

Review

Food Waste in Hospitals: Determining Factors and Sustainable Strategies for Mitigation

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Abstract

Food waste generated by hospitalized patients represents a significant challenge with environmental, economic, and social implications. In this context, Sustainable Development Goal 12, which promotes responsible consumption and production patterns, highlights the urgency of reducing this waste as an essential measure to mitigate climate change, optimize resource use, and improve the sustainability of health and food systems. This study presents a narrative review of the literature, complemented by a bibliometric analysis, aimed at synthesizing the available evidence on food waste in hospitals. Based on the identification of 746 records in different databases published between 2019 and 2024, studies focusing on the determining factors, quantification methods, and sustainable strategies to mitigate hospital food waste were included. The lack of menu personalization, the perceived low quality of food, operational disorganization, and reduced patient appetite are identified as relevant factors associated with waste at the hospital level, while direct weighing remains the most accurate quantification method. The sustainable strategies reviewed can reduce food waste and improve hospital sustainability; however, there remains limited assessment of their long-term impact. Our results highlight the urgent need to address food waste in hospitals through the implementation of comprehensive, evidence-based strategies.

Keywords: hospitals; food waste; sustainability; food waste quantification; food services; sustainable strategies

1. Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that one-third of the food produced worldwide is wasted [1]. Reducing food waste is a key strategy for moving towards sustainable food systems as part of the actions to achieve the Sustainable Development Goals (SDGs) established by the United Nations. Target 12.3 of SDG 12 (Responsible Consumption and Production) states that by 2030, global per capita food waste at the retail and consumer levels should be halved, and food losses in production and distribution chains, including post-harvest losses, should be reduced [2]. In line with target 12.3, the United Nations Environment Programme (UNEP) and FAO have developed guidelines such as the “Target, Measure, Act” approach, which establishes a clear methodology for setting targets, periodically measuring food waste, and acting through strategies defined for each sector (households, food services, and retail). This methodology allows for the establishment of reliable baselines and facilitates the monitoring of progress towards the SDGs. It should be noted that, within this framework, the FAO defines food



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loss as that which occurs from harvest to retail, while food waste is generated at the retail and consumption levels.

Waste generated at the post-consumer stage stands out as one of the sources with the greatest negative impact on the environment, since this waste also involves the direct loss of resources used in its production, such as water, energy, and soil, which contributes significantly to the increase in greenhouse gas (GHG) emissions [3]. It is estimated that between 8 and 10% of global GHG emissions come from food waste [4]. Research shows that among the foods most deposited in post-consumer landfills are fruits and vegetables, bread, meat, poultry, fish, and dairy products, which generate large GHG emissions [5]. Food waste must be reduced, as millions of people do not have access to food. In the United States, 40% of the food produced is not consumed, and in India, each household wastes 50 kg of food per year [6]. In Chile, 15.6% of the population does not have regular access to sufficient nutritious food and suffers from some form of food insecurity [7].

In 2021, Chile generated 5.18 million tons of food waste, with fruit being the largest contributor at 2.5 million tons (48% of the total). Vegetables accounted for 0.8 million tons (16%) of the food waste from industry, restaurants, food services, and households [7]. A review study conducted in Chile analyzed scientific publications generated in the country on food loss and waste (FLW), focusing on its quantification and the application of the “three Rs rule” (reduce, reuse, and recycle). The results showed that only 32% of the articles reviewed addressed the quantification of food waste, with direct weighing standing out as one of the methodologies used. In addition, recycling is the most researched strategy, while actions aimed at reduction and reuse are limited. Currently, there is no information available on the amount of food deposited in landfills in Chile [8].

According to the 2021 Food Waste Index report by the UNEP, most studies addressing the issue of food waste were conducted at the household level or during harvest, highlighting the urgent need for more research in the food service sector, considering that its final destination is usually landfills, which generate large GHG emissions [9]. Within food services, hospital food and nutrition services stand out, as they are designed to meet the specific needs of patients by providing safe food and prepared meals that meet their nutritional requirements [10]. However, this process can lead to leftover portions, uneaten food, and inadequate management of generated waste [11]. Although specific factors related to patients’ health status, medical interventions, surgical procedures, or limitations resulting from acute illnesses can influence reduced food intake, it is also essential to recognize the influence of organizational and management factors. Research has shown that inefficient menu planning, failure to adapt services to patients’ food preferences, and the absence of strategies to properly manage food that is served but not consumed are some of the factors that contribute to food waste in hospitals, which also impacts patient nutrition [12]. Recent studies reveal that up to 25.4% of food served to hospitalized patients is wasted in the Eastern Mediterranean region [13]. Another research study conducted in two wards of a public hospital in the Netherlands measured the food waste generated on the plates of all meals served to adult inpatients over a week, calculating and comparing the average grams of waste per meal, resulting in an average waste of 81 g per serving [12].

Food waste in hospitals is defined as food that has been served and not eaten by patients, and which has the physical and chemical properties necessary to meet the nutritional requirements for proper recovery [14]. It has also been defined as waste from hospital meals, referring to meals served that remain unconsumed by patients [10]. A study conducted in Australia in three public hospitals categorized food waste, also differentiating between trays distributed but not delivered to patients, where it was identified that 20% of the total food discarded corresponded to complete trays that were not consumed, generating total waste of the food served on them [15]. This type of food waste presents a significant

challenge with implications at multiple levels, from environmental and financial impact to the sustainability of health systems, as this problem can reveal inefficiency in food resource management and compromise the ability of hospitals to operate in an economically and environmentally responsible manner [16]. Despite efforts to minimize this problem, studies have identified significant gaps in the implementation of effective strategies [17]. Quantification models for food waste used in hospitals vary in accuracy and scope, ranging from direct measurements by weighing to simpler, but less reliable, visual analyses [14]. Adoption of sustainable approaches, such as menu customization or waste reuse, remains limited, despite their potential to mitigate both waste and its environmental impact [10]. These reviews have mainly focused on partial approaches, such as quantifying waste, evaluating specific strategies, or analyzing sustainable food systems, without systematically integrating determining factors, quantification methods, and mitigation strategies from a joint perspective. Furthermore, there are no bibliometric analyses that allow for the contextualization of temporal evolution, thematic trends, and geographical gaps in scientific production in this field using ScienceDirect, Web of Science, Scopus, and Google Scholar. Our narrative review, complemented by a bibliometric analysis, which is unlike previous reviews that address these components in a fragmented manner, seeks to provide an integrative approach that allows for a comprehensive understanding of the phenomenon of post-consumer food waste in hospitals. Here, we identify common patterns, knowledge gaps relevant to decision-making, and opportunities for the design of sustainable strategies applicable to different health systems.

That is why, to develop effective solutions that promote significant change in managing this waste with an approach that would optimize resources in hospitals and also align their practices with SDG 12, it is essential that research comprehensively addresses the quantification of hospital food waste and identifies the determining factors that contribute to its generation. The lack of efficient management of this waste also represents a significant economic loss. This absence of data highlights the importance of drawing on research conducted in different countries, which can be used as a reference to understand the magnitude of the problem and guide future strategies, as well as recognizing the countries with the highest scientific output and identifying lines of research and collaboration between countries through the development of bibliometric analysis. Therefore, the present study aims to conduct a narrative review of food waste in hospitals, with an emphasis on post-consumer waste generated by hospitalized patients, addressing the main determining factors, the methods used for its quantification, and the sustainable strategies proposed for its mitigation. Additionally, a complementary bibliometric analysis is incorporated to contextualize these findings within the evolution, structure, and geographic distribution of international scientific production in this field.

Through this review, we identify knowledge gaps, relevant opportunities for the management of hospital food services, and the design of public policies aimed at the sustainability of the health system.

