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Food systems and sustainability

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EDITORIAL

Dietitians as change agents for promoting healthy and sustainable food systems

Food systems around the world are in crisis. They are fostering dietary patterns associated with dietary risk factors, which are among the leading contributors to the global (and national) burden of disease.[1] Worryingly, trend data indicate the global prevalence of all forms of malnutrition is moving in the wrong direction, casting increasing doubt that the food and nutrition-related Sustainable Development Goals will be met by 2030.[2] Food systems also are unsustainable. Their profligate use of finite resources and substantial production of waste is threatening humanity's ability to live within planetary boundaries.[3]

Within food systems, there is a bi-directional relationship between dietary consumption patterns and food supply sustainability.[4] On the one hand, the dietary patterns being fostered by food systems are responsible for one third of global greenhouse gas emissions[5] and approximately 70% of freshwater use[6] as well as being the primary drivers of biodiversity loss.[7] Modelling indicates that dietary consumption patterns alone could add nearly 1°C to global warming by the end of the century[8] and this will severely undermine attempts to keep global temperatures below the 1.5°C increase identified as tolerable by the Paris Agreement.[9]

On the other hand, transcending planetary boundaries will compromise the ability of food systems to supply sufficient amounts and variety of nutritious food to support the food and nutrition security of populations. In relation to climate change alone, the Intergovernmental Panel on Climate Change states with 'high confidence' that 'the impacts of climate change on food availability and nutritional quality will increase the number of people at risk of hunger, malnutrition and diet-related mortality'.[10] Mechanisms for explaining these climate change impacts are being identified and modelled. For example, experimental trials in which crops were grown under a CO_2 level of 550 ppm, similar to that projected for 2050, recorded 3%–17% lower concentrations of protein, iron and zinc.[11]

There is an increasing urgency to calls from nutrition scientists to change current food systems, so they become healthy and sustainable and thereby support the achievement of global environmental targets, such as the Paris Agreement[9] and the Sustainable Development Goals.[12] Sustainability in a food systems context has been defined by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security as, 'Food system practices that contribute to long-term regeneration of natural, social and economic systems, ensuring the food needs of the present generations are met without compromising the food needs of future generations'.[13]

The overwhelming majority of nutrition and dietetic experts recognise that a 'business as usual' approach towards the structure and operation of food systems is not tenable. What is less clear is the 'order' of food system change that is necessary. Some people believe that a first-order (adjustment/tweak/nudge) change to food systems will be sufficient, for example, food label information and food reformulation interventions managed by a health department. Others believe that a second-order (reform) change to food systems is needed, for example, coordinated food procurement, fiscal and regulation interventions across government departments to replace the proliferation of ultra-processed foods with a higher proportion of accessible, available and affordable minimally processed foods in the marketplace. Still others believe that a third-order (transformation) change to food systems is necessary, for example, a whole-of-government commitment to a national food and nutrition policy to fundamentally re-frame the purpose of, and power relationships within, food systems. It was this transformational order of change that was the focus of the United Nations Food systems Summit 2021.[14] A strategic combination of all orders of food system change has been proposed as a necessary approach to transitioning to healthy and sustainable food systems and dietary patterns.[15]

Dietitians are particularly well-placed to take a leadership role in changing food systems. We have training in nutrition science, practical skills in food and nutrition, experience in communicating food and diet information, and often work in multi-disciplinary teams. Critically, an increasing number of dietitians are also demonstrating advanced and specialised competencies in food policy, regulation, and advocacy for change. There are still competencies to mainstream to a greater extent than is

evident at present. In the future, an essential competency for dietitians working to promote and protect healthy and sustainable diets and food systems MUST be a deep understanding of ecological nutrition concepts as a basis to analysing the health and sustainability potential of food systems.

Progress towards promoting healthy and sustainable food systems has already been made by many dietitians and Dietitians Australia. In recent years, the Dietitians Australia Food and Environment Interest Group has released its Food Systems and Environmental Sustainability Role Statement,[16] sustainability has been incorporated into the National Competency Standards for Dietitians in Australia[17] and Dietitians Australia has published its Position statement on healthy and sustainable diets.[18] In academia and professional training activities more broadly, there are exciting activities underway with innovative curriculum design and resource development to support dietitians in tackling health and sustainability challenges.

The diversity of nutrition and dietetics research projects investigating healthy and sustainable food systems is well illustrated by the studies reported in this issue of *Nutrition & Dietetics*. There is a coverage of health and sustainability aspects of food systems within health care settings. Collins and Porter[19] report on the results of their audit of food and food packaging waste produced in hospital foodservice. The scale of this problem is starkly highlighted by their finding that, on average, across the three hospital foodservices they audited, there was 502.1 kg/day of waste, which then is usually sent to landfill. Complementing this work, Lewandowski et al.[20] in a separate paper report on findings from a pilot study investigating the safety, operational feasibility and environmental impact of collecting unopened non-perishable packaged hospital food items for reuse. They found a substantial volume of unused packaged hospital food collected from trays was safe, indicating that reusing many non-perishable packaged food items might be one strategy to divert some food waste from landfill. In a related systematic review, Cook et al.[21] describe food and food-related waste management strategies in hospital food services. The review reports that the most frequently reported approaches to divert food and food-related waste from landfill included composting, donating surplus food, and industrial use.

A significant contributor to food waste and inefficient food provision in food service settings is food supply chain disruptions. The COVID-19 pandemic provides a salient lesson in how suddenly food supply chain disruptions can arise. Cook et al.[22] report that despite COVID-19 adversely impacting food service operations, food waste and labour shortages, foodservices can be highly adaptable and transition rapidly in times of unanticipated food supply chain disruption. In her letter published in this issue, Kennewell[23] reflects on her experiences when developing a meal service model for people placed in mandatory COVID-19 hotel quarantine. She describes lessons for dietitians who might be required to respond to future food system shocks—an increasingly plausible scenario with sustainability-associated challenges across food supply chains.

One of the more complex and controversial topics within the healthy and sustainable diet literature is plant-based alternative protein foods. Two papers in this issue provide insights into this topic. Melville et al.[24] report on a cross-sectional study that assessed the nutritional quality of plant-based meat analogues in Australia compared with equivalent meat products. They found that most meat analogues are ultra-processed, vary in their nutrient content and few are fortified. Riddout[25] notes the current uncertainty about the environmental profiles of foods derived from plant protein isolates and concentrates, engineered yeasts, cellular agriculture and insects. These uncertainties arise particularly because many of the processes used are proprietary, and voluntary reporting of environmental data is limited. He provides two powerful observations. First, the current information gaps 'create a state of uncertainty about the actual environmental benefits and potential burden shifting from one environmental aspect to another'. Second, health and sustainability comparisons among foods 'is a minefield ripe for cherry-picking of favourable data'. His letter proceeds to offer suggestions for addressing these uncertainties.

Papers on two other important health and sustainability research topics are included in this issue. McCormack et al.[26] report the findings from a scoping review investigating how dietetics students learn about sustainability. Disappointingly, just 12 articles have been published on this topic, and their synthesis revealed core gaps in teaching approaches as there was minimal reference to the Sustainable Development Goals and published sustainability guidelines. Masters et al.[27] report on a cross-comparison evaluation of the environmental impacts and diet qualities of seven-day isocaloric diet models based on the Mediterranean, Atkins, Ornish, Zone diets, and the Turkiye Diet Guidelines-2015 recommendations.

There are many opportunities for consolidating and expanding dietitians' roles and responsibilities as food systems change agents into the future. Encouragingly, positive activities are increasingly being undertaken by many dietitians. One innovative example is provided by Carino et al.[28] in their letter in this issue describing the establishment and scope of a 'Sustainable Food Systems Dietitian' position created at a large metropolitan public healthcare network in Melbourne. The aim of this novel

dietetics position was to embed environmental sustainability within patient foodservices using a multifaceted approach in collaboration with the foodservice, dietetics, and media and communications teams. Among many activities, it designed and implemented food waste and satisfaction audits to compare two existing foodservice models and planned a local food audit to map the origin of current food procurement. The authors emphasise that a sustainability dimension should be embedded into the responsibilities of clinical, foodservice, manager and student dietitian roles. Critically, they also comment on the need for training in environmental sustainability to be part of dietetics education, placements and professional development.

It is pertinent to reflect on what might happen if dietitians are not engaged in food system change given there is currently no shortage of non-nutrition and non-dietetics opinions on food and nutrition. As Nourishing Australia notes, 'There are many and varied groups that provide a "*cacophony* of noise" (my italics) from which consumers must synthesise the "truth" about food and nutrition'.[29] With our nutrition science training, skills and understandings, I would argue dietitians can provide a '*harmony* of evidence-informed guidance' to be lead change agents in promoting healthy and sustainable food systems.

CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

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REVIEW

Food and food-related waste management strategies in hospital food services: A systematic review

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Abstract

Aim: This review explored peer-reviewed and grey literature to describe the types and characteristics of food or food-related waste management strategies used in hospital food service settings; their financial, environmental and staffing outcomes; and the barriers and enablers associated with their implementation.

Methods: Six electronic databases, 17 Google Advanced searches, and 19 targeted websites were searched for peer-reviewed and grey literature. Literature reporting the financial, environmental, or staffing outcomes of food or food-related waste management strategies that reused, recovered energy from, or recycled waste instead of sending it to landfill were eligible. Document screening and review were completed in duplicate, and included peer-reviewed literature were assessed for quality using the Mixed Methods Appraisal Tool. Data were synthesised narratively.

Results: Four peer-reviewed and 81 grey literature records reported 85 strategies. When grouped from most to least favourable according to the food recovery hierarchy they managed waste by: donating surplus food ($n = 21$); feeding animals ($n = 2$); industrial use ($n = 11$); composting ($n = 34$) and other ($n = 17$). These approaches had the capacity to reduce waste hauling fees ($n = 14$), reduce staff handling of waste ($n = 3$), and decrease the amount of waste sent to landfill ($n = 85$). Barriers included contamination of waste streams, while enablers included leadership and time-neutral changes.

Conclusion: This review summarises the waste management strategies used by hospitals worldwide that divert food and food-related waste from landfill, their outcomes, and position in the food recovery hierarchy to enable hospital food services to implement appropriate practice and policy changes to decrease their environmental footprint.

