

## REVIEW ARTICLE

# The Global Research Trends on Food Waste At Healthcare Setting: A Bibliometric Analysis Using Scopus Database

Nurul Alia Aqilah Samiun<sup>1,2</sup>, Nurul Huda Razalli<sup>1</sup>, Suzana Shahar<sup>1</sup>, Zahara Abdul Manaf<sup>1</sup>, Zurina Kefeli<sup>3</sup>, Jauharah Md Khudzari<sup>4</sup>, Norshariza Jamhuri<sup>5</sup>

<sup>1</sup> Dietetic Programme, Center for Healthy Ageing and Wellness, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia.

<sup>2</sup> School of Nutrition and Dietetics, Faculty of Health Sciences, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Terengganu, Malaysia

<sup>3</sup> Faculty of Economics and Muamalat, Universiti Sains Islam Malaysia, Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.

<sup>4</sup> Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia.

<sup>5</sup> Dietetic and Food Service Department, National Cancer Institute, Jalan P7, Presint 7, 62250 Putrajaya, Malaysia.

## ABSTRACT

The issue of food waste has garnered much attention globally due to its adverse impacts on the economy, food security, natural resources, the environment, and human health. Despite this, the academic literature lacks systematic, historical, and synthesising investigations on healthcare food waste. This bibliometrics analysis study aims to summarise the growing trends of food waste publications and highlight common and potential research topics of food waste in healthcare settings. The Scopus database analysed 193 journal articles published between 1952 and 2022. We identified several common and potential research topics for future research in the area, including food waste and malnutrition, related intervention strategies, the impact of healthcare food service systems on food waste, and their economic and environmental impact. Healthcare food waste research in developing nations is still limited. Thus, it is recommended that policymakers support its development as one of the steps to encounter food waste.

*Malaysian Journal of Medicine and Health Sciences* (2024) 20(1):312-322. doi:10.47836/mjmhs.20.1.39

**Keywords:** Food waste; Plate waste; Healthcare; Bibliometric analysis; Scopus

## Corresponding Author:

Nurul Huda Razalli, PhD

Email:nurulhuda.razalli@ukm.edu.my

Tel: +603 8921 5555

## INTRODUCTION

The literature rarely addresses the differentiation between food losses and food waste, edible and inedible food waste, and avoidable and non-avoidable waste (1). Although the Food and Agriculture Organization (FAO) defines food loss as “the decrease in quantity or quality of food” and food waste as “part of food loss that has been left to spoil or expire as a result of negligence by the actor (predominantly, but not exclusively, the final consumer)” (2), these two terms are often used interchangeably. In this paper, food waste refers to food that is decreased in quantity or quality and has been left to spoil or expire. Food waste from food services can arise from spoilage, preparation, unserved food, or plate waste (3,4). Global food loss and waste mount up to 24% of all food produced when 1/4 of the food calories deliberately grown to feed people are not ultimately consumed by people (5). Meanwhile, food waste in

healthcare facilities can be up to 65% higher than in other food service sectors (6).

In healthcare facilities or any facilities that provide medical services, the food service department is one of the essential services offered to patients. Research on healthcare food waste has always focused on plate waste (7–13). Research on plate waste was also widely studied, along with patient satisfaction (11,14–16). Because the environmental impacts of creating raw materials and processing them into food are significant, wasting edible food rather than eating it is both environmentally and economically unsustainable (17). Due to that, research on plate waste has also emerged in the costing aspect. In 2000, it was indicated that British hospitals’ food waste accounted for 28 million pounds. (18). In Portugal, it was discovered that hospital food waste costs roughly 0.5 per cent of the national health budget, with an estimated €3.90 going to waste every day from each hospitalised patient. (19). In Malaysia, a total of 32.4 billion ringgit have been allocated by the government in the 2022 Budget for healthcare (20). However, there is no data on how much money is being thrown away yearly from hospital food waste.

Despite the growing research interest in food waste in healthcare facilities, there is still a lack of systematic, chronological, and synthesising studies in the academic literature. Thus, this bibliometrics analysis study aims to summarise the growing trends of food waste publications in healthcare settings and highlight common and potential research topics of food waste in healthcare settings. This paper will serve as a basis for researchers, policymakers, and individuals to understand the growing research trends in food waste, specifically in the healthcare setting, and discover the potential and possibilities for further research and collaborations.

## METHODS

Bibliometric analysis is a quantitative and statistical method used to describe publication patterns in a specific area based on academic literature databases (21). This paper chose the Scopus database as the academic literature database. Scopus database was selected because of its world's largest peer-reviewed abstract and citation database, with cutting-edge tracking, analysing, and visualising research tools. Our search strategies followed the methodology described in the literature (22).

### Data Source

The Scopus database was chosen as the data source for this study. The data collection was conducted in the first week of January 2021. Documents were searched by using the following query string: TITLE-ABS-KEY (((“food\* wast\*” OR “plate wast\*” OR “leftover\* food” OR “unserved food” OR “kitchen\* wast\*” OR “food loss” OR “serving wast\*” OR “trolley food wast\*”) AND (hospital OR “health\* care” OR “long\* term care”). With both terms being used interchangeably, in this paper, we included ‘food loss’ and ‘food waste’ in our query string to avoid missing any articles related to the healthcare food waste topic. Documents were searched based on the title, abstract, and keywords. This query string resulted in 490 articles. Then, the query string was limited to the publications up to 2022 from two document sources: journal articles and conference proceedings, and from two document types: articles and conference papers. After refining the search results, 383 articles were left to analyse. In this review, journal articles and conference proceedings will be referred to as articles. To ensure that no review articles were included in our analysis, we appended additional phrases to the query string, resulting in 38 potentially irrelevant articles. These articles’ titles and abstracts included the terms review, recent, progress, critical, revisit, advance, and highlight. After further screening the remaining 345 articles by perusing abstracts and full texts, we identified that only 193 articles were related to our research scope and included in our analysis.

