	1.50×10^7	1.70×10^9	6.07×10^8	2	23	49	49
Hospital	kg/patient/day	9	0.11	1.65	0.44	12	9	71	28
Department	kg/patient/day	3	1.29	5.04	2.63	3	27	65	51
Procedure	kg/procedure	8	0.35	16.00	3.31	7	14	100	43

Table 1. Synthesis of estimation of healthcare plastic waste (kg) and composition (%). Note – kg: kilograms; n: sample number; Min: minimum value; Max: maximum value; Avg: Average. Source: Authors.

For plastic waste generation, estimates varied by study, with hospital- and departmental-level data often reported as total mass, mass per person per year, or mass per bed per day. In contrast, procedure-based estimates were expressed as mass per procedure or treated condition. While no global estimates of healthcare plastic waste generation were identified, four studies provided aggregated national estimates of plastic waste generated by healthcare organizations.

The US produces approximately 1.7 million metric tons (Mt) of healthcare plastic waste annually, followed by 125,000 Mt in Germany and 15,000 Mt in Saudi Arabia. Based on World Bank population data from 2023, these figures correspond to 5.1 kg, 1.5 kg, and 0.4 kg per capita per year, respectively. Additionally, one study from the UK estimated that 590,000 Mt of packaging-specific healthcare plastic waste was generated (2), equating to 8.6 kg per capita per year.

At the hospital scale, an average of 0.44 kg of healthcare plastic waste was generated per patient per day, based on data from nine studies. The US reported the highest value at 1.65 kg/patient/day, while India had the lowest at 0.11 kg/patient/day. Two hospitals, one in Germany and one in Burundi, reported approximately 0.5 kg/patient/day.

At the procedure scale, studies were available for only four countries—

the U.S., Denmark, Italy, and the UK—covering a total of eight procedures (Table 1). Across these procedures, the average plastic waste generation was 3.3 kg per procedure. Ramos et al (4) reported an average of 16 kg of plastic waste per surgical procedure in Denmark, based on observations from 46 procedures across gynecology, orthopedics, gastroenterology, and urology departments. This value represents a significant outlier. When excluding this extreme case, the average plastic waste generation across the remaining seven procedures was 1.5 kg per procedure, with values ranging from a minimum of 0.4 kg to a maximum of 3.4 kg.

Twenty-four studies provided estimates of waste composition, reporting the proportion of medical waste attributed to healthcare plastics across various contexts (Table 1). Only two studies presented country-level composition estimates, with plastics accounting for 23% of medical waste in the UK and 49% in the US. Similarly, only three studies reported composition estimates at the departmental level. In an Australian intensive care unit, plastics comprised 27% of medical waste, whereas in the US, healthcare plastics accounted for 60% of waste in an inpatient unit at an urban quaternary-care hospital, and 65% in a Level I Trauma Center at an urban, tertiary-care academic medical facility.

Figure 1 illustrates the relationship between the mass of healthcare plastic waste at the hospital level (measured in kg per patient per day) and various national indicators: (A) healthcare spending per capita, (B) Healthcare Access and Quality (HAQ) Index, (C) municipal solid waste generation, and (D) Environmental Performance Index (EPI). The strongest correlations are observed with healthcare spending ($r = 0.67$) and municipal solid waste generation ($r = 0.66$), indicating that countries with higher healthcare expenditures and overall waste generation tend to produce more healthcare plastic waste per patient. Conversely, the correlations are weaker with the HAQ Index ($r = 0.35$) and EPI ($r = 0.43$), suggesting that better healthcare access and environmental performance are less directly linked to hospital plastic waste levels. The US consistently appears as an outlier with the highest plastic waste generation, while countries like India and South Korea report significantly lower values. These findings suggest that economic and waste management factors may play a stronger role in determining healthcare plastic waste generation than healthcare quality or environmental policies.