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KEYWORDS
food, food services, health care, hospitals, sustainability, waste management

1 | INTRODUCTION

Food waste is a large contributor to the global environmental footprint, generating up to 10% of emissions.[1,2] When disposed to landfill food waste produces methane, occupies land mass, and is a potential groundwater contaminant 'upstream'.[3] Twenty-two percent[4] of the world's annual 1.3 billion tonnes of food waste[5] occurs at the consumption end of the food supply chain, which encompasses settings such as households, the food service industry, and the retail sector.[6–8] In response to this issue, world leaders, governments, and environmental groups have made commitments to reduce food waste and divert food waste from landfill. For example, the Australian National Food Waste Strategy was published in 2017[9] and the overall aim is to halve Australia's food waste by 2030, contributing to the United Nations Sustainable Development Goal 12—responsible consumption and production. One step to achieving this aim is to move food waste and surplus food up the food recovery hierarchy.[10]

The food recovery hierarchy[11] is a model for managing food waste, illustrating the most to least preferable methods based on the social, economic, and environmental implications of food waste. The food recovery hierarchy recommends avoiding food waste in the first place. While this is the most preferred option and an essential goal to work towards, food waste appears inevitable in some settings and populations, and therefore considering what happens to food waste is warranted. The food recovery hierarchy[11] proposes reusing surplus food for human consumption (e.g., food donation), followed by diverting food waste to animal feed, recovering energy (e.g., via anaerobic digestion), then composting as strategies to manage food waste. Disposing of unavoidable food waste into landfill is the least preferred option. Previous research has highlighted that other waste like plastic, paper and metal should also be diverted from landfill or incineration instead of being recycled, similar to the recommendations of the hierarchy.[12] Donation, anaerobic digestion and composting of food waste, all have unique environmental, financial and social outcomes as well as barriers and enablers to uptake. Donation of food to not-for-profit food rescue organisations is often free for the donor and has potential tax deduction benefits,[13] but does not guarantee food consumption.[14] Anaerobic digestion generates biogas for energy conversion and digestate for composting,[15] however, it has high transportation, construction and operation costs.[16] Composting is the biological degradation of organic matter under aerobic conditions to create a soil amendment, although problems can arise with food waste composition, compost odour, and contamination.[15] Despite their differences, each strategy has the capacity to divert large amounts of food waste from landfill.

Hospitals are one setting where food waste seems inherent, making waste management strategies an essential area of focus. Up to 50% of overall waste is comprised of food waste in some healthcare facilities.[17] This includes organic non-edible material (e.g., vegetable peelings and bones) and edible food fit for human consumption (e.g., leftover meals).[18] There are many reasons why food waste occurs in hospitals. Patient related factors include their health status and length of stay, patient appetite, expectation and satisfaction of food quality and quantity, the meals' appearance, size and taste, and the variety of choice in the menu.[19] Challenges associated with the food service model include the inability to provide certain therapeutic diets,[20] seasonal variability of ingredients, inability to forecast expected meal numbers,[21] food service type and kitchen design, large gaps of time between food ordering and consumption,[22] and the continual provision of excess or incorrect items.[19] Moreover the hospital environment itself impacts food waste due to service interruptions and patient surroundings affecting food intake.[23] Outcomes of interventions that have targeted these problems to attempt to reduce food waste in hospital food service settings have been previously synthesised in a recent systematic review.[17] Even though there are successful research studies demonstrating decreases in food waste, these setting-specific problems are complex to solve due to the obligation and duty of care hospitals, food services and dietitians have to provide patients with abundant opportunity to consume adequate nutrition that can support their recovery from illness.[24] Additionally, there are key performance indicators for acceptable plate waste (<30%) and production waste (<10%) levels for different states in Australia which alludes to food waste in hospitals being a problem that is unlikely to be reduced completely.[25]

Sending food and food-related waste to landfill or to be incinerated is still common practice in hospital food services.[12,23,26,27] However, the World Health Organization categorises paper, cardboard, packaging and food waste as 'non-risk waste',[28] indicating that hospital organic waste does not have to be disposed of in these

TABLE 1 Eligibility criteria for systematic review of food and food-related waste management strategies in hospital food services

	Inclusion criteria
Population	Hospital: including public, private and rehabilitation hospitals OR commissary kitchen that produces food for hospitals AND food service providing food for patients (patient feeding) OR retail/commercial food service onsite at a hospital providing food for patient, staff or visitors such as cafeterias, canteens, food courts, restaurants, vending machines or food carts
Intervention	Food waste management strategy that focuses on organic food waste or non-organic food-related waste (i.e., food packaging) that has been produced from the hospital food service AND/OR strategy from the food recovery hierarchy[21] stages of feed hungry people (donate extra food to food banks, soup kitchens, shelters), feed animals (divert food scraps to animal food), industrial use (providing waste oils for rendering and fuel conversion and food scraps for digestion to recover energy), composting (creating a nutrient rich soil amendment)
Outcome	Financial outcome which were costs (e.g., cost of equipment, labour costs); or savings (e.g., decrease in waste management fees); or resources provided (e.g., funding, grants) OR environmental outcome (e.g., amount of waste diverted from landfill, amount of greenhouse gases reduced) OR staffing outcome (e.g., operational change, behavioural change) AND IF PRESENT (secondary outcome) barriers or enablers associated with implementation of the strategy used
Study design	Primary research using any observational or experimental study design OR studies using quantitative, qualitative or mixed method data collection OR quality improvement activities OR descriptive reports of practice changes completed without a research or quality improvement foundation

ways. Despite the opportunities to divert food waste from landfill using strategies outlined in the food recovery hierarchy, healthcare workers report food waste as the number one waste stream they consider important to recycle but are unable to, or find it difficult to do, in their workplace.[29]

Understanding how food waste management strategies are used in hospital food service settings is essential to benchmark current practice and direct future actions for sustainable healthcare and translational research. This is relevant for nutrition and dietetics professionals who have been called on to become sustainable food system advocates.[30,31] However, there is an absence of literature on waste management in hospital food services, with a recent systematic review of sustainable practices across the hospital food supply chain identifying only eight published studies reporting strategies to manage food waste.[17] A broader search including synthesis of grey literature may provide insight into the true scope of hospital food waste management practices. Therefore, this systematic review aims to explore the peer-reviewed and grey literature to (a) describe the types and characteristics of food and food-related waste management strategies used in hospital food service settings; (b) discuss the effects of such strategies on financial, environmental and staffing outcomes; and (c) identify the barriers and enablers associated with implementing these strategies in hospital food service settings.

2 | METHODS

This review has been reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[32] The review protocol was registered a priori on the International Prospective Register of Systematic Reviews (registration number: CRD42020197634).

The eligibility criteria are outlined in Table 1. Peer-reviewed or grey literature were eligible if they reported on a waste management strategy or intervention that reused, recovered energy from, or recycled food or food-related waste instead of sending it to landfill. As this review focused on food and food-related waste management strategies, no strategies that related to the two other food recovery hierarchy stages of prevention (reducing food waste generation) and disposal (sending food waste to landfill) were considered. Eligible settings were hospitals or an offsite kitchen facility producing food consumed by hospital patients, staff or visitors. Reporting at least one outcome of financial, environmental or staffing-related outcomes was required. Peer-reviewed literature included published research articles, letters to the editor, conference abstracts and theses, with no restrictions on study design. Grey literature retrieved from Google Advanced searches and targeted website searches were included if reports of practice changes met and provided sufficient information aligning with the eligibility criteria. Only literature from the year 2000 onwards was included to ensure that modern solutions to food waste were captured. Literature in English or able to be translated to English using Google Translate were eligible.

Peer-reviewed and grey literature search strategies and terms were trialled and developed through discussion with a subject librarian.

Six electronic databases were searched from 2000 to 19 October 2021 for peer-reviewed literature (Ovid

Medline, Ovid Embase, Ovid Global Health, Scopus, Web of Science, CINAHL Plus). Aside from the date restriction, no additional search limits were applied. The search terms encompassed three fields relating to hospital setting, food, and waste which were customised for each database (Tables S1–S6). All results from the electronic database searches were downloaded into Endnote (Version X9, Clarivate Analytics, Philadelphia) where duplicates were removed. Using Covidence (Veritas Health Innovation, Melbourne) titles and abstracts, then full text papers, were screened individually and in duplicate by two reviewers. Discrepancies were discussed amongst the review team to obtain consensus. Reference lists of the final included library and relevant reviews were also screened by one author and potentially relevant references were considered by the review team.

Grey literature was identified through a series of Google Advanced searches and a hand search of targeted websites following methods recommended by Godin et al.[33] The Google Advanced search was completed during a 1-week period in July 2020 by one author using a combination of keywords (Table S7). No date limit was set to narrow the search and Incognito mode was used to eliminate previous searches affecting the results. The first 20 pages of results (or until the pages ceased) were reviewed against the eligibility criteria. This sought to provide a consistent approach across searches. Weblinks of relevant results were copied to an Excel spreadsheet (Version 2019, Microsoft Corporation, Washington) and a full text review was completed by two reviewers in duplicate by exploring the information available at the source. This process was repeated in October 2021, where the search was narrowed using a limiter 'up to one year ago' and only two pages of results were screened for inclusion. This process was completed to ensure all newly reported and relevant strategies since the original search were located. Furthermore, 19 targeted websites related to food waste and/or sustainable healthcare were identified by the research team (Table S8), and were reviewed in a two-step process to identify if they contained eligible literature during September 2020. One author screened each website using the search term 'hospital food waste' if a search bar was available, or by looking through the information available. Full text review of relevant results replicated the process described for the Google Advanced search.

Data were extracted from included literature using a purpose designed template in Excel (Version 2019, Microsoft Corporation, Washington) developed by the research team. Data collection fields included: document identification (author, year), setting characteristics (type of setting, location, description of food service model), study aim, study design, description and characteristics of the food waste management strategy, type of strategy according to the food recovery hierarchy, types of food waste and meal times where data were collected, financial, environmental or staffing outcomes of the strategy, and any associated enablers or barriers to the strategy implementation reported by the authors.

Quality assessment was completed using the Mixed Methods Appraisal Tool (MMAT) Version 2018,[34] which has undergone testing to establish its validity, reliability and usefulness.[35] It appraises the risk of bias of qualitative, quantitative and mixed methods studies using five criteria classified as 'yes', 'no' or 'can't tell' (Table 2). Included peer-reviewed literature was assessed in duplicate with discrepancies resolved by consensus. Grey literature were not assessed for quality because there is no fit-for-purpose quality assessment tool, and use of a standard peer-reviewed tool such as the MMAT would produce potentially false weak quality assessments.[36]

A narrative approach was used to synthesise data. Information was separated in tables and text according to: classification of the food waste management strategy in relation to the food recovery hierarchy, the type of food waste management strategy used, the financial, environmental, and staffing outcomes of the strategies used and whether barriers or enablers to the intervention were experienced. Food waste management strategies which did not resemble the food waste hierarchy categories of, donate surplus food, feed animals, industrial use (providing waste oils for rendering and fuel conversion and food scraps for digestion to recover energy) or composting but diverted food waste from landfill were categorised as other. Financial outcomes were converted to AUD for consistency using the currency converter[37] at the time of publication consistent with the methods of Mitchell and Porter[38]; financial data reported within grey literature without dates were not converted. All units of mass were converted to kilos, tonnes and litres for consistency.

3 | RESULTS

The electronic database searches provided 18 547 records. There were 10 032 records for title and abstract screening, reducing to 58 records for full text review. The Google Advanced searches yielded 1963 records, with 63 included. Of the 19 targeted websites, 15 were identified for consideration, with 9 included. The final library comprised of 4 peer-reviewed and 81 grey literature records ($n = 85$ total) (Table 3, Figure 1**)**.