### Bibliometric maps

VOSviewer software (version 1.6.19) was used for

constructing and visualising bibliometric maps. Bibliographical information and author keywords for the 193 articles were exported to VOSviewer. In VOSviewer, information such as countries and author keywords was analysed to create co-authorship and co-occurrence maps. The relationship between two items, e.g., two keywords, is visualised with a link, and the strength of the relationship is indicated by the link strength (in numerical value).

For co-authorship analysis, the link strength between the two countries indicates the number of publications co-authored. Similarly, in co-occurrence analysis, the link strength between two author keywords represents the number of articles in which the two keywords appear together. Further details on the features of VOSviewer can be found in the user manual.

### Analysis of co-authorship

The analysis of co-authorship included all 41 countries affiliated with 159 authors. The network visualisation option was selected to display the co-authorship among related nations. Africa, America, Asia, Europe, and Oceania were the five continents to which the affiliated countries belonged.

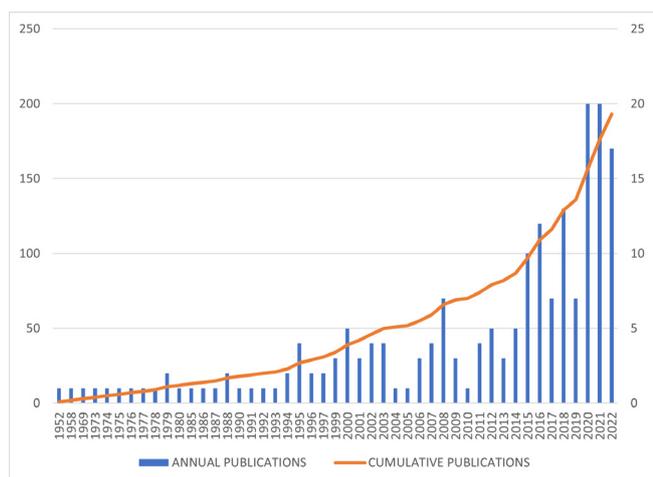
### Analysis of co-occurrence

Only 132 of the 442 author keywords were relevant enough to be included in the co-occurrence analysis. Synonymous single words and congeneric phrases were examined before loading the list of author keywords into VOSviewer. For example, food losses, food loss, food wastage, food waste production, waste of food, and waste per portion were counted as one and re-labelled as food waste. Both network and overlay visualisation modes are used. The network visualisation option was chosen to see the network within and between keyword clusters and the number of occurrences and link strength of the keyword. In contrast, the overlay visualisation style was used to see the keywords’ average publication year. The colour of a keyword indicates different clusters.

## RESULTS AND DISCUSSION

### Publication output and growth of research interest

In the past 70 years, 193 healthcare food waste-related documents have been published (Fig. 1), and the oldest publication dates to 1952 (23). Not many publications were found until 1995, and since then, publications have been recorded annually. It is interesting to note that the first spark of articles started in 2008. The similarity between those articles was that they highlighted strategies to improve patients’ nutritional status and reduce healthcare food waste (24–29). Since 2015, the increment of research articles has doubled to two digits compared to the previous years. From 2011 until 2020, the annual growth rate (AGR) increased by 24.55% compared to previous decades. Although the increase in annual publications was inconsistent, the cumulative



**Figure 1: The annual and cumulative numbers of research articles on healthcare food waste indexed in Scopus from 1952 until 2022**

number of publications continued to rise. The increment in publications is a positive sign, which suggests that food waste issues in healthcare facilities have gained interest among researchers over the years. In previous years, The United Kingdom (UK), the United States of America (USA), the European Union, and Japan have actively reduced food waste; new efforts have recently emerged in Denmark and the Netherlands (30).

The following subject areas were used to classify the majority of the publications: Medicine (104 articles), Nursing (97 articles), Agricultural and Biological Sciences (36 articles), and Environmental Science (29 articles). This pattern was expected since the research scope of this study was focused on healthcare settings. According to the findings, the articles used in this study were also published in five different languages. Publications were mainly in English (184, 95%), followed by French (4, 2%), Portuguese (3, 1%), Spanish (2, 1%), Chinese (1, 0.5%), and Hungarian (1, 0.5%).

### Preferred journal

The 193 research articles discovered were published in 120 publications. Only one of the publications, the Journal of The Academy of Nutrition and Dietetics, has more than 10 articles. Four publishers controlled the top 10 prolific journals (Table I). Five of the most productive journals were published by Elsevier (19,25,27,28,31), and others were Wiley Blackwell (26,32), MDPI AG (33,34), ARAN, and Ediciones SA (35). Approximately 36% of all research publications are published in the top 10 most productive journals.

The most productive journal was the Journal of The Academy of Nutrition and Dietetics, with 16 research articles covering 8.3% of the total publications, followed by the Journal of Human Nutrition (10, 5.2%), Sustainability Switzerland (9, 4.7%), and Clinical Nutrition (7, 3.6%). Clinical Nutrition received the highest total citations (621 times), and its article

entitled 'Food intake in 1707 hospitalised patients: A prospective comprehensive hospital survey.' (27) had been the most cited article (58 times). The study was conducted to assess the ability of the hospital meal service to meet patients' nutritional needs. It was found that most of the hospitalised patients did not meet the energy requirement, even though the food provision was sufficient. Inadequate food intake not only indicates that the majority of the food was wasted, but it also raises the possibility of malnutrition. Consequently, there ought to be room to improve hospital food services.

In Scopus, the CiteScore was introduced as the metric to help measure citation impact for journals, book series, conference proceedings, and trade journals. The calculation of CiteScore for the current year is based on the number of citations received by a journal in the last four years (including the calculation year), divided by the number of documents published in the journal in those four years. Table I states that Waste Management received the highest CiteScore 2021 of 13.5, while Nutricion Hospitalaria received the lowest CiteScore 2021 of 1.9. It was understandable as Nutricion Hospitalaria's primary language of publication was French; hence, it was less accessible to the English reader.