2. Materials and Methods

This study is a narrative review based on the identification, selection, and analysis of relevant studies published between 2019 and 2024, supplemented by a bibliometric review. The bibliographic search was conducted in the academic databases ScienceDirect, Web of Science, Scopus, and Google Scholar, using combinations of keywords related to food waste in hospitals, such as “hospital food waste,” “sustainability,” “food waste quantification,” “hospital nutrition services,” and “determining factors,” Boolean operators, and combinations of terms were used to broaden and refine the results obtained. The selection criteria included original articles published in English and Spanish that met the following

inclusion criteria: (i) studies that explicitly addressed food waste generated by hospitalized patients; (ii) research conducted in the context of hospital food services; and (iii) studies that analyzed at least one of the following aspects: quantification of food waste, determining factors of its generation, and/or sustainable strategies for its mitigation (see Table 1). Studies that were excluded focused on outpatient food services, food waste generated in the home or other non-hospital settings, as well as review articles, editorials, commentaries, and publications that did not present empirical data or adequate methodological rigor. Search strategies were adapted to the specific characteristics of each database. The selection process was carried out progressively, beginning with the initial identification of records based on titles and abstracts, followed by the elimination of duplicates and the exclusion of publications that did not meet the defined criteria. Subsequently, full texts of potentially eligible studies were evaluated in detail to determine their final inclusion, considering their thematic relevance and consistency with the objectives of the review, according to the selection scheme presented in Figure 1.

Table 1. Inclusion and exclusion criteria for studies in the review.

Inclusion Criteria	Exclusion Criteria
- Studies published between 2019 and 2024 - Studies that explicitly addressed food waste generated by hospitalized patients - Research conducted in the context of hospital food services - Studies that analyzed at least one of the following aspects: quantification of food waste, determining factors of its generation, and/or sustainable strategies for its mitigation	Studies that focused on: - Outpatient food services - Food waste generated in the home or other non-hospital settings - Review articles, editorials, commentaries, and publications that did not present empirical data or adequate methodological rigor.

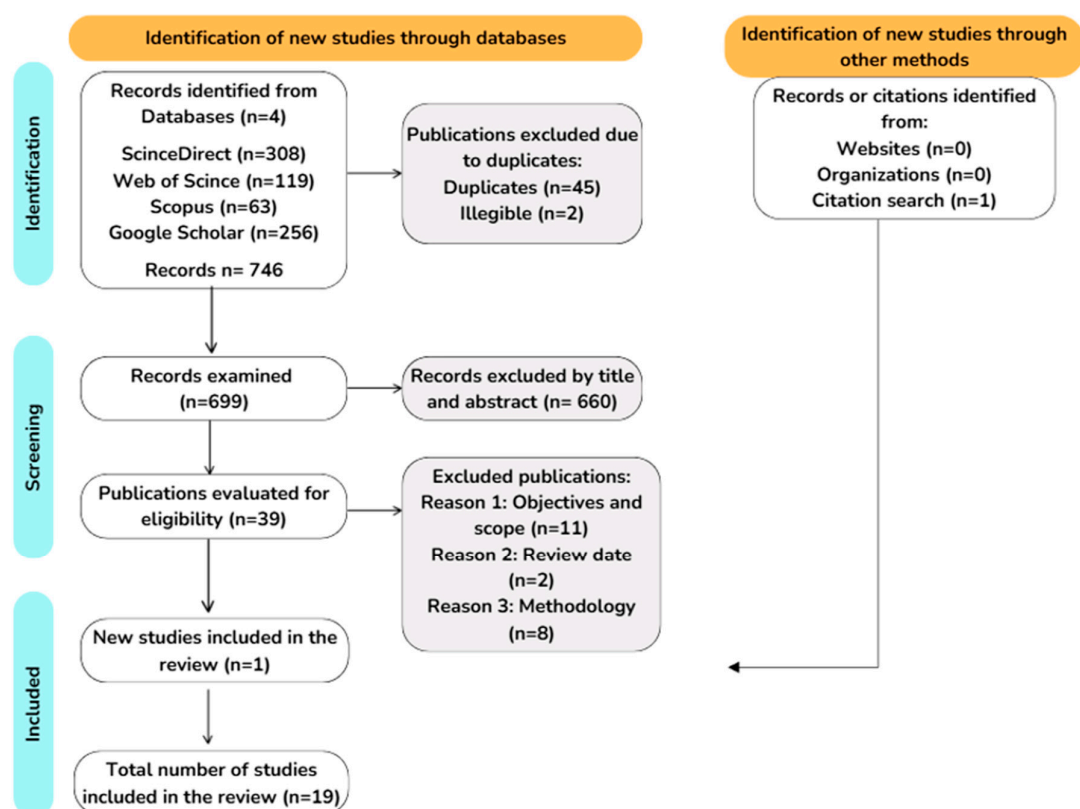


Figure 1. Selection of studies in the narrative review.

In order to comprehensively address the objectives of this review, a combined methodological approach was adopted that integrates a narrative review of the literature with a complementary bibliometric analysis, in order to characterize international scientific production related to hospital food waste, identify recurring lines of research, and explore collaboration networks between countries. To this end, three indexed databases were used: Web of Science, ScienceDirect, and Scopus. Google Scholar was excluded due to its incompatibility with the analysis programs used. Searches were performed using specific Boolean operators in each database: in Scopus, the logical operation hospital AND food AND waste AND sustainability was used; in ScienceDirect, hospital AND “food waste” AND quantification AND factors AND food management AND food service AND sustainability; and in Web of Science, hospital AND food AND waste AND sustainability. The queries were restricted to publications between 2019 and 2024 and limited to titles, abstracts, and author keywords.

A total of 490 scientific articles that met the established criteria were collected, including original studies and research articles. For the bibliometric analysis, Bibliometrix software (version 4.3.0) was used, which allowed working with only one database at a time. Although both Scopus and Web of Science were compatible with this program, it was decided to use only the Web of Science database, as it contained a greater number of articles relevant to the study. Files were exported in Plain Text format to ensure compatibility with the software. This platform was used to analyze global scientific output and the distribution of publications by country, as well as international collaborations. At the same time, scientific articles from Web of Science, Scopus, and ScienceDirect were downloaded in RIS format and processed using VOSviewer software (version 1.16.20), which allowed for the generation of visualizations of keyword co-occurrence networks and their temporal evolution during the period analyzed. For this analysis, a minimum of seven occurrences per word was established, allowing 40 of a total of 1955 identified terms to be included. Figure 2 shows the search plan used to locate the selection of articles included and perform the bibliometric analysis.

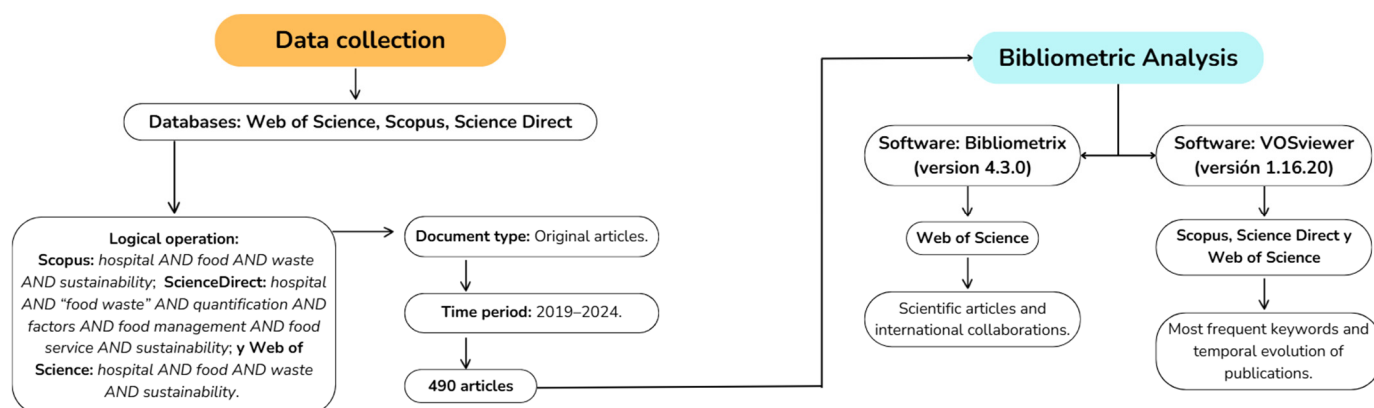


Figure 2. Bibliometric analysis methodology.