Three of four peer-reviewed documents had lower methodological quality, meeting one or two out of five MMAT quality criteria.[39–41] The remaining study met three out of five criteria, indicating higher quality[42] (Table 2). Common

TABLE 2 Risk of bias within included peer-reviewed studies using the MMAT[34]

Reference	S1	S2	Study design	Q1	Q2	Q3	Q4	Q5	Reasons for downgrading quality
do Nascimento et al.[39]	Yes	Yes	Quantitative cross-sectional	Yes	No	Can't Tell	Yes	Can't Tell	Only one site, unclear food waste measurement information, overlooked statistical analysis.
Kristiana et al.[41]	Yes	Yes	Quantitative cross-sectional	Yes	No	No	Yes	Can't Tell	Only one site, ambiguous data collection and measurement, overlooked statistical analysis.
Galvan et al.[40]	Yes	Yes	Quantitative case report	Yes	No	No	No	Can't Tell	Only one site, minimal data collection and results reported, overlooked statistical analysis.
Freedman and Franklin[42]	Yes	Yes	Quantitative case report	Yes	No	Yes	Yes	Can't Tell	Only one site, overlooked statistical analysis.

Note: S1, Are there clear research questions?; S2, Do the collected data allow to address the research questions?; Study design, What type of study design is this paper?; Q1, Is the sampling strategy relevant to address the research question?; Q2, Is the sample representative of the target population?; Q3, Are the measurements appropriate?; Q4, adapted to 'Is there complete data on the case?' following MMAT guidelines for these study designs; Q5, Is the statistical analysis appropriate to answer the research question?
Abbreviation: MMAT, Mixed Methods Appraisal Tool.

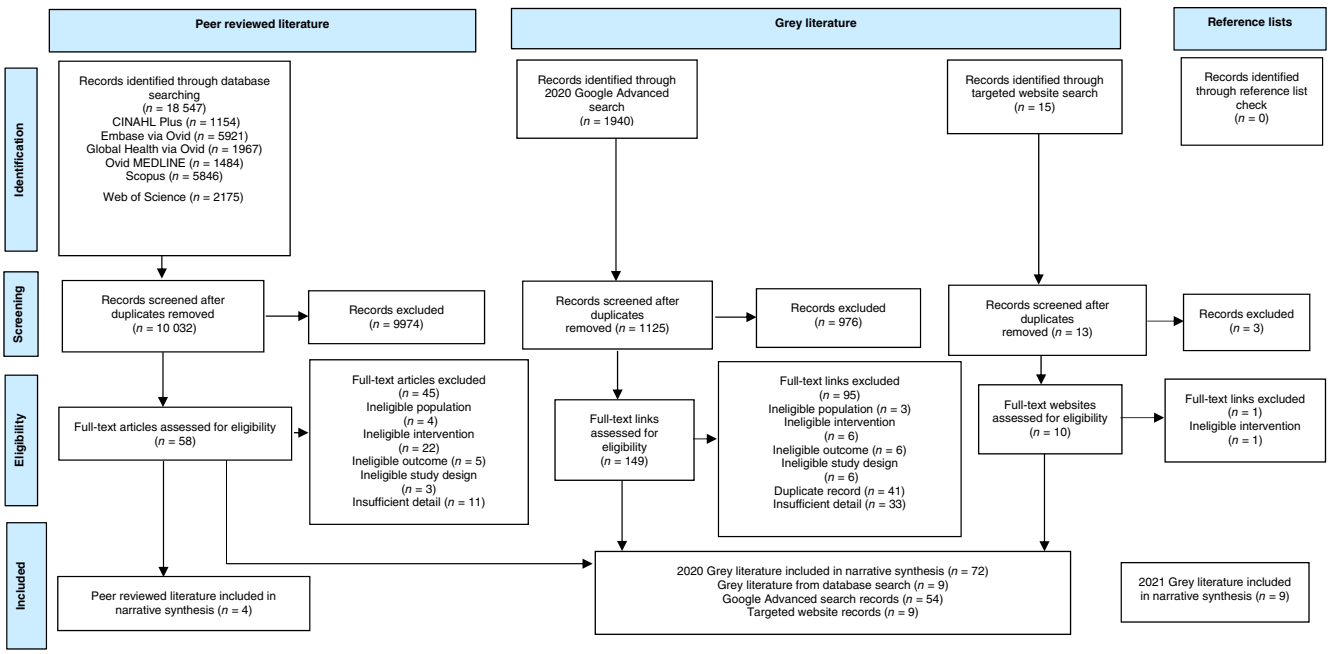

FIGURE 1 PRISMA flow diagram of included records for systematic review of food and food-related waste management strategies in hospital food services

TABLE 3 Study characteristics for systematic review of food and food-related waste management strategies in hospital food services

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Surplus food donation								
Green Impact[101]	Blog post	University medical centre, USA	Hospital food service's food waste (surplus prepared food) was donated to a food rescue organisation	NR	>4536 kg (9073 meals), between 9 and 68 kg/day diverted from landfill over 5 months	NR	NR	NR
HCWH (Health Care Without Harm), n.d.[102]	Case study	Hospital, France	Hospital food service's food waste (surplus prepared food) was donated to two food rescue organisations	NR	10 000 meals/year diverted from landfill	NR	Good management ensured the program's quality and maintenance	NR
Hammes, 2011[103]	Blog post	Health service, USA	Hospital food service's food waste (unsellable food) was donated to a food rescue organisation	NR	1000 meals/month diverted from landfill	NR	NR	NR
The University of Vermont Health Network[104]	Blog post	Medical centre, USA	Hospital café's food waste (surplus prepared food) was donated to a food rescue organisation	NR	91 kg/month diverted from landfill	NR	NR	NR
Rush, 2019[105]	Blog post	Hospital, USA	Hospital food service's food waste (surplus prepared food) was donated to a food rescue organisation	NR	136 kg/month diverted from landfill, 4000 meals diverted in 1 year	NR	NR	NR
Buzalka, 2017[106]	Blog post	Hospital, USA	Hospital food service's food waste (reusable food) was donated to a food rescue organisation	Savings: 2% decrease in food costs	≤22.7 kg/week diverted from landfill	NR	NR	NR
Palma, 2014[107]	Case study	Hospital, Italy	Hospital food service, cafeteria and restaurant's food waste (surplus prepared food) was donated to a food rescue organisation	NR	20 meals/day diverted from landfill	NR	NR	NR
Diariodelweb, 2016[108]	Blog post	Hospital, Italy	Hospital canteen's food waste (surplus prepared food) was	NR	4 tonnes/year (360 first courses, 630 second courses, 660 side	NR	NR	NR

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TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
			donated to a food rescue organisation		dishes) and 30 kg bread/month diverted from landfill			
Kaiser Permanente, 2019[109]	Blog post	Medical centre, USA	Hospital food service's food waste (surplus unserved food) was donated to two food rescue organisations	NR	6350 kg diverted from landfill in 1 year	NR	NR	NR
Vivanco, 2017[110]	Blog post	Medical centre, USA	Hospital food service and cafeteria's food waste (uneaten lunch packs) was donated to a food rescue organisation	NR	623 meals diverted from landfill in 2 weeks	NR	NR	NR
Interreg Central Europe Strefowa[75]	Blog post	Hospital, Italy	Hospital employee canteen's surplus food waste (uneaten lunch packs) was donated to a food rescue organisation	NR	214 kg/month diverted from landfill, 430 tonnes CO_2 equivalent avoided/year	NR	NR	NR
Galindo, 2019[111]	Blog post	Two Medical centres, USA	Hospital food service's food waste (surplus prepared food) was donated to a food rescue organisation	NR	2000 kg diverted from landfill in 6 months (4460 meals)	NR	NR	NR
Global Green and Healthy Hospitals, 2020[54a] The Royal Melbourne Hospital, 2018[112b] Melbourne Health, 2018[113c]	Case study Blog post Blog post	Hospital, CPK, AU	Hospital food service CPK's food waste (surplus prepared food) was donated to a food rescue organisation	Savings: $3000 decrease in landfill fees/year[a]	25 kg/day (100 cook chill main meals, 80 modified texture meals, 60 desserts[b]) diverted from landfill, 9.125 tonnes/year or 3000 meals/month[c] diverted from landfill, >17 tonnes CO_2 equivalent avoided/year[a]	NR	NR	NR
Corrigan, 2019[114]	Blog post	Hospital, USA	Hospital food service, cafeteria and restaurant's food waste (surplus prepared food) was	NR	570 kg in 2016, 2832 kg in 2017, 1361 kg estimated in 6 months of 2018 diverted from landfill	NR	NR	NR

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
			donated to a food rescue organisation					
Corrigan, 2019[114]	Blog post	Two Medical centres, USA	Hospital food service's food waste (surplus prepared food) was donated to a food rescue organisation	NR	2355 kg diverted from landfill in 1 year	NR	NR	NR
Ramsay Health Care Limited, 2019[48]	Report	Hospital, AU	Hospital food service's food waste (preportioned items) was donated to a food rescue organisation	NR	12 kg/week diverted from landfill	NR	NR	NR
Health Care Without Harm, 2018[115a] Germans Trias i Pujol Hospital, nd[116b]	Report Case study	Hospital, Spain	Hospital food service and cafeteria's food waste (surplus prepared food) was donated to a food rescue organisation	NR	45 kg/week[a] (150 meals[b]) diverted from landfill	NR	Cooperation of department[a,b]	NR
Smith, 2020[70]	Blog post	Health service (16 hospitals), USA	Hospital food service food waste (surplus prepared food) was donated to a food rescue organisation	NR	30 390 kg (55 000 meals) diverted from landfill across all sites in 1 year, 133 356 kg CO_2 equivalent avoided, 90 849 882.8 L water saved 63.5 kg (116 meals) diverted from landfill at one site in 1 week 251.7 kg (45 meals) diverted from landfill at one site in 1 week, 109.3 kg of CO_2 equivalent avoided	NR	Facilitated by technology platform	NR
Feed animals								
Neale, 2019[74]	Blog post	Hospital, AU	Hospital food waste was collected by a company who feeds it to maggots	NR	1.4 tonnes diverted from landfill in 6 months, 1261 kg of CO_2 equivalent avoided	NR	NR	NR

(Continues)

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Anaerobic digestion								
do Nascimento et al. 2017[39]	Journal article	Hospital, Brazil	Hospital food service's food waste was fed to a biodigester	Costs: $30 983 expected to run biodigester at $0.58 c/kWh over 10 years (6 times more than current waste hauling service)	5229 kg of food waste estimated to be consumed by the biodigester, creating 209 m^3 of biogas and generating 446 kWh of energy in 3 months	NR	NR	NR
WRAP (Waste and Resources Programme) 2014[117]	Case study	Four Hospital sites, cook chill, UK	Hospital food service, staff and public restaurant's food and food-related waste (biodegradable liners) were collected for anaerobic digestion	NR	163 tonnes (average 1.6 kg/bed/week) diverted from landfill in 1 year	NR	NR	NR
NHS England (National Health Service), 2019[118]	Report	Hospital, UK	Hospital food waste was collected for anaerobic digestion	NR	12 tonnes/month diverted from landfill	NR	NR	NR
WRAP, 2014[66]	Case study	Hospital, cook chill, UK	Hospital food service (28 wards) and one staff canteen's food waste was collected for anaerobic digestion	Savings: decrease in maintenance and repair costs and energy use from previously run macerator (no amount provided)	11.1 tonnes diverted from landfill in 13 months	NR	NR	Initial staff resistance, worry about smell and vermin
WRAP, 2014[79]	Case study	Healthcare service (four hospitals), cook chill, UK	Hospital food service (40 ward kitchens), one staff canteen and five restaurant's food and food-related waste (biodegradable liners) were collected for anaerobic digestion	NR	120 tonnes/year (1.9 kg/bed/week) diverted/year	NR	NR	Initial contamination of bins
WRAP, 2014[119]	Case study	Health service (eight hospitals), cook chill, UK	The hospital food service, three onsite restaurants and one CPK's food waste and food-related waste (biodegradable liners) were collected for anaerobic digestion	Savings: decrease in waste management costs (no amount provided)	62 tonnes/year diverted from landfill (0.52 kg/bed/week)	NR	NR	NR