Most of the top 10 productive journals were in Q1 of the SCImago Journal Rank (SJR). The SJR helps compare journals within the same field and forms the basis for subject category ranking. Q1 represents the top 25% of the impact factor distribution, Q2 the middle-high position (between the top 50% and the top 25%), Q3 the middle-low position (between the top 75 per cent and the top 50%), and Q4 the lowest position (bottom 25 per cent of the impact factor distribution).

### Publication distribution of countries and institutes

The 193 articles published from 1952 to 2022 were analysed, covering 41 countries. The USA mostly dominated publications with 31, followed by Australia with 26. Higher healthcare food waste publications in the USA and Australia could also be due to the national interest in improving food waste management, especially in healthcare. Shockingly, food waste reported in the USA amounted to 188 kg per capita per year, valued at \$165.6 billion (36). Due to food waste, adverse impacts on food security (30), natural resources (37), environment (19) and human health (38). Therefore, reducing food waste has become a global and national political priority (1). Australia's federal government also has taken the first step to provide a framework to support collective action towards halving Australia's food waste by 2030, aligned with Sustainable Development Goal 12, to ensure sustainable consumption and production patterns (30,39).

Most countries had less than 25% of multi-country publications (MCP), suggesting that international

**Table 1: The top 10 most productive journals on healthcare food waste research with their most cited article.**

Rank	Journal	TP (%)	TC	Cite-Score 2021	SJR 2021	The most cited article (reference)	Times cited	Publisher
1	Journal of the Academy of Nutrition and Dietetics	16 (8.3)	293	7.2	Q1	Getting a taste for food waste: A mixed methods ethnographic study into hospital food waste before patient consumption conducted at three New Zealand foodservice facilities (19)	49	Elsevier
2	Journal of Human Nutrition and Dietetics	10 (5.2)	137	5.3	Q1	A comparison of the amount of food served and consumed according to meal service system (25)	34	Wiley-Blackwell
3	Sustainability Switzerland	9 (4.7)	120	5.0	Q2	Towards a baseline for food-waste quantification in the hospitality(31)	38	MDPI AG
4	Clinical Nutrition	7 (3.6)	621	9.9	Q1	Food intake in 1707 hospitalised patients: A prospective comprehensive hospital survey (24)consumed and wasted during a 24 h period were compared to patients' needs estimated as energy: 110% Harris-Benedict formula; protein: 1.2 or 1.0 g/kg body weight/day for patients ≤ or > 65 years old, respectively. A structured interview recorded patients' evaluation of the meal quality, their reasons for non-consumption of food and the relationship between food intake and disease. Results: Out of 1707 patients included, 1416 were fully assessable (59% women; 68 ± 21 years; body mass index: 24.3 ± 5.1 kg/m2	174	Elsevier
5	Nutrition and Dietetics	6 (3.1)	41	4.8	Q2	Does presentation of smooth pureed meals improve patient's consumption in an acute care setting: A pilot study (30)with a further 10% exacerbated by the presence of dysphagia. Providing adequate nutrition for patients requiring a texture-modified diet often results in meals that look and taste less appealing and which are nutritionally diluted. This article aims to review change in oral intake using food moulding techniques within an acute care institution for patients on Texture C—smooth pureed meals. Methods: This was a 2 week pilot study. Patients were provided smooth pureed lunch either as non-moulded or a moulded meal. Main meal wastage was weighed and reasons for waste were documented. If patients met the inclusion criteria, a short satisfaction survey was also administered. Results: Analysis using a chi-squared test comparison saw significance in the proportion of patients increasing oral intake from <1/4 meal eaten to >3/4 meal, when in the moulded form (P = 0.03	22	Wiley-Blackwell
6	Appetite	5 (2.6)	133	7.7	Q1	A volunteer feeding assistance program can improve dietary intakes of elderly patients - A Pilot Study (26)	40	Elsevier
7	Nutricion Hospitalaria	5 (2.6)	43	1.9	Q3	Food intake, plate waste and its association with malnutrition in hospitalized patients(33)	18	ARAN Ediciones S.A
8	Clinical Nutrition Espen	4 (2.1)	37	3.2	Q2	Improving nutrition care and intake for older hospital patients through system-level dietary and mealtime interventions(27)	17	Elsevier
9	Nutrients	4 (2.1)	10	7.9	Q1	A prospective study identifying a change in energy and protein intake of older adults during inpatient rehabilitation(32)	5	MDPI AG
10	Waste Management	4 (2.1)	134	13.5	Q1	Hospital food waste and environmental and economic indicators - A Portuguese case study(29)	52	Elsevier

\*Previously known as Journal of The American Dietetic Association, the number of publications and citations have been merged.  
TP: total publication; TC: total citation; SJR: SClmago Journal Rank

research collaboration in healthcare food waste was still low. A similar trend was reported in a previous food waste bibliometric analysis in a non-healthcare setting. Among the 2420 articles they analysed, 80.8% were single-country publications, and only 19.2% were MCP (40). Since the MCP is still limited, collaboration should be encouraged to extend the possibilities of discovery. The top 15 most productive countries contribute to the growth of worldwide research activity on food waste in the healthcare setting. The network between countries required higher attraction in the VOSviewer analysis since the MCP is rare in this research area (<http://bit.ly/3YJmsQg>). The top three most productive countries (the US, Australia, and the UK) have collaborated from different continents, while others are comfortable collaborating within their continents. Although the USA holds the highest link of strength (7), Germany has

the highest MCP (75%) compared to other countries. It is worth noting that only one of Germany's four publications was not an MCP. Thus, even though the USA has higher numbers of MCP (six publications), Germany prevailed on a percentage basis.