3. Results

3.1. Narrative Review

A total of 19 studies were included in this review. Initially, 746 records were identified through searches in databases such as ScienceDirect (308), Web of Science (119), Scopus (63), and Google Scholar (256). After removing 47 duplicate or unreadable publications, 699 records remained for review of titles and abstracts. Of these, 660 records were discarded for not meeting the inclusion criteria, leaving 39 publications for detailed evaluation. Subsequently, 21 additional studies were excluded for reasons such as limited

focus in terms of objectives and scope (11 studies), outdated publication date (2 studies), and methodological problems (8 studies). One study identified through a citation search was included. Finally, 19 studies met all inclusion criteria and were selected for this review.

3.1.1. Determinants of Hospital Food Waste

Of the 19 articles analyzed in this review, 8 (42%) conducted direct measurement and analysis of the results of the determinants of hospital food waste within their research. These studies highlight various factors that influence the generation of this waste, providing a perspective for analyzing the components that affect this phenomenon within food services (see Table 2).

Table 2. Summary of the determining factors of hospital food waste identified in the review.

Determining Factors	Description	Main Results	Population or Sample	Country	Type of Study	Author
Lack of appetite and interest in food on the part of the patient. Poor quality of raw materials and excessive quantity of food. Lack of personalization of menus.	Low appetite or lack of interest in food due to medical conditions or personal preferences. Includes aspects such as taste, esthetics, lack of variety, and excessive portions. Standardized menus.	Reduced appetite, food quality and quantity, and lack of personalization were identified as contributing factors to food waste.	n = 40 hospitalized patients.	Australia	Qualitative (semi-structured interviews)	Porter and Collins [17]
Poor quality of raw materials and poor patient perception of food.	Bad smell, bland taste, and inadequate texture affect food acceptance.	22.63% indicated that the food had a bad smell, 19.26% rated it as tasteless, and 17.23% considered it overcooked.	n = 984 hospitalized patients.	Italy	Quantitative (measurements and satisfaction surveys)	Bux et al. [18]
Disease-specific factors. Poor quality of prepared meals. Excessive portion sizes.	Acute and chronic diseases limit adequate food intake. Poor taste of food, presentation, and cooking method. Excessive portions.	Anorexia, nausea, and personal dietary restrictions were identified as causes of waste. Hospital food was not appropriate according to patients' perceptions. More food is delivered than necessary, as indicated by directors.	n = 12 hospitalized patients n = 9 nurses n = 3 hospital directors n = 3 food suppliers n = 8 nutritionists n = 13 kitchen staff	Iran	Qualitative (semi-structured interviews)	Anari et al. [19]
Lack of menu customization and anticipation of requests. Disorganization among clinical staff.	Standardized menus and requests made by dietitians 24 h in advance. Inefficient coordination between the clinical team and food services, generating extra tray requests.	The time between ordering food and delivery, as well as the variety of food options, were identified as factors contributing to food waste. Poor communication between the ward and food service staff about a patient's low consumption often resulted in food waste.	n = 8 nurses n = 2 hospital directors n = 6 food suppliers n = 9 nutritionists n = 8 production staff	Australia	Generic qualitative (open-ended questions)	Carino et al. [20]
Poor quality of prepared meals. Lack of menu customization	Poor quality of food served and raw materials used. Lack of menu variety according to patients' individual preferences	56.4% of reasons for food rejection.	n = 713 hospitalized patients	Italy	Quantitative cross-sectional study	Schiavone et al. [21]

Table 2. Cont.

Determining Factors	Description	Main Results	Population or Sample	Country	Type of Study	Author
Disorganization among clinical staff. Lack of menu customization and inflexible schedules. Poor quality of prepared meals.	Inefficient coordination between the clinical team and food services, leading to extra tray requests. Standard menus versus patient preferences. Poor taste of meals.	“Patient discharge” accounts for 43% of total food tray waste. Flexibility in schedules and adaptation to patient preferences at mealtimes minimizes food waste. Patients do not like the taste or aroma of the food. like the food, its taste, or its aroma.	n = 16 hospitalized patients n = 6 nurses n = 2 hospital directors n = 2 nutritionists n = 2 kitchen staff n = 10 experts in the field	United States	Sequential explanatory mixed-methods design. Quantitative and qualitative methods (semi-structured interviews)	Fuleihan et al. [22]
Disorganization among clinical staff.	Overproduction of meals for patients.	The researchers determined that this was the largest source of food waste, accounting for 45.5% of the total sent.	Observation of n = 336 patient meal trays	Canada	Exploratory study. Quantitative methods and field observations	McAdams et al. [23]
Poor quality of prepared meals.	Poor taste and temperature of meals.	Researchers concluded that temperature and taste directly influence food waste, $p < 0.05$	n = 256 hospitalized patients	Malaysia	Quantitative study (structured questionnaire)	Chemah et al. [24]

Source: Own elaboration. n = number of hospitalized patients.

Among factors identified in this review are problems related to patient appetite and interest in food, which are often influenced by medical conditions and personal preferences. This aspect is reflected in the qualitative study conducted in Australia, which found that reduced appetite and lack of personalization in menus contribute to food waste [17]. In terms of food quality and perception, research conducted in Italy and Malaysia revealed that aspects such as bad smell, bland taste, inadequate texture, and food temperature are influential factors [18,24]. For example, in Italy, 22.63% of patients reported bad smell as the main cause of food rejection, while in Malaysia, temperature and taste were identified as determining factors in increased waste.

Another determining factor is the organization and coordination between food services and clinical teams. Studies in the United States and Australia highlight the influence of operational problems, such as the preparation of trays for discharged patients or the long time between ordering and delivery of meals, which increase waste [20,22]. Likewise, excessive portions and overproduction of meal trays are highlighted, especially in a study conducted in Canada, where it was observed that 45.5% of waste comes from the surplus generated when attempting to cover multiple main course options [23]. This finding suggests inefficiencies in the planning and production of food services. The quality of ingredients and cultural practices also emerge as important factors. In Iran, dietary restrictions and cultural perceptions about certain foods limited their consumption, while the quality of ingredients impacted patients' acceptance of food [19].

Seventy-five percent of studies reported poor quality of prepared dishes and/or raw materials as the main factor. This was followed by a lack of menu customization (50%), disorganization among clinical staff (38%), and both excessive portions and patient-related factors, with 25% each (see Figure 3).

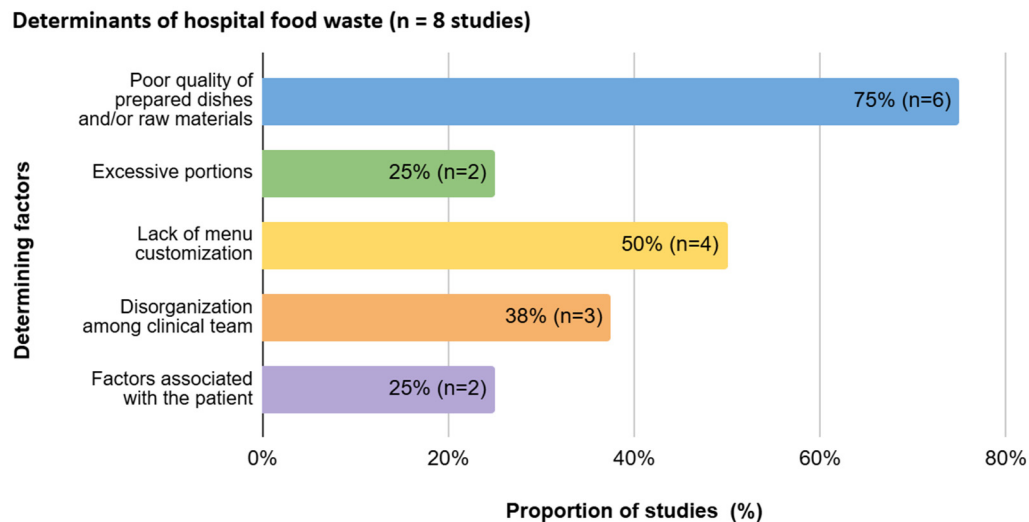


Figure 3. Distribution of determinants of hospital food waste identified in the studies reviewed (n = 8).