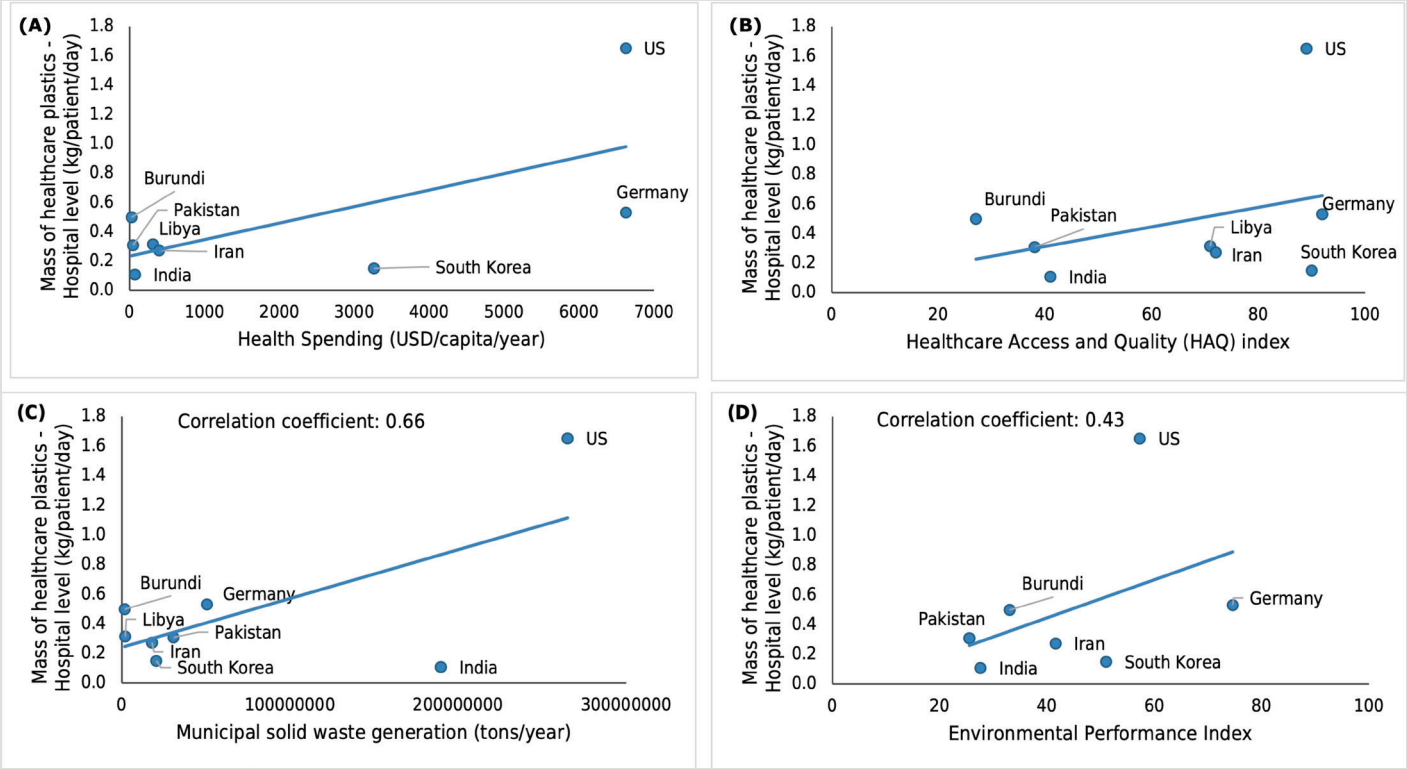

Figure 1. Healthcare plastics mass per country at the hospital level and (A) Healthcare expenditure (USD/capita/year). Note: Data retrieved from World Bank[1]. (B) Healthcare Access and Quality (HAQ) index. Note: Data retrieved from the GBD 2016 Healthcare Access and Quality Collaborators[2]. (C) Municipal solid waste generation per country (tons/year). Note: Data retrieved from Block et al[3]. (D) Environmental Performance Index (EPI). Note: Data retrieved from Patrucco, Gavelli and Balbo[4].

CONCLUSION

This study synthesized existing literature on healthcare plastic waste, quantifying its generation across different scales and geographical contexts. The findings highlight significant variations in plastic waste production, with national estimates ranging from 15,000 metric tons in Saudi Arabia to 1.7 million metric tons in the US, and hospital-level waste generation differing widely between countries. Procedure-specific data further demonstrated the substantial plastic footprint of medical interventions, with some surgical procedures generating up to 16 kg of plastic waste. Waste composition estimates also varied, with plastics accounting for 23% to 49% of total medical waste at the national level and reaching as high as 65% in certain hospital departments. These insights underscore the urgent need for improved plastic waste management strategies in healthcare settings. Future research should focus on refining data collection methodologies, expanding geographical coverage, and evaluating the effectiveness of circular economy approaches in reducing healthcare plastic waste.

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