**Leading Authors**

Table II lists the ten most prolific authors in healthcare food waste research, affiliated with four countries as follows: Australia (6 authors), Japan (2 authors), the UK (1 author), and Denmark (1 author). Among the authors, E. Bannerman was the first to publish in 2006, followed by M. Batterham and K. Walton in 2007. Meanwhile, most published their first publication between 2014 and 2019. The authors' affiliations showed that food waste in healthcare research was related to agriculture, nutrition, food service, health, and dietetics.

**Table II: List of the most prolific authors in healthcare food waste research area**

Rank	Authors	Scopus author ID	Year of 1st publication	TP	h-index	TC	Affiliation	Country
1	Collins, Jorja	55790525900	2019	5	3	16	Department of Nutrition, Dietetics and Food at Monash University	Australia
2	Mauder, Kirsty	56453217800	2018	5	5	84	Faculty of Science, Medicine and Health, University of Wollongong	Australia
3	Porter, Judi	7403426851	2019	5	3	16	Department of Nutrition, Dietetics and Food at Monash University	Australia
4	Batterham, Marijka	6602566841	2007	4	4	102	Statistical Consulting Centre, University of Wollongong	Australia
5	McCray, Sally	7003490860	2018	4	4	75	Dietetics and Foodservices, Mater Health, Brisbane	Australia
6	Walton, Karen	35275986200	2007	4	3	100	School of Medicine, University of Wollongong	Australia
7	Akamatsu, Rie	17433494300	2016	3	3	37	Dept. of Nutrition and Food Science, Ochanomizu University	Japan
8	Bannerman, Elaine	6603667608	2006	3	3	35	Global Academy of Agriculture and Food Security, The University of Edinburgh	UK
9	Holst, Mette	24076041800	2014	3	3	68	Department of Clinical Medicine, Aalborg University Hospital	Denmark
10	Kawasaki, Yui	57189000736	2016	3	3	37	Department of Nutrition and Food Science, Ochanomizu University	Japan

TP: total publication; TC: total citation

The top three authors published five documents, with J. Collins from Australia topping the chart with an h-index of 3 and total citations of 16 since 2019, followed by K. Maunders from Australia, with an h-index of 5 and 84 citations since 2018. Meanwhile, J. Porter had an h-index of 3, with a total citation count of 16. The rest of the authors each published three to four publications.

The University of Wollongong was named the second most productive academic institution in Australia (Supplemental File 2), and it was home to three of the ten top authors in healthcare food waste. Six of the most productive authors are from Australia. Among other authors, K. Walton and M. Batterham received the highest citations. Authors from Ochanomizu University, Japan, ranked 7th (R. Akamatsu) and 10th (Y. Kawasaki) with 37 total citations since 2016. The other two authors were from The University of Edinburgh, UK, ranked 8th (E. Bannerman), and Aalborg University Hospital, Denmark, ranked 9th (M. Holst).

### Author Keywords

A total of 442 author keywords were recorded, among which 364 (82.4%) were used only once, 44 (10.0%) were used twice, and 6 (1.4%) were used three times. After re-labelling synonymic single words and congeneric phrases, the keywords were reduced to 132 and displayed on the VOSviewer map. Author keywords are the terms selected and created by authors in the research paper. The author keywords in this paper are discussed based on their occurrences and the average normalised citations score. The average normalised citation in VOSviewer indicates the average normalised number of citations received by documents containing a keyword or term or by documents published by a source, author, organisation, or country. The average normalised citation is a score with a correction for publication year, making comparing documents published in different years fairer. The brighter the colour, the higher the

average normalised citation score.

### Topic of interest

The topic of interest can be identified using the VOSviewer map of author keywords (Fig. 2). Food waste related to malnutrition, related intervention strategies, the impact of healthcare food service systems on food waste, and their economic and environmental impact are all topics of interest addressed by these author keywords.

The keyword 'food waste' has been widely used in the literature and repeated 42 times in the VOSviewer map. In comparing these types of food waste in the healthcare setting, 'plate waste' appeared the most with 29 occurrences. In contrast, 'kitchen waste' and 'unserved food' only appeared once or twice. Even though 'plate waste' is the common term used in food waste research related to the healthcare setting, its average normalised citation was lower (0.89) than 'food waste' (1.25). In contrast, the 'unserved food' is the main highlight, with an average normalised citation score of 1.61. There are two types of food waste: avoidable and unavoidable. The main issue is frequently the avoidable food waste that could have been prevented by better portioning, management, storage, or preparation (4). Healthcare institutions may produce avoidable food waste in the kitchen, on the wards, or in the dining area. Avoidable food waste was divided into three categories: plate waste (food served to the patient and diner but not consumed), unserved meals (overordered or regenerated patient meals), and kitchen waste (food waste during preparation or deterioration of food during manufacturing) (17,41). Unavoidable food waste, on the other hand, arises from food preparation that is not and has not been edible under normal circumstances (e.g., meat bones, egg shells, pineapple skin, tea bags) (4). Several previous works of literature took plate waste as their primary focus in healthcare food waste research



eat without interruption during these periods, and the staff can offer help (52). It was suggested to focus on assisted mealtimes rather than only protected mealtimes to improve their dietary intake and reduce food waste (53). Meanwhile, the dissatisfaction of receiving wrong menus may contribute to plate waste, and this issue can be addressed by using an electronic food ordering system. Electronic ordering can directly respond to the patient's demands, reducing the number of wrong orders, increasing food consumption, and reducing plate waste (54). The growing research trends in food waste have allowed researchers to study the strategies to improve the existing system. Such topics can become potential most discussed topics in healthcare food waste research based on their average publication years (2016 – 2018).