3.1.2. Methods for Quantifying Hospital Food Waste

Of the 19 articles analyzed in this review, 14 (74%) address methods of direct or indirect quantification of food waste in hospitals, focusing on waste generated in patients' dishes or trays. These studies use various methodologies to measure, classify, and quantify waste, allowing for the analysis and comparison of waste management practices within hospital food services (see Table 3).

Table 3. Methods and results of food waste quantification in hospitals identified in the review.

Quantification Method	Description	Main Results	Identification of Main Sources of Waste	Population or Sample	Country	Author
Direct weighing.	Direct quantification of the weight of food waste generated by dishes not consumed by patients. Breakfast, lunch, and dinner were counted.	An average of 81 g of food waste per meal served, equivalent to an average waste per plate of between approximately 12% and 21%.	Lunch is the meal that generates the most waste.	n = 4362 meals for adult inpatients	Netherlands	van Bakel et al. [12]
Visual estimation with structured survey	Meals categorized using a circle divided into four equal segments. Average weights of dishes served are used. Lunch and dinner were evaluated.	141 g of food waste per meal served on average, equivalent to an average waste per dish of between approximately 11 and 29%.	Dinner was identified as the meal that generates the most waste.	n = 984 hospitalized patients.	Italy	Bux et al. [18]
Direct weighing.	Direct quantification of the weight of food waste generated by dishes not consumed by patients.	Patients in the pediatric ward generate an average of 200 g of food waste per day, which is equivalent to 35.43% of their meals. Adult patients generate an average of 160 to 190 g of waste per day.	The research mentions the vegetarian diet as the one that generated the most waste.	n = 1 hospital with a capacity of 1000 beds	United States	Arriz-Jorquiera et al. [25]

Table 3. Cont.

Quantification Method	Description	Main Results	Identification of Main Sources of Waste	Population or Sample	Country	Author
Direct weighing.	Direct quantification of the weight of food waste generated by patients in a psychiatric hospital.	A total of 4089 kg of waste was determined from the total sample, where 818 kg, or 20% of the waste, was equivalent to meals that were not “touched” by patients.	“Untouched” meals, lunch, and dinner constitute the meal times with the most waste.	n = 25,540 meals served in a psychiatric center with 277 beds	Switzerland	Liowski et al. [26]
Direct weighing and visual estimation.	Direct quantification of the weight of solid food waste and visual inspection of liquid waste (soups).	On average, total food waste from the plate served was 56.4%. Only the lunch service was evaluated.	Pediatric service had the highest percentage of food waste per plate (67.1%). Vegetables were the least consumed category in this group (65%). The highest waste occurred on the day of hospital admission in adults and pediatrics.	n = 321 meals from pediatric and adult inpatients	Portugal	Gomes et al. [27]
Direct weighing.	Direct quantification of the weight of food waste generated by dishes not consumed by patients. Breakfast, lunch, and dinner were counted.	The average daily food waste per patient was 410 g.	Dinner was identified as the meal that generated the most food waste, with an average of 160 g per day.	n = 939 meal trays for hospitalized adult patients (solid diets only)	Saudi Arabia	Alharbi et al. [28]
Visual estimation with structured survey.	Main question: What percentage of your meals did you consume? A 5-point Likert scale was used.	The average daily food waste per patient was 41.6% of the food served. Women wasted more food than men (59.1% vs. 38.2%).	Vegetables and potatoes were the foods with the highest waste, accounting for 55.0% of the total served.	n = 713 hospitalized patients	Italy	Schiavone et al. [21]
Direct weighing	Quantification of waste weight in three categories: food waste, service waste, and kitchen waste.	The average waste was 111 g per person per meal, distributed as 42% food waste, 36% service waste, and 22% kitchen waste.	Most waste is generated at lunch and dinner.	n = 17 hospitals	Sweden	Eriksson et al. [29]
Direct weighing.	Direct quantification of the weight of food waste generated by dishes not consumed by patients.	On average, 29.5% of the food served was discarded, with chicken and fish being the most critical.	Milk, chicken, and fish at lunch generated more than 25% of food waste and were classified as critical dishes, with the à la carte menu having the lowest waste percentages.	n = 4641 meals	Spain	Paiva et al. [30]
Direct weighing.	Quantification of total waste weight in three categories: food waste on plates, undelivered trays, and packaging. Breakfast, lunch, and dinner were counted.	On average, 502.1 kg/day of food waste was generated, with 45% coming from plates (food not consumed by patients), 20% from trays (not delivered), and 35% from packaging.	Lunch is the meal that generates the most waste, with 95.3 kg/day of food waste. The average number of unused trays per day in these hospitals is 171.	n = 3 hospitals n = 198 breakfasts n = 294 lunches n = 98 dinners	Australia	Collins and Porter [15]

Table 3. *Cont.*

Quantification Method	Description	Main Results	Identification of Main Sources of Waste	Population or Sample	Country	Author
Direct weighing.	Direct quantification of the weight of food waste generated by dishes not consumed by patients. Separation by category: organic, recyclable, plastic, and metal. Breakfast, lunch, and dinner.	1515.2 kg of waste was generated in one day, of which 230 g corresponded to food served and not consumed per day.	Dinner generates the most waste.	n = 1 hospital with 750 beds n = 2010 patient meals	United States	Thiel et al. [31]
Direct weighing.	Direct quantification of the weight of food waste generated on plates by patients and waste generated during production.	The average food waste rate from plates was 22.66%.	Total waste was higher during dinners.	n = 366 meals for patients	Canada	McAdams et al. [23]
Direct weighing.	Direct quantification of the weight of food waste generated by meals not consumed by patients.	The average food waste generated per plate per patient was 383 g/day. This value includes waste generated at breakfast, lunch, and dinner.	Vegetables were the most discarded item at dinner, followed by milk and yogurt at breakfast.	n = 260 meals from hospitalized patients	New Zealand	Lawrence [32]
Visual estimation with structured survey.	Visual observation and categorization of food waste on plates divided into carbohydrates, proteins, vegetables, and fruits. Only lunches were measured.	Waste generated in relation to the portion served consisted of vegetables and proteins (86.7%), followed by carbohydrates (84.8%) and fruits (73.4%).	The highest waste was protein and vegetables at lunch.	n = 246 hospitalized patients	Malaysia	Chemah et al. [24]

The reviewed articles present various methodologies for quantifying food waste in hospitals, with a predominant focus on direct weighing of discarded food and the use of complementary techniques such as visual estimation with structured surveys. Direct weighing stands out as the most widely used method due to its accuracy, identifying an average of 81 g of waste per meal per day in the Netherlands and a total of up to 4089 kg of total food waste in Switzerland, where it is noteworthy that 20% were meals “untouched” by patients [12,26]. In Canada, a waste rate of 22.6% was recorded, with dinners generating the most waste [23]. In Australia, 45% of waste was reported to correspond to uneaten dishes, with an average of 171 unused trays per day [15]. In pediatric areas in the United States, an average waste of 200 g per day was noted, equivalent to 35.43% of meals served, with vegetarian diets generating the most waste [25].

Surveys and visual estimates can identify waste patterns based on patient perception, as in Italy, where vegetables and potatoes accounted for 55% of wasted food, and in Malaysia, where proteins and vegetables were wasted the most during lunch [21,24].