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Massachusetts General Hospital, 2021[120]	Blog post	Hospital, USA	Hospital cafeteria food waste was collected for anaerobic digestion	NR	523 tonnes diverted from landfill in 1 year, since 2014, 2835 tonnes diverted from landfill, produced 150.5 m^2 of compost and 271 035.5 L of liquid fertiliser	NR	NR	NR
Clugston, 2021[121]	Blog post	Health service (207 sites), UK	Some of the hospital food service's in this health service food waste is collected for anaerobic digestion (no number of sites specified)	NR	6228 kg diverted in 1 year and 14 015 kg diverted in another year from landfill	NR	NR	NR
Dehydrator								
Epworth Health, 2020[122a] Sustainability Matters, 2021[123b] Green Eco Technologies[76 c]	Blog post	Hospital, AU	Hospital food waste were dehydrated before being sent for anaerobic digestion	NR	>20 tonnes of food used by the digester to create >2610 kWh energy in 1 year,[a] enough to power 1512 homes for 1 day[b] 12.17 tonnes CO_2 equivalent avoided[c]	NR	NR	NR
Green Eco Technologies, 2018[62 a] Green Eco Technologies, 2018[124 b] Green Eco Technologies[125c]	Case study Blog post	Hospital, UK	Hospital food service preparation and plate waste were dehydrated before being sent for anaerobic digestion	Savings: 35% decrease in costs[a] and $75 293 forecasted decrease in drainage/sewage costs[b]	50 tonnes/year diverted from landfill 11 000 L of water saved in 3 months, and 69 888 L water[a] saved in 1 year	NR	Easy machine set up[a], motivated staff[c]	NR
Offsite composting								
Galvan et al. 2018[40]	Journal article	Hospital, USA	Hospital food service's food waste (preparation waste) was sent to an offsite community garden for composting	Resource: $3250 grant provided to purchase bins and a compost tumbler	2358 kg of food waste diverted from landfill during the 2017 growing season	Hospital chefs now have a plot at the community garden to grow herbs	Students led project, no cost to organisation, and having a project manager	Hospital staff perceived food waste waiting for collection may become a hazard and the project was too costly and time demanding, the

(Continues)

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
								community garden leader was worried about bins filling up too quickly
Freedman and Franklin, 2010[42]	Journal article	Medical centre, cook serve, USA	Hospital food service's food (no liquids) and food-related waste (compostable/ recyclable items) were sent to a composting facility to create fertiliser	Savings: decrease in waste disposal fees (no amount provided)	567 kg of food waste and 18 kg recyclables diverted from landfill in 5 days	NR	NR	Contamination of compostable waste and time required to sort waste
Jamieson et al. 2004[80]	Blog post	Hospital, USA	Hospital cafeteria's food waste (preparation waste and table scraps) was sent for offsite composting	Savings: $472 decrease in landfill fees	5.2 tonnes diverted from landfill in 5 months	NR	NR	Contamination, broken bin bags, workers concerned with odour and vectors
Emerson, 2013[50]	Blog post	Medical centre, USA	Hospital food service's food waste (preparation waste and surplus food) was sent for offsite composting	Savings: $41 776/year decrease from reduced hauling fees	3 tonnes/month diverted from landfill	NR	No extra time involved	NR
Lehman, 2003[56]	Article	Medical centre, USA	Hospital food service, cafeteria and onsite restaurant's food waste (preparation waste, leftovers and plate waste) was sent for offsite composting	Costs: $9530 to purchase cooler and bins	181 kg/day diverted from landfill	NR	NR	NR
Lehman, 2003[56]	Article	Health service, USA	Hospital food waste (kitchen setting unclear) is sent for offsite composting	Savings: $24 861 decrease in waste hauling fees Costs: $1243/year	NR	NR	NR	NR
Twemlow[69]	Guideline	Hospital, UK	Hospital catering unit's food and food-related waste (compostable napkins and cutlery) were sent for offsite composting	NR	50% less waste sent to landfill, 4.7 less tons of CO_2 equivalent avoided	NR	NR	NR

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Wrobel, 2010[126]	Blog post	Two hospitals, USA	Hospital food services food waste (preparation waste and surplus food) was sent for offsite composting	NR	2268 kg diverted from landfill at one site in 1 month, 3175–3629 kg diverted from landfill at one site in 1 month	NR	NR	Pickup and delivery have to be constantly scheduled at one site
Recycling Works, 2013[77]	Case study	Hospital, USA	Hospital food service and cafeteria's plate waste and food-related waste (wax cardboard, compostable plates, utensils) were sent for offsite composting	Savings: decrease in costs (no amount provided)	60 tonnes/year diverted from landfill	NR	Having a champion, starting change with the kitchen staff first	NR
Illinois Food Scrap Association[81]	Case study	Hospital, USA	Hospital food service's food waste (kitchen waste and plate waste) and food-related waste (coffee filters, waxed cardboard, food soiled paper) were sent for offsite composting	NR	24.42 tonnes diverted from landfill in 2013 and 40.99 tonnes in 2014	NR	NR	New process for waste vendor, inconsistent pick up, turnover of staff at hospital and waste vendor, incorrect bins provided
VT Digger, 2018[127]	Blog post	Medical centre, USA	Hospital food service and café's food and food-related waste (compostable service ware) were sent for offsite composting	NR	467.76 tonnes of waste diverted from landfill (including two other organisations waste)	NR	NR	
Ramsay Health Care Limited, 2019[48]	Report	Hospital, AU	Hospital food service and staff cafeteria's waste (preparation waste and plate waste) was sent for offsite composting	NR	Nearly 3 tonnes/month diverted from landfill	NR	NR	NR
HCWH, 2016[71]	Blog post	Medical centre, USA	Hospital food service and cafeteria's food (preparation waste and plate waste) and food-related waste (service ware) were	NR	Estimated 12–15 tonnes/month diverted from landfill, nearly 200 tonnes total in 2013,	NR	NR	NR

(Continues)

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
			sent for offsite compositing		30.23 tonnes of CO_2 equivalent avoided			
Waddington, 2013[61]	Report	Hospital, CAN	Hospital food service's food waste (preparation and plate waste) was sent for offsite composting	Costs: $1848/month (cost neutral)	264 tonnes diverted from landfill in 15 years	NR	NR	NR
Recycling Works, 2013[64]	Case study	Hospital, USA	Hospital food service preparation and plate waste were sent for offsite composting	Savings: $383/month from decreased servicing of yard compactor and removed dumpster, overall $30 702 decrease from waste management over 10 years	25 tonnes (2010), 17 tonnes (2011), 19 tonnes (2012) amounts of food waste diverted from landfill (no units provided)	Source separation and transport are completed by hospital/facilities staff	Hospital green team, reports provided on performance	NR
University of California, Los Angeles Health[128]	Blog post	Hospital, USA	Hospital (kitchen setting unclear) food waste and compostable service ware were sent for offsite composting	NR	70760 kg diverted from landfill in 1 year	NR	NR	NR
Carvalho, 2012[49]	Blog post	Two Hospitals, USA	Hospital food service's food waste (preparation waste, plate waste and spoilage) were collected and sent for offsite composting	Savings: $3325 decrease in hauling fees	3.5 tonnes/week diverted from landfill between both facilities	NR	NR	2 years for implementation, concerns about odour
Biocycle, 2012[129]	Blog post	Medical centre, USA	Hospital food and food-related waste (cardboard, paper, cans, plastic) were sent for offsite composting	Resource: $24 231 grant received to purchase bin	6 tonnes/month diverted from landfill	NR	NR	NR
Zero Waste SA[130]	Case study	Hospital, AU	Hospital food service's food waste (preparation waste) was collected and sent for offsite composting	NR	218 tonnes/year (4.2 tonnes/week) diverted from landfill	NR	NR	NR

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Composting (unclear)								
Rethink Waste Tasmania, 2020[84]	Blog post	Hospital, AU	Hospital food service composts their food waste (unclear if offsite or onsite)	NR	1750 kg/week diverted from landfill	NR	Engaged public and private stakeholders, waste contractors and consumers	NR
Onsite composting								
Biocycle, 2015[131]	Blog post	Health service, USA	Hospital canteen's kitchen food waste was composted onsite	NR	12 tonnes/year vegetative waste and 6 tonnes/year coffee grounds diverted from landfill	NR	NR	NR
Closed Loop[73]	Case study	Health service, CPK, AU	A health service's CPK kitchen uses a commercial composter to compost food waste onsite	NR	127 tonnes/year diverted from landfill, 150 tonnes CO_2 equivalent avoided/year	NR	NR	NR
Soares and Chagas[85]	Case study	Hospital, Brazil	Hospital food service's food waste (preparation waste) was composted onsite	NR	6 tonnes diverted from landfill in 6 months	NR	City hall provided compost to facilitate waste breakdown and an engineer to provide advice on the process	NR
Worm farm								
Kristiana et al. 2005[41]	Journal article	Hospital, AU	Hospital food service's food and food-related waste (salad bar) were fed to worms onsite at the hospital	NR	480 ± 60 kg of food and food-related waste diverted from landfill in 8 weeks	NR	NR	NR
Waddington, 2013[61]	Report	Hospital, CAN	A hospital food service uses a worm farm to compost food waste (vegetable waste)	NR	4336 kg diverted from landfill (2 tonnes/year)	NR	NR	NR
Premier[132]	Case study	Health service (two hospitals), USA	Hospital food service's food waste (preparation waste) was sent to a community worm farm	NR	>272 kg diverted from landfill in 2010	NR	Planned before implementation	NR

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TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
US EPA (United States Environmental Protection Agency), 2002[82]	Case study	Hospital, USA	Hospital food service and cafeteria's food waste (preparation waste and surplus food) and food-related waste (cardboard) were composted using an onsite worm farm	NR	52 kg/day diverted from landfill	NR	NR	Employee resistance therefore only using 30%–70% of digester capacity
In-vessel composting								
WRAP, 2014[78]	Case study	Two Hospitals, UK	Hospital food service (8 wards, 3 day centres), 2 staff/public canteen's and onsite restaurants food waste (preparation and plate waste) was sent for in-vessel composting	NR	77 tonnes diverted from landfill between the two sites	Staff are responsible for operation and maintenance	NR	Initial contamination from small service ware items, cannot view waste after collection (hard to judge contamination), hard to interpret cost savings as related to sewer and power savings
Purdy, 2013[59]	Thesis	Hospital, CAN	Hospital food service and cafeteria food waste was collected in two onsite in-vessel composters that produce a fertiliser, which is then donated to a community organisation	Savings: $7386/year from decrease in operational labour and waste hauling and elimination of pulpers Costs: $57 283 to instal both in-vessel composters	83 tonnes/year (227 kg/day) diverted from landfill	NR	NR	NR
Grey water digester								
Greenwalt, 2016[52a] Levin, 2017[133b] Straseske, 2017[60c] Practice Greenhealth[83d]	Blog post Case study	Two Hospitals, USA	Hospital food service and cafeteria's food waste (preparation waste) was fed to a grey water digester	Savings: $20 874 decrease in waste hauling fees, additional labour savings after changing to this practice (no amount provided)[a]	113 398kgs diverted from landfill, 104 326kgs CO_2 equivalent avoided, >125 tonnes diverted in less than 2 years at 1 site[a] 283 495 kg diverted from landfill across both sites[c]	Heavy lifting eliminated	All digestion is done onsite (no additional storage/transport needed)[c]	Department resistance[d]