Food service systems need good management in healthcare settings to minimise food waste. Even though the average normalised citation keyword of 'foodservice' is 0.92, it has appeared 44 times in the maps and been linked with other higher average normalised citation keywords. Forecasting the total number of patients to be served and portion flexibility are perceived barriers to reducing food waste across most food service settings (54). Portion flexibility allows patients to select portion sizes concerning recommended intakes (54). Portion flexibility is usually practised trolley meal service system. Excess food was somehow preferable to food service professionals. However, this would lead to a waste of unserved meals (17,54). The perspectives and experiences of healthcare food service staff facilitated the understanding of various aspects involved in providing hospital food, influencing patients' acceptance of eating food. Employees lack initiative and interpersonal skills, and food service operations lack funding and authority to improve healthcare food provision. These are some of the challenges of managing healthcare food services. (50). This points out that educating and training the staff involved in healthcare food service would help improve the issue of healthcare food waste. Such a qualitative study on the roles of food service staff is encouraged, as it can provide insight into the challenges that food service providers need to overcome in reducing healthcare food waste.

The keywords that branch out from the food service keyword, such as 'plated system' and 'trolley meal service', had higher average normalised citations of 3.38 and 1.94, respectively. Different plating systems (centralised or decentralised) and catering systems (outsourcing or in-house) were noted as influencing factors for patients' food consumption (11). Thus, different food service systems can also be confounding variables, and it is important to consider them when conducting research. Besides that, 'nutritional assessment' with 20 occurrences is also a vital keyword to accurately assess patients' daily intake. Collecting accurate dietary intake information can be challenging

and resource-intensive (55). Using photo-assisted tools to assess dietary intake is emerging in healthcare food service research. A Pictorial Dietary Assessment Tools (PDAT) is a valid and reliable tool to assess a patient's dietary intake (55). However, the effectiveness of this kind of assessment tool in reducing food waste has yet to be determined.

It is essential to highlight that the average publication year for the keywords' 'wastage management' is 2016, and the average normalised citation is 3.24. This score shows that the environmental topic area can become another potential most discussed topic in the future. In recent years, many international organisations have highlighted the economic and environmental impact of waste generated by food systems in recent years (56,57). In a case study conducted in Saudi Arabian hospitals, patients threw away 412 g of food daily, indicating an 18% waste rate (58). Similar studies undertaken in the United Kingdom, Portugal, the Netherlands, and Australia found that food wastage ranged from 29 per cent to 42 per cent. (19,49,59,60). It is important to reduce serving losses to minimise overproduction and reduce plate waste while complying with consumer desires, needs, and preferences for meal quality and quantity. In addition, developing an effective coordination system that includes all players (suppliers, food service staff, government agencies, investors and shareholders, and consumers) along the food supply chain leads to decreased food waste (61).

It was also found that the keywords' 'finance' (13 occurrences) were linked with several keywords such as 'malnutrition,' 'plate waste,' 'nutritional intake,' 'food waste,' 'food service,' and 'plated system.' There is no doubt that food waste impacts the cost of a healthcare budget. Proper and feasible intervention may reduce the cost. Compared to a traditional food service model, room service was found to have reduced 15% of patients' meal costs (15). Electronic bedside meal ordering systems (eBMOS) was found to be effective in reducing the cost of food service while still maintaining patient satisfaction. A 19% reduction in overall patient feeding costs for eBMOS was found compared to the traditional menu over the same 12-month period (62). The cost of the efficacy of eBMOS installation is determined by the payback method (i.e., the time necessary to recoup their project's initial investment). Each model's costs were calculated based on labour, software, and printed menus. They indicated that using the eBMOS instead of the traditional method would result in a monthly savings of \$1197 (\$615 vs. \$2093) and an expected payback period of 8.4 months. They also proposed that additional savings might be realised by reducing food waste due to improved forecasting and tallying accuracy with the eBMOS (63,64). According to a recent study, integrating Foodservice Dietitian increases patient adherence to the nutritional treatment plan and results in cost savings. The role of the Foodservice Dietitian is not only limited to the

kitchen but also actively monitoring food provided in the ward, such as ensuring that foods are not delivered to fasting patients or those receiving parenteral/enteral nutrition, tailoring and monitoring of food delivered to the wards and staff, checking expiration dates of medical foods, and improving communication between the wards, the kitchen, and the food distribution centres, and performing nutritional analyses, tailoring of food provided according to the patient's medical and nutrition needs (65). These intervention studies have shown a positive impact and can be seen as the future hotspot topic in healthcare food waste publications.

Aside from that, food losses and food waste have led to multiple challenges in sustaining food security because of climate change and water depletion (66,67). Food waste is also associated with 'global warming' (3 occurrences, 1.69 of the average normalised citation). The emissions of greenhouse gases through the process of treating (composting, anaerobic digestion) or eliminating (incineration, landfilling) them thus contribute to global warming (19). Municipal solid waste management that was improper and unscientific increased numerous types of pollution in the air, water, and soil. The garbage that serves as a breeding ground for disease vectors such as flies, mosquitoes, rodents, and other animals would also impact public health (68). Although the research on this matter was quite outdated, it highlights the high prevalence of food waste, how it affects the environment, and the proper handling of food waste management, which is still neglected in most countries.

### Limitations

The query string potentially lacked other keywords related to food waste in healthcare settings, such as 'food residue', 'kitchen residue' and 'kitchen garbage'. As a result, it possibly does not cover all food waste-related studies available on Scopus. Furthermore, due to missing author keywords information from specific journals, such as the Journal of the American Dietetic Association, Hospital Progress, PLOSONe, and others, co-occurrence analysis of author keywords covered only 71% of 193 articles. Future bibliometric research should compare multiple databases, such as Scopus and Web of Science, as they can supplement each other's shortcomings. Searching for these papers in the grey literature would also be beneficial.

### CONCLUSION

This paper presented an overview of food waste research in healthcare based on 193 articles from the Scopus database. The publication of healthcare food waste has been seen to increase over the years, and the annual publication became more frequent and consistent starting in 1991, with the first spark of articles starting in 2008. Australia, the UK, and the USA topped the publication charts, dominating 35%

of published articles. We highlighted several research topics commonly and potentially discussed in this area, such as food waste related to malnutrition, intervention strategies to reduce food waste in healthcare and its cost, the impact of the healthcare food service system on food waste, and the economic and environmental impact of food waste. Since healthcare food waste publications are still limited, these research topics are relevant and should be explored. Policymakers should promote the development of healthcare food waste research, particularly in developing nations where it is still sparse, as it has become a national problem worldwide.