Seventy-two percent (n = 10) of the studies used direct weighing as the main measurement technique. Twenty-one percent (n = 3) used visual estimation supplemented by structured surveys, while 7% (n = 1) combined both methodological approaches in the same study (see Figure 4).

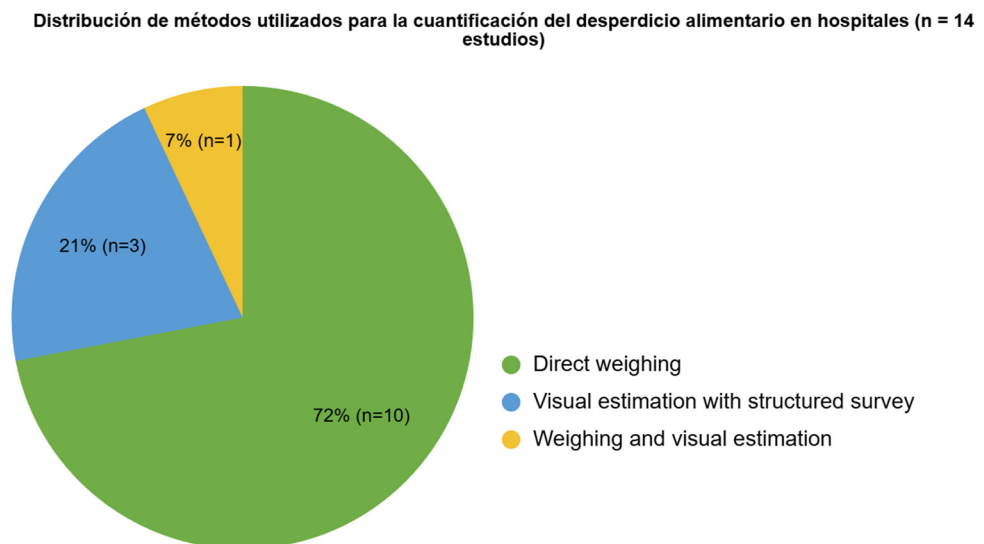


Figure 4. Distribution of methods for quantifying hospital food waste in the studies reviewed (n = 14).

Seventy-one percent (n = 10) of the studies categorized food waste, while 29% (n = 4) did not apply any classification system (see Figure 5).

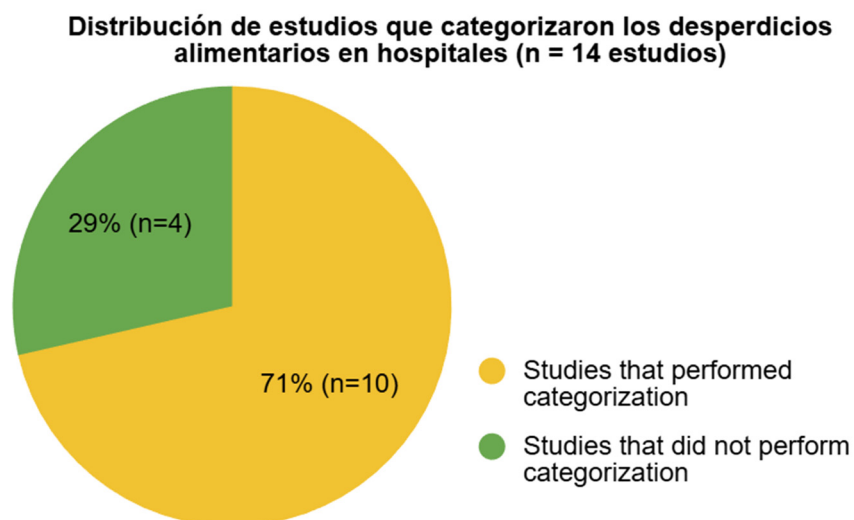


Figure 5. Distribution of studies that categorized hospital food waste (n = 14).

3.1.3. Mitigation Strategies for Reducing Hospital Food Waste

Of the 19 articles analyzed in this review, 7 (37%) addressed specific strategies aimed at mitigating food waste in hospital settings. These strategies include interventions at different organizational levels, such as the implementation of personalized ordering systems, improvements in perceived quality of food, and sustainable practices intended to reduce hospital food waste, in line with the SDGs (see Table 4).

Table 4. Mitigation strategies for reducing food waste in hospitals that were identified in the review.

Mitigation Strategy	Description of the Strategy	Main Results	Population or Sample	Country	Author
Implementation of a digital ration request system.	Transition from a traditional paper-based system to a digitized and personalized system with options such as on-demand ordering.	Significant reduction in food waste per meal served (from 81 to 33–49 g). Decrease in food waste costs by 32–56%. Estimated annual savings of €38,291 to €77,228.	n = 4362 traditional meals n = 7815 personalized digital meals	The Netherlands	van Bakel et al. [12]
Change in the food production system (cook-hold vs. cook-chill).	Comparison between two food preparation and distribution systems: cook-hold (traditional method) and cook-chill (pre-cooked and refrigerated). The aim was to improve the organoleptic quality of the food served.	85% reduction in food waste when using the cook-hold method. Greater patient satisfaction with cook-hold (97.88%) compared to cook-chill (86.21%). The cook-hold method also resulted in lower energy and diesel consumption.	n = 984 hospitalized patients	Italy	Bux et al. [18]
Implementation of a mixed digital mathematical model.	Mixed digital programming models for meal planning, minimizing waste and costs while meeting dietary and nutritional requirements.	Reduction in waste by 22.53% and costs by 32.66%. Projected annual reduction: 5.66 tons of waste and \$132,372.24.	n = 1 hospital with a capacity of 1000 beds	United States	Arriz-Jorquiera et al. [25]
Integration of more nutritionists into clinical and food services.	Comprehensive nutritional supervision through menu analysis, training, and communication between clinical units and food service.	25% reduction in total portions wasted; improvement in food safety and patient satisfaction.	n = 18 hospitals (9 with intervention, 9 control) n = 305 meals per day	Israel	Yona et al. [33]
Implementation of protocols/audits for quantifying food waste.	Implementation of standardized procedures to measure food waste in hospitals, focusing on waste per serving.	Reduction in waste through temporal analysis. 39% reduction in food waste between 2013 and 2019, from 149 g/patient/meal to 90 g/patient/meal.	n = 17 hospitals	Sweden	Eriksson et al. [29]
Modifications in the planning of critical dishes with higher food waste.	Adjustments to recipes and variety of dishes (new chicken recipes and greater variety of fish); reduction in portion sizes.	Significant reduction in waste for chicken (35.7% to 7.2%) and fish (29.5% to 12.8%).	n = 695 trays (second phase of the study)	Spain	Paiva et al. [30]
Timely coordination between clinical staff and food services.	Encourage communication and constant updates on changes in patient status (e.g., discharge, diet changes).	Waste related to the delivery of incorrect and extra trays was reduced due to timely real-time communication and direct collaboration between teams.	n = 16 hospitalized patients n = 6 nurses n = 2 hospital directors n = 2 nutritionists n = 2 kitchen staff n = 10 experts in the field	United States	Fuleihan et al. [22]

The mitigation strategies to reduce hospital food waste implemented in the reviewed studies indicate several approaches that combine digital systems, planning, and operational adjustments to optimize food services and reduce environmental impact. Adjustments to recipes and portion sizes, along with standardized procedures for quantifying waste, have proven effective for reducing waste in critical foods, as demonstrated in studies conducted in hospitals in Spain and Sweden, respectively, where waste per patient/meal decreased significantly [29,30]. Another study conducted in the United States found that implementing better coordination and timely operational communication between clinical professionals and the food team minimized errors in the delivery of trays to hospitalized patients, reducing waste associated with food logistics and handling [22]. In addition, the use of digital systems, such as personalized requests or digital mathematical

models for meal planning, shows a significant reduction in waste per meal served, along with considerable economic savings in studies conducted in the Netherlands and the United States [12,25].