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
				$159/tonnes decrease, ROI in 34 months at one site[b] $49 381 decrease in waste disposal fees across both sites[c]				
Gerlat, 2014[51]	Blog post	Medical centre, USA	The hospital (kitchen setting unclear) fed food waste to a grey water digester	Savings: 50% decrease in waste disposal fees (no amount provided)	11 tonnes/month diverted from landfill	NR	NR	NR
Chumari, 2018[134]	Blog post	Hospital, Singapore	Hospital food service's food waste (preparation and plate waste) was fed to a grey water digester	NR	725 kg/day diverted from landfill	NR	NR	NR
Parkland Health and Hospital System, 2004[72]	Blog post	Health service, USA	Hospital (kitchen setting unclear) food waste (preparation and plate waste) was fed to a grey water digester	Savings: $17 609/year decrease in waste hauling fees	Estimated 360 tonnes/year diverted from landfill	NR	NR	NR
Power Knot, 2018[135]	Blog post	Hospital, CAN	Hospital food service's food waste (kitchen waste) was fed to a grey water digester	NR	110 kg/day diverted from landfill	NR	NR	NR
Iugis[55]	Case study	Hospital, AU	Hospital food service's food waste (preparation and plate waste) was fed to a grey water digester	Savings: decrease in pick up and disposal frequency (no amount provided)	200 tonnes diverted from landfill in 2 years, 180 tonnes CO_2 equivalent avoided, >130 kg methane emissions prevented, 16 500 L less fuel used by transport trucks	Heavy lifting eliminated	NR	NR
NHS England Sustainable development Unit[65a] Moss, 2013 [136b]	Case study	Hospital, UK	Hospital food waste (kitchen setting unclear) was fed to two grey water digesters	Savings: 90% decrease in operational costs, estimated £84 690–96 000 savings over 5 years and estimated £100 000 000 savings	1200 kg/week diverted from landfill[b]	Change from using macerator to collecting and moving waste to digester,[a] which minimally	Demonstrating good ROI and environmental impact helped the project continue[a]	Staff buy-in was challenging[a]

(Continues)

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
				in 5–6 years if used at all NHS hospitals[a] ROI achieved in 1 year[a,b] Costs: £2220/year to run and maintain digesters[a]		impacted operations[b]		
Practice Greenhealth[68]	Report	Hospital, NR	Hospital food service's food waste was fed to a grey water digester (estimated outcomes)	Savings: Estimated $14 760/year, ROI achieved in 2.8 years Costs: Estimated $41 350	Estimated 150 tonnes/year diverted from landfill	Decrease food waste handling, increase safety and heavy lifting eliminated	Decreased vermin, increase sanitation, decrease in maintenance of blocked drains	NR
Hensley, 2021[137]	Conference abstract	Hospital, AU	Hospital food service's food waste was fed to a grey water digester and the output was converted to fertiliser	Savings: $7000 decrease in power costs, $7500 decrease in water costs	48 000 kg diverted from landfill, 43 033 kWh decrease in energy use and 985 500 L decrease in water use	NR	NR	NR
Dehydrator								
Hinchliffe, 2020[53]	Blog post	Hospital, AU	Hospital (kitchen setting unclear) food waste was fed to a dehydrator and the output was used on hospital grounds for fertiliser and watering	Savings: $50 000/year decrease in waste hauling fees	80%–94% decrease in food waste	NR	NR	NR
Global Green and Healthy Hospitals, 2020[54]	Case study	Hospital AU	Hospital food service's food waste (preparation and plate waste) was fed to a dehydrator and converted to fertiliser	Savings: $2500/month in disposal fees	14.5 tonnes/month are processed, 27 tonnes CO_2 equivalent avoided	NR	NR	NR
Metropolitan Waste and Resource Recovery Group, 2017[63]	Case study	Hospital, AU	Hospital food service's food waste was fed to a dehydrator	Savings: Estimated $100 000/year depending on machine run time, decrease in trade waste (no insinkerators)	Estimated 310 tonnes/year diverted from landfill	NR	NR	Contamination from bin liners, time to weigh and load/unload machine was too long

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
Waddington, 2013[61]	Report	Hospital, CAN	Hospital food service's food waste (kitchen waste) was fed to a dehydrator and the output was used on their gardens	Savings: $5645/year in waste hauling fees	>30 tonnes diverted from landfill	NR	NR	NR
Catholic health association of the United States, 2013[67a] Neale, 2014[138b]	Blog post	Hospital, USA	Hospital food service, three coffee bistros and cafeteria's food waste were fed to a dehydrator and the output was used as a soil amendment	Costs: Estimated $260 538 Savings: $20 485/year return for 15 years due to decrease in water consumption and staff time[a]	Decrease in waste size from 816 kg a day to 113 kg/week[b]	Faster kitchen clean up[a]	NR	NR
Oostrom, 2016[58]	Article	Health service (six hospitals), CAN	Hospital food waste was fed to a dehydrator	Savings: $39 604/year across sites, $6253/year saved in energy, water and maintenance costs across sites $18 760 saved at one site from removing bins Costs: Dehydrator maintenance (no amount provided)	170 tonnes diverted from landfill (no time period)	Heavy lifting eliminated, additional labour tasks and training required, only one person assigned per new task	NR	Ventilation problems, by-product cannot be used on soil and had to be moved off site, machine off during some data collection times and not all waste collected, waste not collected in cafeterias or lunch room, dehydrator distributor no longer available
Recycling								
Mior, 2010[57]	Case study	Rehab hospital, CAN	Hospital food service food-related waste was recycled	Savings: Estimated $2375/year decrease in garbage collection	Estimated 33 000 milk cartons, 24 000 juice cups, 44 000 beverage lids, 48 000 soup bowl lids diverted from landfill	NR	NR	NR
Multiple strategies (donation, animal feed, biodiesel, offsite composting, onsite composting, composting [unclear], recycling)								
McKinney, 2015[45a] Jordan, date unknown[43b]	Article Blog post	Medical centre, USA	Hospital (kitchen setting unclear) food waste (surplus food) was donated to a food rescue organisation[a]	Savings: 20% decrease in food waste costs/serving ($0.08c to $0.06c)[a] Costs: $38 000/year for compost collection,	Estimated 293 kg in 2012, 1043 kg in 2013, estimated 2041 kg in 2015[a] diverted from landfill	NR	NR	Waste reduction needs to be coordinated across all departments[a]

(Continues)

TABLE 3 (Continued)

Author, year	Document type	Setting, food service type, location	Brief description of strategy	Financial outcomes (savings, costs, financial resources provided in $AUD)	Environmental outcomes	Staffing outcomes	Enablers reported by author	Barriers reported by author
			Food and food-related waste (compostable containers) were also sent for offsite composting[b]	compostable containers cost $102 000/year[b]	Estimated 77 tonnes in 1 year and 100 tonnes in 2nd year diverted from landfill[b]			
Ohio State University, 2019[46]	Blog post	Medical centre, USA	Hospital food service's food waste (surplus tray waste) was donated to a food rescue organisation[a] Hospital food service's food waste (preparation waste) and cafeteria's coffee grounds were sent for offsite composting[b]	NR	18 144 kg/year diverted from landfill[a] Estimated 40 823 kg waste/year and 45 359 kg coffee grounds/year diverted from landfill[b]	NR	NR	NR
Ramsay Health Care Limited, 2019[48]	Report	Hospital, AU	Hospital food service's food waste was donated to a food rescue organisation Hospital food service's used cooking oil were collected to make biofuel	NR	8610 kg diverted from landfill in 2 years 1000 L cooking oil/year diverted from landfill	NR	NR	NR
Practice Greenhealth[47]	Case study	Health service (three hospitals), USA	Hospital food service and cafeteria's food waste (preparation waste and surplus food) was collected and sent for animal feed (one site), composted onsite (one site) and sent for offsite composting (one site)	Savings: $8800 decrease in hauling fees across the health service in 2015 Resource: $50 000 grant received to create a food waste collection program in 2016	88 tonnes diverted from landfill at one site in 2015 (fed to livestock) 1.5 tonnes diverted from landfill at one site in 2015 (composted on site) 17 tonnes diverted from landfill at one site in 2015 (sent for composting)	NR	Signage, educational resources with an educational plan, having financial leaders involved	NR
Madsen et al. 2010[44]	Conference abstract	Hospital, traditional tray line, NR	Hospital food service's food and food-related waste were sent for composting (unclear onsite or offsite) and recycling, respectively	NR	115 tonnes decrease in total waste, composting increased from 0–100 tonnes, recycling increased from 0–17 tonnes	NR	NR	NR

Abbreviations: CPK, central production kitchen; kWh, kilowatt hour; NR, not reported; ROI, return on investment; a, b, c, d, for strategies which were reported across multiple located documents, the reference from which the data originated from is indicated by the superscripted letter.

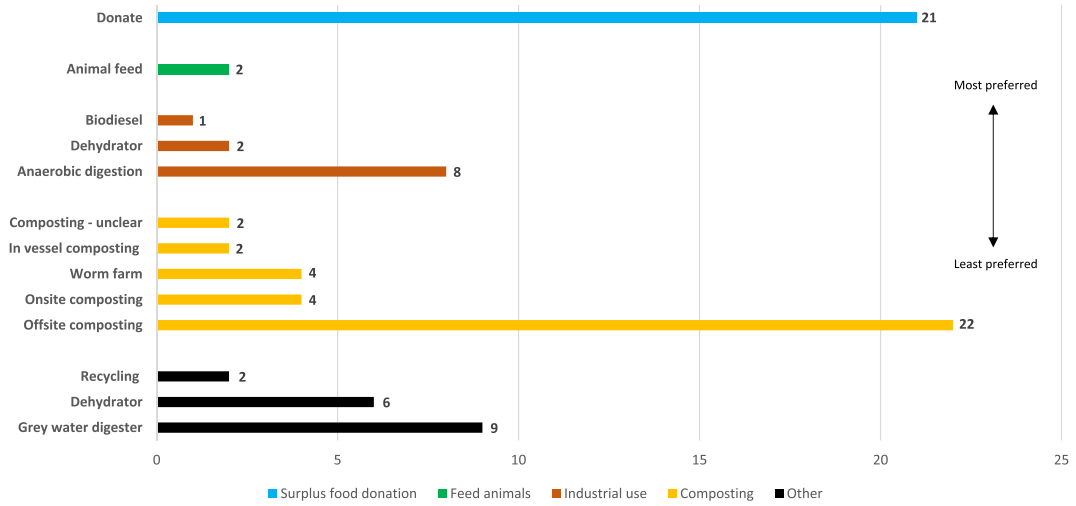

FIGURE 2 The number of food and food-related waste management strategies used in hospital food service settings according to their position in the food recovery hierarchy[11]

issues were representativeness (Q2) because all studies were conducted in a single hospital, and explicit explanation of statistical analysis methods used for data interpretation were absent (Q5). Only one study[42] used clear and defined measurements for their research question while others lacked detail (Q3).