### ACKNOWLEDGEMENT

This study is supported by the Fundamental Research Grant Scheme (FRGS) (ID: FRGS/1/2018/SS08/UKM/02/5), funded by the Ministry of Higher Education of Malaysia.

### REFERENCES

1. Xue L, Liu G, Par J, Liu X, Herpen E Van, Stenmarck E, et al. Missing food, missing data? A critical review of global food losses and food waste data. *Environ Sci Technol*. 2017;51:6618–33. doi: 10.1021/acs.est.7b00401.
2. Food and Agriculture Organization (FAO). Definitional framework of food loss [Internet]. Rome, Italy; 2014. Available from: [http://www.fao.org/fileadmin/user\\_upload/save-food/PDF/FLW\\_Definition\\_and\\_Scope\\_2014.pdf](http://www.fao.org/fileadmin/user_upload/save-food/PDF/FLW_Definition_and_Scope_2014.pdf)
3. Clean Technology Centre. Reducing Food Waste in Irish Healthcare Facilities. Bishopstown, Cork, Ireland: CIT Press, Institute of Technology; 2014. 1–44 p.
4. Waste & Resources Action Programme (WRAP). Where food waste arises within the UK hospitality and food service sector : spoilage , preparation and plate waste [Internet]. Banbury; 2013. Available from: <http://www.wrap.org.uk/sites/files/wrap/HaFS%2520sector%2520spoilage%2520preparation%25%0A20and%2520plate%2520waste%2520FINAL.pdf>
5. Searchinger T, Hanson C, Ranganathan J, Lipinski B, Waite R, Winterbottom R, et al. The great balancing act. 2013.
6. Williams P, Walton K. Plate waste in hospitals and strategies for change. *E Spen Eur E J Clin Nutr Metab* [Internet]. 2011;6:e235–41. doi:10.1016/j.eclnm.2011.09.006
7. Hong W, Kirk D. The analysis of edible plate waste results in 11 hospitals in the UK. *J Foodserv Syst*. 1995;8:115–23. doi: 10.1111/j.1745-4506.1995.tb00081.x
8. Holdt CS, Sitter K, Gates GE. Comparison of plate waste estimation measures in a pediatric hospital. *J Foodserv Syst*. 1993;7:81–91. doi: 10.1111/j.1745-4506.1993.tb00206.x

9. Shahar S, Chee KY, Wan Chik WCP. Food intakes and preferences of hospitalised geriatric patients. *BMC Geriatr.* 2002;2:1–6. doi: 10.1186/1471-2318-2-3.
10. Zakiah L, Saimy I, Maimunah A. Plate Waste among Hospital Inpatients. *Malaysian J Public Heal Med.* 2005;5(2):19–24.
11. Aminuddin NF, Vijayakumaran RK, Abdul Razak S. Patient satisfaction with hospital foodservice and its impact on plate waste in public hospitals in East Malaysia. *Hosp Pract Res.* 2018;3(3):90–7. doi: 10.15171/hpr.2018.20
12. Chik CT, Zulkipli NA, Bachok S. Plate Waste in Public Hospitals Foodservice Management in Selangor, Malaysia. *Indian J Sci Technol.* 2018;11(36):1–5. doi: 10.17485/ijst/2018/v11i36/98468
13. Razalli NH, Cheah CF, Mohammad NMA, Abdul Manaf Z. Plate waste study among hospitalised patients receiving texture-modified diet. *Nutr Res Pract.* 2021;15(e21):1–17. doi: 10.4162/nrp.2021.15.5.655
14. Hartwell HJ, Edwards JSA, Beavis J. Plate versus bulk trolley food service in a hospital: comparison of patients' satisfaction. *Nutrition.* 2007;23:211–8. doi: 10.1016/j.nut.2006.12.005.
15. McCray S, Maunder K, Krikowa R, Mackenzie-shalders K. Room Service Improves Nutritional Intake and Increases Patient Satisfaction While Decreasing Food Waste and Cost. *J Acad Nutr Diet [Internet].* 2018;118(2):284–93. doi:10.1016/j.jand.2017.05.014
16. Azeman AR, Adenan H, Ripin A. Patient's satisfaction towards private hospital's food service in Melaka. *J Hosp Networks.* 2018;1(2015):32–6.
17. Silvennoinen K, Heikkilä L, Katajajuuri J, Reinikainen A. Food waste volume and origin: Case studies in the Finnish food service sector. *Waste Manag [Internet].* 2015;46:140–5. doi: 10.1016/j.wasman.2015.09.010
18. Cereda E, Pedrolli C. Food waste: other issues and settings should be considered. *Nutr Bull.* 2009;34:238–9.
19. Dias-ferreira C, Santos T, Oliveira V. Hospital food waste and environmental and economic indicators – A Portuguese case study. *Waste Manag [Internet].* 2015; doi:10.1016/j.wasman.2015.09.025
20. Ministry of Finance M. *Ucapan Bajet 2022 [Internet].* Percetakan Nasional Malaysia Berhad. 2021. Available from: <https://budget.mof.gov.my/pdf/2022/ucapan/ub22.pdf>
21. Ellegaard O, Wallin JA. The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics.* 2015;105(3):1809–31. doi: 10.1007/s11192-015-1645-z
22. Md Khudzari J, Kurian J, Tartakovsky B, Raghavan GSV. Bibliometric analysis of global research trends on microbial fuel cells using Scopus database. *Biochem Eng J.* 2018;136:51–60. doi: 10.1016/j.bej.2018.05.002
23. CHECKING garbage for pointers on unnecessary food waste. *Hospitals (Lond).* 1952;26(7):100–1.
24. Brine CL, Tate EB. Effect of food losses on nutritive content of diets in four institutions. *J Am Diet Assoc [Internet].* 1956;32:19–23. Available from: <https://www.cabdirect.org/cabdirect/abstract/19501100562>
25. Goonan S, Miroso M, Spence H. Getting a Taste for Food Waste : A Mixed Methods. *Acad Nutr Diet.* 2013;114(1):2212–672. doi: 10.1016/j.jand.2013.09.022.
26. Wilson A, Evans S, Frost G. A comparison of the amount of food served and consumed according to meal service system. *J Hum Nutr Diet.* 2000;13(4):271–5. doi: 10.1046/j.1365-277x.2000.00235.x
27. Dupertuis YM, Kossovsky MP, Kyle UG, Raguso CA, Genton L, Pichard C. Food intake in 1707 hospitalised patients: A prospective comprehensive hospital survey. *Clin Nutr.* 2003;22(2):115–23. doi: 10.1054/clnu.2002.0623.
28. Walton K, Williams P, Bracks J, Zhang Q, Pond L, Smoothy R, et al. A volunteer feeding assistance program can improve dietary intakes of elderly patients - A Pilot Study. *Appetite.* 2008;51(2):244–8. doi: 10.1016/j.appet.2008.02.012.
29. Valero Díaz A, Caracuel García Á. Evaluation of factors affecting plate waste of inpatients in different healthcare settings. *Nutr Hosp.* 2013;28(2):419–27. doi: 10.3305/nh.2013.28.2.6262.
30. Flanagan K, Clowes A, Lipinski B, Goodwin L, Swannell R. *SDG Target 12.3 on food loss and waste: 2018 progress report. An annual update on behalf of Champions, 12.3.* 2018.
31. Young AM, Banks MD, Mudge AM. Improving nutrition care and intake for older hospital patients through system-level dietary and mealtime interventions. *Clin Nutr ESPEN [Internet].* 2017;24:140–7. doi:10.1016/j.clnesp.2017.12.009
32. Farrer O, Olsen C, Mousley K, Teo E. Does presentation of smooth pureed meals improve patients consumption in an acute care setting: A pilot study. *Nutr Diet.* 2015;73(5):405–9. doi: 10.1111/1747-0080.12198
33. Malefors, C., Callewaert, P., Hansson, P. A., Hartikainen, H., Pietiläinen, O., Strid, I., ... & Eriksson M. Towards a baseline for food-waste quantification in the hospitality sector—quantities and data processing criteria. *Sustainability.* 2019;11(13):3541. doi: 10.3390/su11133541
34. Collins J, Porter J, Truby H, Huggis CE. A Prospective Study Identifying a Change in Energy and Protein Intake of Older Adults during Inpatient Rehabilitation. *Nutrients.* 2019;11(2):453. doi: 10.3390/nu11020453
35. Simzari K, Vahabzadeh D, Saeidlou SN, Khoshbin S, Bektas Y. Food intake, plate waste and its