In Israeli hospitals, it was shown that integrating more nutritionists into food services and training staff reduced waste by 25%, while also promoting better practices at the organizational level [18]. These strategies show positive results by adopting a systematic and comprehensive approach to addressing hospital food waste, incorporating digital systems, coordination, and operational adjustments. It is important to note that, in this review, only seven studies implemented and evaluated mitigation strategies, which reduced food waste.

The rest of the studies limited themselves to suggesting or proposing mitigation strategies without implementing them. Among the proposed strategies, staff training and awareness-raising on environmental sustainability and waste management, adjustments to food portions, and quality improvements of raw materials stand out as key measures to reduce food waste [19,21,26]. Likewise, some studies suggest implementing waste audits at the hospital level to optimize requests and minimize surpluses, in addition to the importance of establishing clear public policies to guide the transition to sustainable practices and patient personalization of menus [15,20,28,31,32]. Waste management strategies such as composting and food donation are also proposed, which could play an important role in reducing food waste [23,32].

The strategies reported to be most effective in reducing post-consumer food waste (PCFW) were changes in the food production system (cook-hold), with an 85% reduction, followed by the implementation of digital ordering models and quantification audits, both with a 39% reduction. Other strategies also reported effects, such as modifications to critical dishes (30%), the incorporation of nutritionists (25%), and the use of digital planning models (23%) (see Figure 6).

Estrategias de mitigación y disminución en el DAP (n=7 estudios)

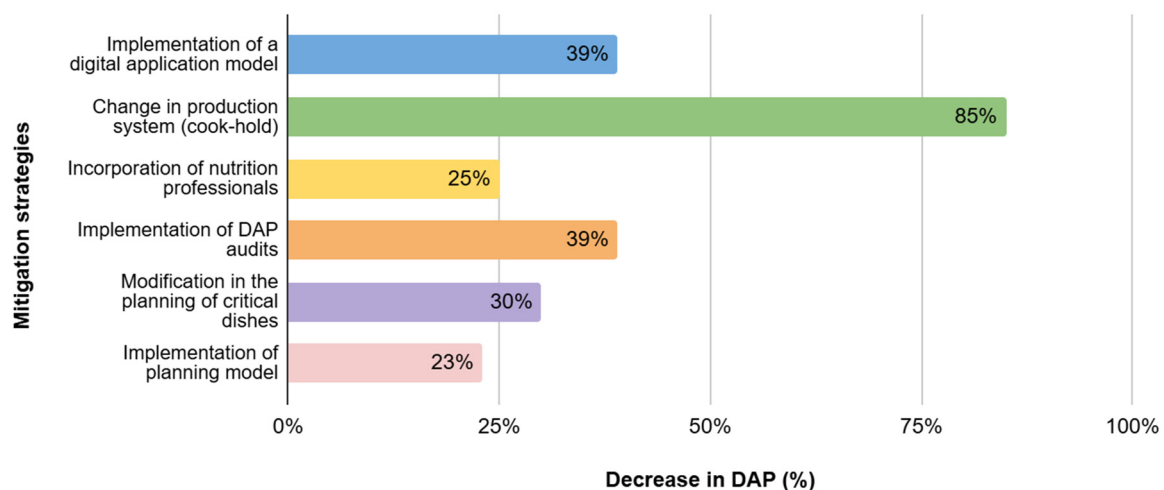


Figure 6. Distribution of strategies for mitigating and reducing hospital food waste (n = 7).

3.2. Bibliometric Analysis

According to the analyses carried out, there has been an increase in annual scientific production since 2019, with considerable increases between 2023 and 2024 (see Table 5).

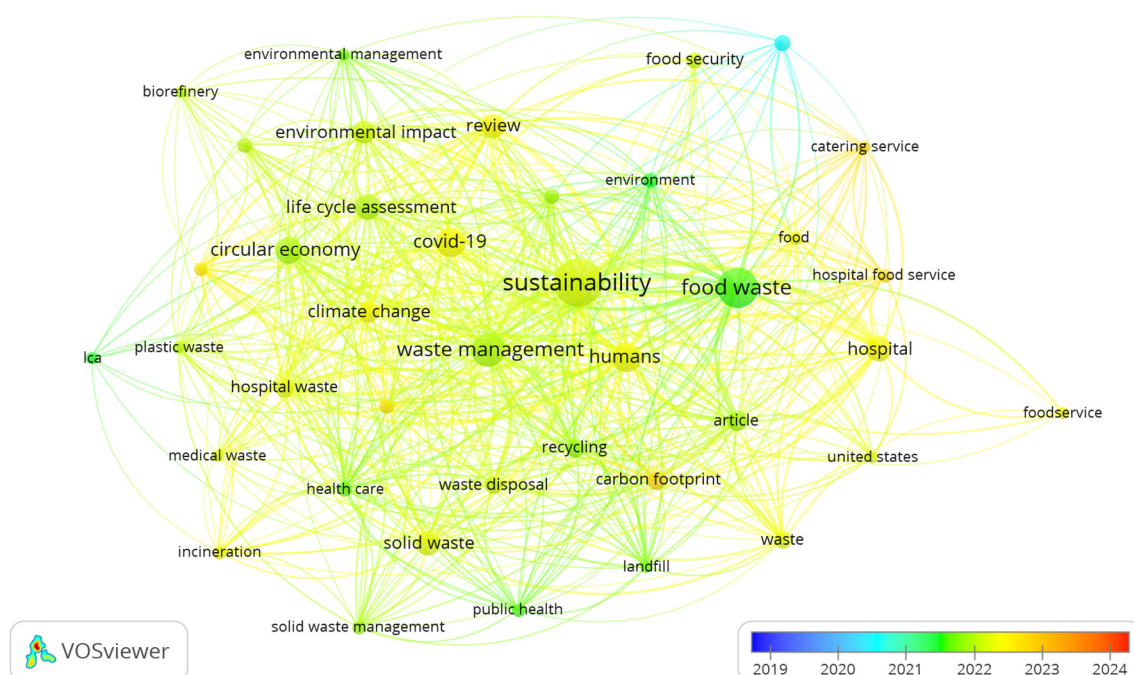
Table 5. Scientific output 2019–2024. Web of Science. Bibliometrix.

Year	2019	2020	2021	2022	2023	2024
Articles	3	11	18	15	28	44

3.2.1. Temporal Evolution of Publications Based on Keywords

Bibliometric analysis of keywords showed that the most frequent terms in scientific publications between 2019 and 2024 were sustainability, food waste, and waste management, positioned as the largest nodes in the visualization, which highlights their thematic centrality in the literature reviewed. These concepts are strongly linked to other terms such as hospital, health care, recycling, public health, and climate change, forming a thematic network around the sustainability of food services in hospital settings.

Temporal evolution of keyword usage, represented by the color scale, indicates that between 2019 and 2020, concepts such as solid waste, waste disposal, and life cycle assessment predominated. In contrast, the terms that emerge most frequently from 2022 onwards, such as hospital food service, food security, catering service, and environment, reflect a recent trend towards addressing waste from a more integrated perspective, linking environmental management with hospital food services (see Figure 7).

**Figure 7.** Clustering of the most frequent keywords and temporal evolution of publications. VosViewer.

3.2.2. Scientific Article Publications by Country and International Collaborations

This bibliometric analysis presents the countries with the highest number of publications in this area, differentiating between articles generated through national (SCP) or international (MCP) collaborations. India leads the ranking with the highest number of publications, standing out for its predominance of international collaborations. The United States ranks second, showing a predominance of national publications (SCP), as does Australia, which ranks third. On the other hand, China combines an equitable production that reflects a relevant scientific contribution and the presence of both national and internationally co-authored publications. The United Kingdom shows a predominance of international collaborations, while Spain, Italy, and Portugal show a similar pattern, with a predominance of national publications. In contrast, countries such as Colombia, Argentina,

and Saudi Arabia have low levels of production, mostly focused on individual publications or national collaborations (see Figure 8).