Across all literature ($n = 85$ records) the majority of records discussed food waste management strategies occurring in North America ($n = 46$) followed by Europe ($n = 21$), Australia ($n = 15$), South America ($n = 2$) and Asia ($n = 1$). The settings where food waste management strategies were implemented were: hospital food service kitchens ($n = 41$), a mixture of more than one setting at a single hospital site ($n = 18$) such as the patient kitchen and an onsite cafeteria, cafeterias ($n = 7$), central production kitchens ($n = 2$) and a catering unit ($n = 1$). All peer-reviewed literature were quantitative reports ($n = 4$) and the grey literature were mainly in the form of blog posts ($n = 42$), others included case studies, reports, guidelines, theses and conference abstracts.

Across the 85 records, 85 food or food-related waste management strategies were reported. Managing food waste was the focus of 70 strategies, 15 were a combination of food and food-related waste management strategies (e.g., food packaging), and one strategy focused on food-related waste only (Table 3). When classified according to the food recovery hierarchy, composting ($n = 34$) was the most common type of food and food-related waste management strategy employed, followed by donating surplus food ($n = 21$) then industrial use ($n = 11$) (Figure 2). Seven records reported a combination of strategies being used at the same hospital/health care service.[42–48]

Financial outcomes were provided in 38 records across the peer-reviewed and grey literature (Table 3). The most common type of financial outcome reported from strategy implementation was cost savings due to a reduction in food waste disposal fees ($n = 14$).[42,49–61] Other financial savings occurred due to changes in equipment ($n = 7$)[58,59,62–66] and labour use ($n = 3$).[52,59,67] One grey literature[53] record reported the largest amount saved (AUD 50000/year) from reduced hauling fees, while another[64] reported the smallest saving, (AUD 383/month) achieved by removing a rented dumpster that was no longer needed. Several records ($n = 10$)[39,43,56,57,59,61,65,67–69] also reported the costs of setting up or implementing a food or food-related waste management strategy. The largest cost (AUD 260538) was for setting up dehydrators[67] and the smallest cost (AUD 1243/year) was for food waste collection by a composting company.[56]

Nearly all strategies ($n = 84$) reported an environmental outcome, although various measurements were used including: the number of meals or the weight of food and food-related waste diverted from landfill, reduction in CO_2 emissions, energy and biogas production, water savings and reduced transport needs (Table 3). The largest amount of food donated was 30 390 kg from a health network with 16 hospitals across the United States[70] followed by 18 144 kg/year at a single site in the United States.[46] From the various composting strategies (off site, on site, in vessel, worm farm) the largest amount of food waste diverted was just under 200 tonnes/year at one site.[71] A grey water digester and dehydrator were estimated to be able to process 360 tonnes/year[72] and 310 tonnes/year[63] of food waste, respectively. One hospital identified that >140 000 recyclable items annually could be prevented from disposal

in landfill.[57] Another prevented 11.3 tonnes of excess packaging going to landfill over a 3-year period through recycling and purchasing compostable packaging instead.[69] Reduction in carbon emissions released from food waste was reported in 12 records[52,54,55,66,69,71,73–76] with results ranging from 1 to 430 tonnes of gas emissions prevented through various diversion strategies.

Staffing outcomes were reported for nine strategies (Table 3). Three records described less manual handling of food waste by staff after a digestor was implemented[55,60,68] and one record reported a reduction in time staff spent cleaning following installation of a dehydrator.[67] Additional staff responsibilities related to waste management strategies such as separating waste streams,[77] transporting waste,[65,77] or operating and maintaining equipment were also reported.[40,78]

The barriers and enablers of the implementation of food and food-related waste management strategies were reported less frequently (Table 3). Barriers were described in 15 records, with recurrent themes of contamination of waste streams,[63,78–80] time demands (e.g., to sort waste),[42] equipment problems (e.g., broken bin bags,[80] incorrect bins being provided,[81] bins filling up too fast[40] and machines being off during data collection periods[58] or not being used to their full capacity[82]), stakeholder coordination (e.g., between the food waste vendors and all hospital departments[45]) and staff who were resistant to change.[66,82,83] Enablers were reported in 16 records, and dedicated leadership (e.g., via a green team, project coordinator or champion) was most common.[40,64,77] Other enablers were no increase in the labour/time requirement,[50] ease of equipment use,[62] demonstrating return on investment,[65] engaging[84] and receiving support[85] from stakeholders, technology (software)[70] and access to data (e.g., performance reports).[64]

4 | DISCUSSION

This systematic literature review explores food and food-related waste management strategies employed in hospital food service settings since 2000, using the food recovery hierarchy[11] as a descriptive framework. It summarises the effects of these strategies on financial, environmental, and staffing outcomes and describes barriers and enablers associated with implementation. Extending beyond traditional peer-reviewed literature ($n = 4$ records) (Table 3) and examining grey literature reported on the internet ($n = 81$ records), a large body of evidence has been generated that can be used to inform environmentally sustainable practices in hospital food services and future research opportunities. Presented within this review are 85 different examples of food and food-related waste management strategies being used in hospitals internationally. While it is encouraging to see some evidence of hospitals employing desirable waste management practices, this is only a small number. It is likely there are other hospitals that sustainably manage food and food-related waste and have not publicly reported their activities. The review identifies that hospitals use a diverse range of strategies to manage their food and food-related waste. The findings indicate that composting is the most commonly used strategy in practice, even though it is lower (less preferred) on the food recovery hierarchy,[11] meanwhile donating surplus food is also common and is the most preferred strategy. The authors recommend that hospitals consider the food recovery hierarchy[11] when addressing food and food-related waste. Avoiding waste in the first place using evidence-based strategies and simultaneously diverting waste from landfill using the most preferred strategies where possible will enhance sustainability efforts. Furthermore, measuring food waste using an evidence-based method[86] can capture the impact of these actions. The benefits, resources and the barriers and enablers of different waste management strategies synthesised in this review, can be used to determine the most feasible and appropriate approach to manage food service waste.

Reusing food is the most preferred strategy in the food recovery hierarchy[11] for dealing with food waste if it cannot be avoided. There are many different ways surplus edible food can be reused by hospital food services: incorporating it into different dishes, re-serving it to patients, making it available to staff, or donating it to food rescue organisations. This review found no examples of reusing food within a hospital to feed patients, and, to the knowledge of the authors, only one exists.[87] However it has previously been recognised by Ireland's Environmental Protection Agency Green Healthcare Programme in 2009[88] as a strategy to manage unserved food waste and is also currently used in the private hospitality sector.[89] Another alternate solution to reuse surplus edible food proposed by Ofei et al.[90] is to sell it to hospital visitors and staff which may result in increased patient-family interaction, reduced food waste, and financial return. Regulations and legislations are key barriers which must be overcome before reusing food within a hospital is possible or popular. For example, food safety regulations in some hospitals do not allow the reuse of food onsite[21] and national legislation (e.g., US Bill Emerson Good Samaritan Food Donation Act) that offers legal protection to organisations when they donate food does not extend to using food onsite for feeding patrons.[91,92] Instead of reusing food within a hospital, this review shows food donation is a common method to repurpose surplus edible food, especially in the United States. Although, food donation is a successful strategy to solve immediate hunger

needs and reduce food waste, it does not target the root causes of food insecurity[93] or promote regular sustainable access, quality and availability.[94]

Using food waste for industrial purposes such as anaerobic digestion that can generate energy is the third preferred strategy recommended along the food recovery hierarchy.[11] Food waste is a fitting substrate for anaerobic digestion due to its abundancy, energy content and availability.[16] However, industrial uses of food waste ($n = 11$) are far less common than composting ($n = 34$) in hospital food services. This may be because there are logistical and financial issues associated with establishing an effective anaerobic digestion process that are not experienced with composting.[16] Most of these challenges are chemical, including the processing instability and lack of buffering capacity of food waste and foam generation inside the digester.[16] The cost of anaerobic digestion and the reduced market opportunity for output products appear to be the largest barriers.[95] Cost-effective designs to improve uptake,[96] hybrid collection and management strategies that have synergistic outcomes,[16,95,97] legislation to support output product use,[95] and policy penalising projects that generate larger carbon emissions including composting[96] have been suggested as ways to increase anaerobic digestion infrastructure utilisation. These changes require the collaboration of industry, academia and government[16,98] to achieve mutual economic and environmental outcomes.[96] Additionally, Xu et al.[16] suggest that if industries were encouraged to report on their waste generation, characteristics, and disposal destinations, it may indicate where food waste as a substrate could be sourced from (e.g., hospitals).

In this review only four peer-reviewed papers were identified, with the majority of evidence sourced from the grey literature. It is likely that many hospitals have food and food-related waste management strategies in place, but research of higher quality and methodological rigour is not regularly conducted to explore them. Rather, this review identifies that online reports and blogs are more likely to be chosen for information sharing than published literature. What is essential is that planning for, collecting, and sharing evaluation data on food waste management strategies in healthcare occurs so that other organisations can make informed decisions; whether a research or quality improvement lens is used, or a peer-reviewed or non-peer-reviewed method of dissemination is selected, is less relevant. Using this information to increase public and patient awareness and advocacy may also drive change at a systems level, and for the individual patient who is choosing what to (or not to) order and eat. Furthermore, future reporting should include food-related waste (e.g., food packaging, single use crockery) due to its large environmental impact[99] and low representation in this review. Additionally, secondary outcomes prioritising social impact such as community engagement, local economy improvement, and program awareness should be targeted, as these outcomes have been proposed to enhance an organisations' image, help organisations fulfil corporate responsibilities, and generate value for the community.[100]

A strength of this review is the inclusion of both peer-reviewed and grey literature from multiple data sources to broaden and increase the number and diversity of findings. However, the peer-reviewed literature was minimal and of low methodological quality while the grey literature was abundant but could not be assessed for risk of bias. This is a limitation of the review and a limitation of research synthesising grey literature in general. Adams et al.[36] recommend a 'value of information' approach to assess risk of bias in grey literature that considers relevance and rigour. All included grey literature were deemed relevant as eligibility criteria were met. It was difficult to assess rigour as, like the peer-reviewed literature, information describing the methods for evaluating waste management strategies was limited or absent. However, inability to determine rigour is not the same as not being rigorous. When searching in Google Incognito mode and using Google Advanced search methods respectively, the tracking of the searcher's location (Queensland, Australia) and the inability to select a search date range are unavoidable limitations that transpired.

This systematic literature review has identified composting, followed by donating, and industrial use as the most prominent strategies to manage food and food-related waste generated by hospital food services. Worthwhile financial and environmental outcomes were identified from implementing these strategies which provide convincing evidence for hospitals to consider their adoption. This research summarises key opportunities, evidence, and practical information about waste management for hospital food services to consider to ensure they are acting through a planetary health lens and working towards global food waste targets.