- association with malnutrition in hospitalised patients. *Nutr Hosp.* 2017;34(6):1376–81.
36. Garrone P, Melacini M, Perego A. Opening the Black Box of Food Waste Reduction. *Food Policy.* 2014;46:129–39. doi: 10.2139/ssrn.2109594
  37. FAO. Food wastage footprint. Impacts on natural resources. Summary Report [Internet]. 2013. Available from: [https://reliefweb.int/report/world/food-wastage-footprint-impacts-natural-resources?gclid=Cj0KCCQjw4NujBhC5ARIsAF4lv6d1rH8i06rWgwy2OeL9lcZBaafmnxWfLFk1JXF2kVwT2WwVcKc40doaAsymEALw\\_wcB](https://reliefweb.int/report/world/food-wastage-footprint-impacts-natural-resources?gclid=Cj0KCCQjw4NujBhC5ARIsAF4lv6d1rH8i06rWgwy2OeL9lcZBaafmnxWfLFk1JXF2kVwT2WwVcKc40doaAsymEALw_wcB)
  38. Barton AD, Beigg CL, Macdonald IA, Allison SP. High food wastage and low nutritional intakes in hospital patients. *Clin Nutr.* 2000;19(6):445–9. doi: 10.1054/clnu.2000.0150.
  39. Kelton N. National food waste strategy: Halve food waste in Australia by 2030. *Food Aust.* 2019;71(1):30–1.
  40. Zhang M, Gao M, Yue S, Zheng T, Gao Z, Ma X, et al. Global trends and future prospects of food waste research: A bibliometric analysis. *Environ Sci Pollut Res.* 2018;25(25):24600–10. doi: 10.1007/s11356-018-2598-6
  41. Waste & Resources Action Programme (WRAP). Healthcare: Five steps to reduce food waste [Internet]. 2016. Available from: <http://www.wrap.org.uk/content/waste-prevention-toolkit—helping-hospitals-cut-food-waste>
  42. Ofei KT, Holst M, Rasmussen HH, Mikkelsen BE. How practice contributes to trolley food waste. A qualitative study among staff involved in serving meals to hospital patients. *Appetite* [Internet]. 2014;83:49–56. Adoi:10.1016/j.appet.2014.08.001
  43. Alshqaqeeq F, Twomey JM, Overcash M, Sadkhi A. A study of food waste in St. Francis Hospital. *Int J Healthc Manag.* 2020;13(S1). doi: 10.1080/20479700.2017.1414982
  44. Alshqaqeeq F, Twomey JM. Food waste in hospitals: Review. *Int J Healthc Technol Manag.* 2019;17(Nos. 2/3):186–96. doi: 10.1504/IJHTM.2018.098389
  45. Agarwal E, Ferguson M, Banks M, Batterham M, Bauer J, Capra S, et al. Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: Results from the Nutrition Care Day Survey 2010. *Clin Nutr* [Internet]. 2013;32(5):737–45. doi:10.1016/j.clnu.2012.11.021
  46. Mudge AM, Ross LJ, Young AM, Isenring EA, Banks MD. Helping understand nutritional gaps in the elderly (HUNGER): A prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. *Clin Nutr* [Internet]. 2011;30(3):320–5. doi:10.1016/j.clnu.2010.12.007
  47. Hamilton K, Spalding D, Steele C, Waldron S. An audit of nutritional care delivered to elderly inpatients in community hospitals. *J Hum Nutr Diet.* 2002;15(1):49–58. doi: 10.1046/j.1365-277X.2002.00333.x
  48. Schiavone S, Pistone MT, Finale E, Guala A, Attena F. Patient satisfaction and food waste in obstetrics and gynaecology wards. *Patient Prefer Adherence.* 2020;14:1381–8. doi: 10.2147/PPA.S256314
  49. Van Bokhorst-De Van Der Schueren MAE, Roosemalen MM, Weijs PJM, Langius JAE. High waste contributes to low food intake in hospitalised patients. *Nutr Clin Pract.* 2012;27(2):274–80. doi: 10.1177/0884533611433602
  50. Rathnayake D, Dalpatadu S. A systematic approach to reduce hospital food waste based on patient experience. *Br J Heal Care Manag.* 2020;26(10):1–7. doi: 10.12968/bjhc.2019.0100
  51. Edwards D, Carrier J, Hopkinson J. Assistance at mealtimes in hospital settings and rehabilitation units for older adults from the perspective of patients, families and healthcare professionals: a mixed methods systematic review protocol. *JBIS database Syst Rev Implement reports.* 2015;13(11):17–32. doi: 10.11124/JBISRIR-2016-003100
  52. Hospital Caterers Association. Protected Mealtimes Policy. London; 2004.
  53. Young A, Allia A, Jolliffe L, De Jersey S, Mudge A, Mcrae P, et al. Assisted or protected mealtimes? Exploring the impact of hospital mealtime practices on meal intake. *J Adv Nurs.* 2016;72(7):1616–25. doi: 10.1111/jan.12940
  54. Ofei KT, Holst M, Rasmussen HH, Mikkelsen BE. Effect of meal portion size choice on plate waste generation among patients with different nutritional status. An investigation using Dietary Intake Monitoring System (DIMS). *Appetite* [Internet]. 2015;91:157–64. doi:10.1016/j.appet.2015.04.043
  55. Budiningsari D, Shahar S, Manaf ZA, Susetyowati S. A simple dietary assessment tool to monitor food intake of hospitalised adult patients. *J Multidiscip Healthc.* 2016;2016(9):311–22. doi: 10.2147/JMDH.S105000
  56. Gustavsson J, Cederberg C, Sonesson U, Van Otterdijk R, Meybeck A. Global Food Losses and Food Waste. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy,; 2011. 1–204 p.
  57. Schneider F. The evolution of food donation with respect to waste prevention. *Waste Manag* [Internet]. 2013;33(3):755–63. doi: 10.1016/j.wasman.2012.10.025
  58. Alharbi NS, Qattan MY, Alhaji JH. Towards sustainable food services in hospitals: Expanding the concept of ‘plate waste’ to ‘tray waste.’ *Sustainability.* 2020;12(6872):16–9. doi: 10.3390/su12176872
  59. Barrington V, Maunder K, Kelaart A. Engaging the patient: improving dietary intake and meal experience through bedside terminal meal ordering