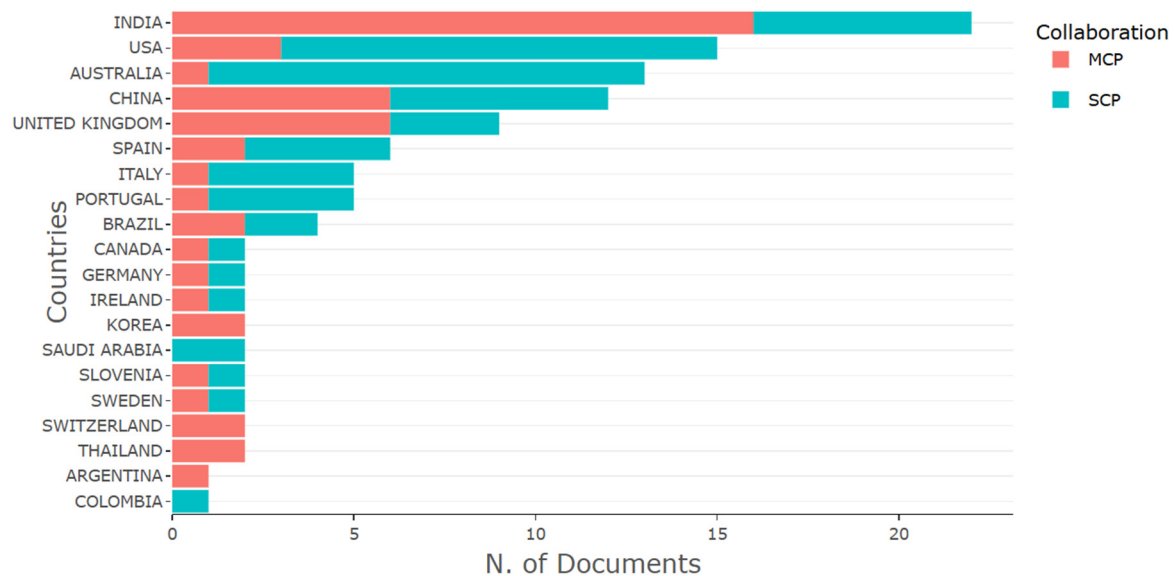


Figure 8. Scientific article publications by country and international collaborations. Web of Science. Bibliometrix.

4. Discussion

This review approaches hospital food waste from a comprehensive perspective, considering the factors that determine its generation, the methods of quantification, and the strategies that have been implemented for its mitigation. This is due to the consequences and impact on resource sustainability, the operational efficiency of hospital food services, as well as its contribution to GHG emissions and increased healthcare costs, as well as affecting the quality of patient care [25]. Hence, reducing hospital food waste is essential for contributing to sustainable and environmentally responsible healthcare systems.

This issue is directly linked to the SDGs established by the FAO, specifically SDG 12, which seeks to ensure responsible consumption and production patterns. In this regard, UNEP and FAO propose that countries implement programs with a “Target, Measure, Act” approach, which has been successfully tested in some countries, such as the United Kingdom. Together with initiatives led by organizations such as WRAP (Waste and Resources Action Programme), reductions in food waste have been achieved in different sectors [34].

These approaches proposed by international organizations establish the need to define clear objectives, periodically measure waste levels using a defined methodological framework, and act through strategies adapted to each context (households, food services, and retail sales). It is suggested that countries adopt and implement effective quantification and mitigation strategies to contribute to the achievement of SDG target 12.3, which seeks to halve food waste by 2030. According to the UNEP 2021 Food Waste Index Report, only 23 countries have reported quantifying food waste associated with food services, with 15 of the 23 countries, or 65%, located in Europe [9]. It is important to mention that this quantification is a challenge, as the heterogeneity of the subsectors associated with food services makes it difficult to obtain an overview.

In this context, hospital food services need to be analyzed, and food waste considered, adapting measurement and mitigation strategies to ensure accurate data and effective action. Studies have highlighted the global magnitude of this problem. For example, a systematic review study conducted in Italy in 2023 indicates that hospital food services

generate large volumes of food waste compared to other types of collective catering, with food waste ranging from 17% to 67% [35].

In relation to the results obtained in this review, only eight articles investigated the determining factors that contribute to hospital food waste, finding that the main factors include poor quality raw materials and patients' poor perceptions of the food. For example, bad smell, bland taste, inadequate texture, and temperature were reported as the main causes of rejection in studies conducted in Italy and Malaysia [18,24].

Likewise, the lack of communication and organization between food services and the clinical team in charge of hospitalized patients represents a significant percentage of the results obtained as determining factors for waste. This includes a lack of coordination between teams, overproduction of ready-to-eat food trays, unreported surpluses, and delays between meal requests and delivery, as reported in studies conducted in the United States, Canada, and Australia. One of these studies even found that up to 45.5% of waste comes from the surplus generated by additional trays [20,22]. This factor is very relevant, as it does not require large budgetary investments for change, but rather a commitment from the team and management to provide guidelines and make modifications to planning strategies for proper communication between the parties involved.

Finally, reduced appetite and disinterest in food, often influenced by medical conditions or personal preferences, also contribute to food waste, as demonstrated by a qualitative study conducted in Australia [17]. Similar results were reported in a systematic review study conducted in 2024 in the Eastern Mediterranean region, which included data from countries such as Iran, Saudi Arabia, and Qatar, where they concluded that factors such as patients' clinical conditions, food preferences, meal quality, and service schedules significantly influence waste levels [13]. It is important to consider these results, as these factors highlight the need to improve both planning and operational coordination of food services, as well as quality of the raw materials used, the personalization of menus, and the organoleptic characteristics of dishes, such as taste, texture, aroma, and presentation. These strategies can be combined to increase patient acceptance and contribute to reducing food waste and improving overall satisfaction with the services offered.

Regarding the quantification of hospital food waste, or food not consumed by patients, 14 of the articles selected in this review investigated this variable, using various methods for its measurement, with direct weighing and structured surveys being predominant. Direct weighing is considered the most accurate method, as it measures the exact amount of unconsumed food, providing reliable quantitative data. However, it can be more expensive and require more time and operational resources. On the other hand, structured surveys and visual estimates are more practical and accessible, especially in resource-limited settings, but tend to be less accurate as they rely on subjective perceptions or approximations. These techniques are useful for obtaining general data, but may underestimate or overestimate actual levels of waste. The direct weighing studies in this review reported an average of 31% hospital food waste, while those using surveys or visual estimates reached an average of 43%. This reflects the differences that can arise depending on the method used. Lunch and dinner were the meals that generated the most food waste in hospitals in the different studies reviewed. In the Netherlands and Canada, lunch was identified as the main generator of waste, while in Italy and Saudi Arabia, dinner stood out as the meal with the highest amounts of food waste [12,18,23,28]. Vegetables, proteins such as fish and chicken, and poorly cooked foods were most frequently rejected by patients, according to studies in Italy, Spain, and Malaysia [18,24,30]. Average waste values of 22.6% were observed in Canada, 35.4% in the United States, and up to 56.4% in Portugal, suggesting the need to adopt mitigation strategies to reduce these percentages [23,25,27].

The results obtained in this review are similar to those published in an exploratory review study conducted in Malaysia in 2023, which showed alarming waste percentages, with an average of 47.5% in modified diets for patients with eating difficulties, such as pureed and blended diets, reaching up to 65% waste for standard diets [36]. This was also demonstrated in a systematic review conducted in the Eastern Mediterranean region, where food waste was estimated to account for 25.4% of the food served to hospitalized patients [13]. Similarly, a review article on sustainable food services in European hospitals reported that approximately 30% of the total weight of food served ends up as waste [37].