AUTHOR CONTRIBUTIONS

NC conducted the literature search, collated, analysed and interpreted the data and wrote the manuscript. JP, JC, DG supervised this process and critically reviewed the manuscript. All authors contributed to the conceptualisation of this review, the study selection and quality assessment process and have read and approved the final publication. The contents of this manuscript have not been published elsewhere. The funders had no role in the design, analysis or writing of this article.

CONFLICT OF INTEREST

Prof. Judi Porter is Editor-in-Chief of *Nutrition & Dietetics*. She was excluded from the peer-review process and all decision making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere. Other authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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REVIEW

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How do dietetics students learn about sustainability? A scoping review

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Abstract

Aim: Globally, sustainability and planetary health are emerging as areas of critical importance. In 2015, the 2030 Agenda for Sustainable Development was adopted by the United Nations member states. Since then, the United Nations Educational, Scientific and Cultural Organization and the Commonwealth Secretariat have published guidelines for educators to embed sustainability content into curricula. This scoping review aims to identify how student dietitians learn about sustainability, how learning opportunities are evaluated, their outcomes, and whether these guidelines have translated into teaching activities contained in dietetic degrees.

Methods: A scoping review was used to address the aims. Eight electronic databases and Google Scholar were searched from inception to March 2022 for articles describing dietetics students' participation in learning activities focused on sustainability. Data that addressed the research aims were charted independently by two researchers, then narratively synthesised.

Results: Twelve articles met the inclusion criteria. A range of teaching approaches and evaluation methods were used, from passive learning in lectures to experiential learning activities. A change in knowledge or behaviour was found for experiential learning activities ($n = 5$). For articles published after 2015 ($n = 9$), two mentioned the Sustainable Development Goals and no articles referenced the published guidelines.

Conclusions: A paucity of evidence exists describing how dietetics students learn about sustainability and their learning outcomes. Of the 12 articles published, varied teaching approaches and evaluation methods have resulted in inconsistencies in the reporting of outcomes. The minimal reference to the Sustainable Development Goals and published guidelines suggests a slow translation of knowledge to practice.

KEYWORDS

curricula, dietitians, learning, students, sustainability, Sustainable Development Goals

1 | INTRODUCTION

Embedding sustainability and planetary health into our planning and policies, in particular for food, is critical to ensuring a healthy future for all.[1,2] For this reason, sustainability and planetary health are becoming central concepts for dietetics professionals.[3–7] The criticality of sustainability and planetary health to the global population is reflected in the 2030 Agenda for Sustainable Development and the subsequent adoption of the Sustainable Development Goals,[8] by all United Nations Member States. The Sustainable Development Goals, which consist of 17 Goals and 169 targets, aim to 'secure a sustainable, peaceful, prosperous and equitable life on earth for everyone now and in the future' (p6).[9] The goals, amongst other uses, are intended to be incorporated into curricula across all levels of education, including university degrees.[9] However, the extent to which the Sustainable Development Goals and sustainability are adopted into dietetics curricula is not well understood. A scoping review was, therefore, conducted to identify how student dietitians learn about sustainability, how learning opportunities are being evaluated and their outcomes, and whether relevant guidelines have directed the development of the learning activities.

There are many definitions of sustainability. For the purpose of this review, sustainability was framed around the United Nations Sustainable Development Goals,[8] and their three pillars; Social Equity, Economic Viability, and Environmental Protection. This framework has been used extensively, including by the United Nations Food and Agricultural Organization which recognises the Sustainable Development Goals as foundational to a sustainable food system.[10] The recent position statement published by Dietitians Australia on healthy and sustainable diets,[6] and the Academy of Nutrition and Dietetics' 'revised 2020 standards of professional performance for registered dietitian nutritionists (competent, proficient and expert) in sustainable, resilient, and healthy food and water systems',[3] also use the three Sustainable Development Goals' pillars, in addition to a fourth domain (nutrition and health), which aligns with the goal 'Good Health and Wellbeing'.[8] As the Sustainable Development Goals were implemented in 2015, this review uses the term 'sustainability' to refer to any concept that aligns with the Sustainable Development Goals and the three pillars, either before or since their publication.

The Sustainable Development Goals recognise that environmental sustainability, such as addressing climate change and preserving our land and oceans, go hand-in-hand with ending poverty, reducing inequalities, and improving health and education, all while facilitating economic growth.[9] Arguably, dietitians can positively contribute to all 17 goals, as the World Health Organization has identified how food is linked to each goal.[11] Moreover, several dietitians and national dietetics associations have identified that dietitians are well placed to apply the Sustainable Development Goals to their practice and act as change agents to improve planetary health through a more sustainable food system.[6,7,12,13]

The 'EAT-Lancet Commission on healthy diets from sustainable food systems' recognised that a transformation to a sustainable food system is necessary to achieve the Sustainable Development Goals.[14] However, a sustainable food system is incredibly complex,[15] and requires scientific targets for healthy diets and sustainable food production.[14] It is widely recognised that transforming the food system to a sustainable one requires many key stakeholders, including but not limited to collaboration across professions and sectors, including community members, policymakers and researchers.[7,13] Thus, it is important for dietitians to understand their role and how they can best contribute to this transformation. This demand for understanding has been recognised, resulting in the recent publication of role statements and position statements by national professional dietetics bodies.[6,7,16] With the right knowledge, skills, and scope of practice, dietitians can act as change agents and advocate for the transformation of the food system to a sustainable one through the promotion of sustainable food production practices and facilitating the consumption of healthy sustainable diets,[7,12,15,17,18] which supports local agriculture, the reduction of food waste and conserves the natural environment.[19] To achieve this goal, student dietitians must first be exposed to and develop foundational sustainability knowledge,[8,9] and understand how dietitians can impact the food system.[5]

The United Nations Educational, Scientific and Cultural Organization (UNESCO), as the United Nations' specialised agency for education, is entrusted to lead and coordinate the global movement to embed the 17 Sustainable Development Goals into all levels of education, and are intended to support all educators with curricula design.[9] The learning initiatives outlined by UNESCO can be used to facilitate students' construction of sustainability knowledge and competency,[9] which can also be applied to dietetics curricula. Yet many of the national professional bodies responsible for the publication of dietetics competencies are yet to embed sustainability into their competencies, and therefore, the national curricula. The International Competency Standards for Dietitian-Nutritionist,[20] published by the International Confederation of Dietetic Associations, include limited consideration of the knowledge and skills in sustainable food systems required for the future dietetics workforce. One possible explanation is that these competencies were published soon after the 2030 Agenda for Sustainable Development was released,[8] which may have limited the time

needed to embed the Sustainable Development Goals into the competencies, or to identify sustainability as a central concept in the dietetics profession,[6,7,16] to support a sustainable food system.[10]

Despite the lack of sustainability competencies published by the International Confederation of Dietetic Associations, a Sustainability Toolkit has been developed to assist dietitians to develop knowledge to facilitate the integration of sustainability into practice.[13] Furthermore, the Academy of Nutrition and Dietetics, the US dietetics professional body, does not include sustainability in their entry-level competency standards. Though, they have published (in 2014), the 'Standards of Professional Performance for Registered Dietitian Nutritionists (Competent, Proficient and Expert) in Sustainable, Resilient, and Healthy Food and Water Systems' which was updated in 2020,[3,4] but this specifically relates to qualified dietitians.[3,4] Dietitians of Canada have also made progress through their paper 'The Role of Dietitians in Sustainable Food Systems and Sustainable Diets' which highlights the role that dietitians can play in supporting a sustainable food system, across diverse practice areas.[7] While internationally there is work being done to acknowledge the impact dietitians can have on the food system and sustainability, there is a paucity of literature that addresses the development of dietetics students' (i.e., the future workforce) knowledge and skills.

The updated 2021 'National Competency Standards for Dietitians in Australia' (the competencies) includes competencies that strongly relate to sustainability, such as '2.3.2 Uses Food legislation, regulations and standards to develop, implement and evaluate food systems and sustainability to maintain food safety'.[21] Australian university dietetics programs must provide evidence that their curriculum addresses all competencies so that the university program can be accredited.[21] The UNESCO recommendations, while voluntary, may provide university programs and academics with a useful set of cognitive, socio-emotional, and behavioural learning objectives to embed sustainability into curricula to address these competencies,[9] and develop dietitians who are competent in sustainability thinking, that is, dietitians who are 'leaders and advocates for food system practices that facilitate a healthy planet and healthy humans' (p1210).[22] Furthermore, the recommendations include the scaffolding of sustainability throughout the curriculum, with sustainability not taught exclusively in one course/unit/subject (herein referred to as 'course').[9] This recommendation by UNESCO implies that all educators should understand how sustainability applies to their course content,[9] including dietetics educators. Yet a study by Carino et al. found that fewer than 8% of Australian nutrition and/or dietetics tertiary degrees contained courses on sustainable food systems.[12] A number of studies have examined the barriers to embedding sustainability into curricula, including competing priorities, lack of knowledge and skill, insufficient leadership and support, and the few examples that are available to assist academics in framing sustainability and developing authentic learning opportunities for dietetics students.[5,22,23]

Due to the emerging nature of sustainability in entry-level nutrition and dietetics curricula and the diversity of literature sources expected to be identified, a scoping review was undertaken to include all relevant literature regardless of the methodology used or its quality.[24,25] To this end, the primary objective of this scoping review was to describe how student dietitians learn about sustainability. To meet these objectives, this review sought to answer the following research questions to identify gaps in the existing literature:

1. What teaching approaches and evaluation strategies have been used to underpin the learning activities focused on sustainability in dietetics entry-level curricula?
2. What are the learning outcomes of these activities based on the Kirkpatrick-Barr framework?[26]
3. Have the UNESCO and Commonwealth Secretariat recommendations translated into the delivery of sustainability content in nutrition and dietetics entry-level curricula based on articles published since their development?[9,27]

2 | METHODS

This study used a scoping review methodology to address the aims and research questions. Arksey and O'Malley's 5-staged process for scoping reviews,[24] was used in addition to enhancements by Levac et al. and the Joanna Briggs Institute.[25,28] This review is reported according to the PRISMA extension for Scoping Reviews (PRISMA-ScR) checklist.[29]

The protocol ('the protocol') for the planned scoping review methodology is described in detail and published.[30] The method used was iterative and through this process the study's objectives and research questions were broadened due to insufficient literature. The following section summarises the methods used to address the research objectives while highlighting the differences between these methods and those reported in the protocol as recommended by PRISMA-ScR.[29,30]

The original inclusion criteria outlined in the protocol were updated to align with the final research questions.[30] To be included in this review, articles needed to focus on how dietetics students learn about sustainability and included all published and unpublished studies (focusing

TABLE 1 Inclusion criteria

Inclusion criteria
1. The learning activity primarily focused on education of sustainability.
2. The learning activity involved student dietitians attending a university program recognised by the professions' national body, and was part of the university curriculum, and
3. The learning opportunity was planned and intentional,
4. All study designs were considered suitable, as well as content sourced from the grey literature
5. No language or date restrictions were applied

TABLE 2 Search strategy for CINAHL database

Search strategy
1. Dietitian* OR Dietician* OR nutritionist* AND
2. Learn* OR education OR understand OR knowledge OR curriculum AND
3. Sustainab* OR environment* AND
4. Tertiary OR university OR college

TABLE 3 The Kirkpatrick-Barr framework[16]

Kirkpatrick-Barr framework	
Level 1	**Learners' reaction: learner evaluations with the professional activity**
Level 2a	Change in attitude: a change in the learners' attitude towards the impact their practice will have on sustainability
Level 2b:	Change in knowledge or skills: how has the learners' knowledge of sustainability changed?
Level 3	Behavioural change: the change in knowledge has had a direct impact on workplace behaviour or a students' subsequent work or projects
Level 4	Overall results: the organisation has adopted changes which can be attributable to the professional learning activity, or students' career success and accomplishments are measured

on dietetics students or including a subgroup of dietetics students), and grey literature. Abstracts from grey literature were included if sufficient data could be charted to meet the inclusion criteria of the scoping review. To maximise the breadth of literature identified, no language or date restrictions were applied. The full inclusion criteria are detailed in Table 1.