- for oncology patients. *J Hum Nutr Diet*. 2018;1–7. doi: 10.1111/jhn.12573
60. Sonnino R, McWilliam S. Food waste, catering practices and public procurement: A case study of hospital food systems in Wales. *Food Policy* [Internet]. 2011;36(6):823–9. doi: 10.1016/j.foodpol.2011.09.003
  61. Strotmann C, Ritter G. Comparing food provided and wasted before and after implementing measures against food waste in three healthcare food service facilities. *Sustainability*. 2017;9(1409):1–18. doi: 10.3390/su9081409
  62. McCray S, Maunder K, Norris R, Moir J, MacKenzie-Shalders K. Bedside Menu Ordering System increases energy and protein intake while decreasing plate waste and food costs in hospital patients. *Clin Nutr ESPEN* [Internet]. 2018;26:66–71. doi:10.1016/j.clnesp.2018.04.012
  63. Jamison J, Bednar C, Alford B, Hsueh A. A computerized interactive menu selector system for hospitals. *J Am Diet Assoc*. 1996;96(10):1046–1047. doi:10.1016/S0002-8223(96)00277-5
  64. MacKenzie-Shalders K, Maunder K, So D, Norris R, McCray S. Impact of electronic bedside meal ordering systems on dietary intake, patient satisfaction, plate waste and costs: A systematic literature review. *Nutr Diet*. 2020;77(1):103–111. doi:10.1111/1747-0080.12600
  65. Yona O, Goldsmith R, Endevelt R. Improved meals service and reduced food waste and costs in medical institutions resulting from employment of a food service dietitian - a case study. *Isr J Health Policy Res*. 2020;9(5):1–9. doi: 10.1186/s13584-020-0362-0.
  66. Liu G. Food Losses and Food Waste in China: A First Estimate [Internet]. OECD Food, Agriculture and Fisheries Papers. Paris: OECD Publishing; 2014. Available from: <http://www.oecd-ilibrary.org/docserver/download/5jz5sq5173lq.pdf?expires=1399902900&id=id&accname=guest&checksum=827763753514AD7F847D436DEE7F24A0>
  67. Jereme IA, Siwar C, Begum RA, Abdul B. Food wastes and food security: The case of Malaysia. *Int J Adv Appl Sci*. 2017;4(8):6–13.
  68. Kumar S, Bhattacharyya JK, Vaidya AN, Chakrabarti T, Devotta S, Akolkar AB. Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An insight. *Waste Manag* [Internet]. 2009;29(2):883–95. Available from: <http://dx.doi.org/10.1016/j.wasman.2008.04.011>