In this context, this review shows differences in the quantification methods used in the studies, mainly in the classification and identification of food waste, which makes it difficult to compare results at the hospital level. Given these limitations, the “Target, Measure, Act” approach proposed by the FAO, in conjunction with various international associations, launched the Food Loss and Waste Accounting and Reporting Standard, known as the FLW Standard, in 2016. This standardizes food waste measurement, establishing a common basis for quantification, as well as the importance of classifying waste according to the type of material and final destination. The adoption of this protocol would help to overcome the inconsistencies observed in the studies reviewed, promoting a more accurate assessment and more effective actions aimed at reducing food waste in hospitals [38].

Finally, the strategies implemented in the selected studies were analyzed to assess their impact on reducing food waste. It was observed that of the 19 articles analyzed in this review, 7 (37%) directly addressed and measured the effect of implementing these strategies. Most are limited to proposing measures without considering their final impact. Among the strategies evaluated, the personalization of menus through the development of digital technologies stands out, which has demonstrated significant reductions in waste generated, with benefits in sustainability and operational efficiency. This was demonstrated in a study conducted in the Netherlands, where these initiatives managed to reduce food waste by between 32% and 56% [12]. This strategy was also addressed in the review study conducted in European countries; however, it emphasizes that its implementation remains limited due to operational and budgetary barriers, highlighting the need to overcome these challenges to maximize its impact [37].

On the other hand, the integration of nutritionists into food services and clinical teams, together with the strengthening of effective communication between professionals involved in patient care, are effective interventions to mitigate hospital food waste. This strategy includes comprehensive nutritional supervision through menu analysis, staff training in waste management, and the promotion of sustainable practices. In Israel, this measure reduced waste by 25% and also promoted better practices at the organizational level [33]. Similarly, in the United States, waste associated with trays not used by patients was reduced by making changes that favored coordination between hospital clinical staff and food services, demonstrating the positive impact of effective communication in hospital logistics [22]. Other strategies, such as adjusting portion sizes, especially for critical foods, have also proven effective. For example, in Spain, waste reduction in these foods was reported to be 35.7% to 7.2% for chicken and 29.5% to 12.8% for fish [30].

These strategies are relevant because they address organizational systems, patient preferences, and optimize available resources. Similar results were reported in an exploratory review that evaluated specific strategies to reduce food waste in Malaysian hospitals, suggesting the need to adjust portions and menus to individual patient requirements, considering both their nutritional needs and specific food preferences, and to strengthen communication and coordination between clinical and food services with the aim of minimizing surpluses and improving efficiency in food resource management [36]. From an analytical perspective, the results of this narrative review allow us to interpret hospital

food waste as a multifactorial phenomenon that transcends the technical aspects of food production and distribution, integrating organizational, management, communication, and institutional coordination factors.

The evidence reviewed shows that factors such as perceived food quality, lack of menu customization, disorganization between clinical teams and food services, and the absence of systematic measurement systems present a complex scenario that limits the efficiency of hospital food systems. Of the strategies reviewed and implemented in this review, there is a lack of studies evaluating their long-term impact, which hinders regulatory compliance and the consolidation of sustainable management frameworks in hospital food systems. While the literature reviewed highlights the potential of these strategies, their effective implementation may be constrained by multiple contextual barriers. Among the main limitations identified are financial constraints, staff availability and training, the definition of responsibilities between clinical and food teams, and the absence of standardized monitoring systems. Additionally, regulatory factors, organizational resistance to change, and limitations in infrastructure and technological resources can hinder the sustained adoption of these strategies, particularly in hospitals in low- and middle-income countries.

Furthermore, this knowledge gap restricts the development of public policies and institutional guidelines that promote the standardization of practices, continuous monitoring of food waste, and efficient allocation of resources, which are key aspects for advancing toward management models aligned with the SDGs. It is important to note that, during the literature search conducted, following the defined inclusion criteria and using the databases selected for this review, no specific studies on food waste in hospitals conducted in Chile were identified, which is concerning, especially considering the need to advance in the fulfillment of SDG 12.3. It is essential to develop lines of research that address existing methodological and geographical gaps, helping to strengthen the empirical basis for sustainable food waste management in hospitals.

The bibliometric analysis identified the thematic and geographical evolution of scientific production on food waste in hospitals during the period 2019–2024. The temporal evolution of keywords shows a change in the focus of research. Between 2019 and 2020, terms associated with traditional waste management, such as solid waste, waste disposal, and life cycle assessment, predominated, reflecting an initial interest focused on environmental impacts and waste disposal strategies. However, from 2022 onwards, a new orientation emerges, incorporating concepts such as hospital food service, food security, and environment, indicating a transition towards a systemic and interdisciplinary approach. This change suggests an evolution from waste management to waste prevention, incorporating social, nutritional, and sustainability dimensions.

These findings coincide with the global trend promoted by the international FLW standard, which encourages the measurement and management of food waste based on criteria of relevance, integrity, and comparability [38]. In this sense, the increase in publications related to the hospital setting reflects a growing concern for quantifying and mitigating post-consumer waste within health services.

In terms of the geographical distribution of scientific output, India leads in the number of publications, characterized by a high level of international collaboration. This pattern can be attributed to its extensive hospital network and greater prioritization of public policies aimed at health sustainability. The United States and Australia, in second and third place, respectively, have a predominance of national publications, which demonstrates significant research capacity and sustained internal funding. In contrast, China shows a balance between national and international publications, suggesting an integrated global knowledge network. On the other hand, European countries such as the United Kingdom, Italy, Spain, and Portugal maintain moderate productivity. The low production observed

in Latin America, particularly in Colombia and Argentina, and in regions such as Saudi Arabia, indicates the existence of geographical research gaps. This difference reflects limited prioritization of hospital food waste in national scientific agendas, as well as possible barriers in funding, research infrastructure, and data availability. In the case of Chile, this trend is evident, since despite regulatory advances in sustainability and food loss and waste reduction, there is still no scientific evidence applied to the hospital context.

5. Conclusions

Food waste in hospitals represents a significant challenge, both because of its environmental implications and its impact on the operational and economic efficiency of healthcare systems. The results of this review show that adopting comprehensive approaches that combine food planning, organizational improvements, staff training, progressive incorporation of technologies, and operational adjustments is an effective way to reduce post-consumer waste generated by hospitalized patients, in line with the SDGs.

In line with these findings, the sustainable strategies identified have a high potential for adaptation to different institutional contexts, considering the operational capacities and resources available. Likewise, the bibliometric analysis allowed these results to be contextualized within the evolution and distribution of international scientific production, revealing thematic trends and relevant geographical gaps in the study of hospital food waste. In particular, in environments with budgetary constraints, organizational and management interventions emerge as feasible and high-impact alternatives, while the gradual incorporation of digital tools and monitoring systems contributes to improving the efficiency and traceability of food waste.

However, the lack of standardization in quantification methods limits comparability between studies and hinders the generation of robust evidence for decision-making, even though direct weighing is recognized as the most reliable method. Likewise, there continues to be limited evaluation of the long-term impact of the strategies implemented, which reinforces the need to move toward evidence-based management models with continuous monitoring systems that allow for the evaluation of their effectiveness and sustainability over time. In this context, strengthening the institutional and regulatory framework is key to consolidating practices aligned with sustainable development priorities.

These limitations also reflect gaps in the existing literature, particularly in relation to the scarcity of longitudinal studies, methodological heterogeneity, and the underrepresentation of certain geographical contexts. Addressing these gaps is a priority for future research, which should focus on the systematic and long-term evaluation of the strategies implemented, as well as the development of comparable methodological approaches that facilitate the formulation of public policies and the strengthening of sustainable food waste management in hospitals.

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Abbreviations

The following abbreviations are used in this manuscript:

FAO	Food and Agriculture Organization of the United Nations
FLW	Food loss and waste
GHG	Greenhouse gas
MCP	International collaborations
PCFW	Post-consumer food waste
SCP	National collaborations
SDGs	Sustainable Development Goals
UNEP	United Nations Environment Programme

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