To identify relevant articles, eight databases (Business Source Complete, CINAHL, Cochrane, EMBASE, MEDLINE, Proquest, Scopus and Web of Science) were searched from their inception to 1 March 2022. Grey literature was identified by searching Google Scholar and reviewing the first 80 pages of hits as Haddaway et al. identified that most grey literature was found by page 80.[31] Three experts in the field were identified through publications that focused on dietetics education and sustainability and were consulted to identify other relevant literature.[30] Secondary searching of the reference lists and citations of the included articles was used to identify additional literature, which was subsequently evaluated against the inclusion criteria. All captured articles were imported into EndNote 20 (Clarivate Analytics, London, UK) and duplicates removed. Abstracts were included if they provided adequate information to meet the inclusion criteria; one abstract did not provide sufficient information to be automatically included and attempts to contact the author, to gain further information, were unsuccessful.

The search strategy was developed, piloted and refined in the CINAHL database using keywords, their synonyms, and subject headings (where appropriate) (Table 2). It was then customised for each database as required. All literature captured during the search process underwent two levels of screening. First, the title and abstract were independently screened against the inclusion criteria by the primary investigator, and each research team member independently screened their allocated section of the captured literature. Any discrepancies were resolved by discussion with the research team. Second, full-text articles were screened by two independent reviewers against the inclusion criteria, including the primary investigator and one other research team member. Inter-rater discrepancies occurred with three full-text articles, and these were resolved by discussion and consensus gained amongst the research team.

To evaluate the impact of the learning activities on student learning outcomes, a consistent method of evaluation was needed. Therefore, the Kirkpatrick-Barr framework, used widely to evaluate learning activities in the health sector and to differentiate between a learner's reaction to the learning activity, a change in attitude, a change in knowledge or skill, or a change in behaviour,[26,32,33] was used to evaluate all articles included in this scoping review.

The data-charting process was developed by the research team using an iterative approach. The primary investigator charted the data using the tool which was continuously updated during the process in consultation with the research team. The research team then checked the charted data, and any discrepancies were resolved by discussion. The data charted included information on the citation (e.g., title, authors, country, source of publication, year of publication, study design) and to answer the research questions, that is, location where the intervention took place, participant characteristics, the teaching approach adopted, a description of the learning activity and evaluation tools used to assess the intervention, the

reported outcomes of the learning activity (which were then classified according to the Kirkpatrick-Barr framework) (Table 3),[26] and the alignment of the intervention with the UNESCO and Commonwealth Secretariat guidelines.[9,27]

Charted data were summarised and presented in table format based on the year of publication. These data were narratively synthesised to answer the three research questions. As per the recommendations by Arksey and O'Malley and Levac et al. critical appraisal of the literature was not completed.[24,25] All the data and forms are available from the lead author on request.

3 | RESULTS

The database search yielded 1640 items, 277 of which were duplicates, resulting in 1363 unique items (Figure 1). After the initial screening process, 22 articles underwent full-text review. Nine articles met the inclusion criteria. Of the 13 articles excluded during the full-text review, 12 articles did not involve dietetics students, and one article did not focus on sustainability. The Google Scholar search resulted in 12 articles for full-text review. Seven articles met the inclusion criteria, however, five of these were duplicates from the database search, resulting in the addition of two included articles. One further article was identified from consultation with experts in the field.[34] No additional articles were identified by secondary searching. A total of 12 articles were therefore included in this scoping review. Of these, two were abstracts from conference publications.[35,36]

Table 4 summarises the study designs, participant characteristics, teaching approaches, assessment/evaluation, and outcomes based on the Kirkpatrick-Barr framework,[26] and reference to the UNESCO and The Commonwealth Secretariat documents (where appropriate).[9,27] Most of the articles were from North America, including the United States ($n = 4$; 33%) and Canada ($n = 4$; 33%),[17,34,36–41] with the remainder from Australia ($n = 2$; 17%),[35,42] New Zealand ($n = 1$, 8%) and Spain ($n = 1$, 8%) (Table 4).[43,44] The study designs included six case studies report,[34–39] four intervention studies,[17,42–44] an exploratory study[40] and a descriptive study.[41]

No consistency was apparent when considering the number or the timing of learning activities, in the dietetics program. Learning activities were either contained in one course or spread across several courses within a program. In articles where content was delivered in a specific course, these courses were variably located from first year through to the fourth year of the degree, including in placement experiences and internships. Two articles reported that sustainability was taught in multiple courses across many years of the dietetics program.[37,44]

There was variability in the teaching approaches used to enhance student knowledge of sustainability. Three

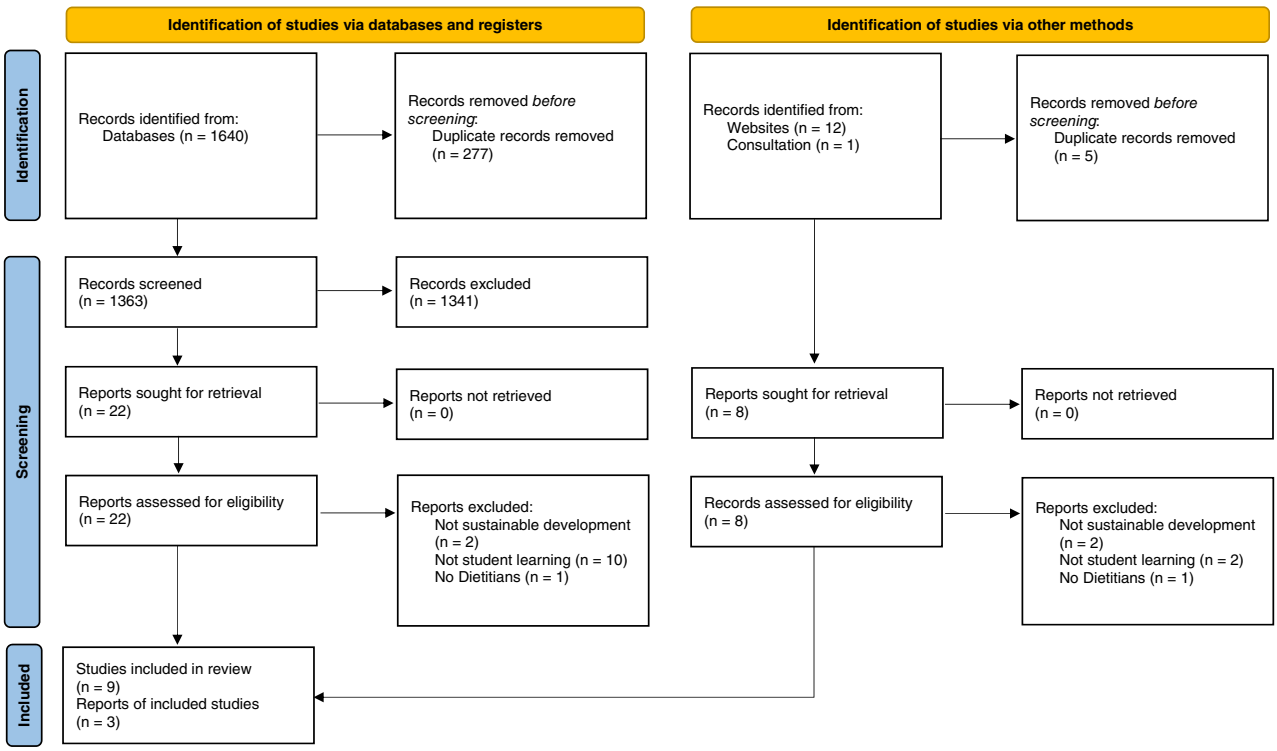

FIGURE 1 PRISMA flow diagram describing the process of article selection[46]

TABLE 4 A summary of the teaching approaches and outcomes from the included studies.

Study	Study design	Participant characteristics	Intervention/teaching approach and assessment or evaluation tools and methods used	Outcomes
Lapp, 2010 USA	Case study report	Sample size: Unknown Course: A Food and Society undergraduate course	Intervention or teaching approach: CK embedded within a course Assessment/evaluation: Student journaling, pre- and post-survey of food knowledge, beliefs and practices	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS guidelines: n/a
Pontikas et al, 2011 USA	Case study report	Sample size: Unknown Course: 'Community Nutrition', 'Nutrition for Life', 'Human Nutrition' and 'Sustainability in Family and Consumer Sciences' - Four courses across a Nutrition and Dietetics program	Intervention or teaching approach: CK embedded within 4 courses Assessment/evaluation: Not discussed	Kirkpatrick-Barr: Unable to determine SDGs, UNESCO and CS guidelines: n/a.
Matthews, 2013 Canada	Case study report	Sample size: 165 students Course: 'Fundamentals of Human Nutrition', a first-year course in a Food and Nutritional Sciences program	Intervention or teaching approach: 1 course spanning 8 months, including 25% on sustainability. Experiential learning included Assessment/Evaluation: Students used the Photovoice technique, and discussed in focus groups. Further evaluation included: Adhoc feedback, open-ended comments, and course evaluations	Kirkpatrick-Barr: Unable to determine SDGs, UNESCO and CS guidelines: n/a
Bonham et al, 2016 Australia	Case study report	Sample size: Unknown Course: 'Food and the Environment' course, as part of a Nutrition Science program	Intervention or teaching approach: CK embedded within a course Assessment/evaluation: Student satisfaction with teaching, confidence, and self-perceived ability to translate theory to practice	Kirkpatrick-Barr: Level 1 SDGs, UNESCO and CS guidelines: SDGs not discussed. UNESCO and CS n/a
Maher and Burkhart, 2017 Australia	Intervention study	Sample size: $n = 143$ students Course: 'Food and Nutrition', a first-year course, as part of a Nutrition and Dietetics program	Intervention or teaching approach: A 3-week experiential learning task, including CK delivered via lecture, and 2 task-orientation tutorials Assessment/evaluation: A descriptive qualitative content analysis of blogs completed by the students	Kirkpatrick-Barr: Level 3 SDGs, UNESCO and CS guidelines: Not discussed
Innes et al, 2018 New Zealand	Intervention study	Sample size: $n = 55$ students Course: A second-year course in human nutrition	Intervention or teaching approach: 2-weeks of environmental sustainability study incl. 4 h of formal instruction, 6 h of problem-based learning and self-study Assessment/evaluation: Validated tools used to assess knowledge, attitudes, and behaviours.	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS Guidelines: Not discussed

TABLE 4 (Continued)

Study	Study design	Participant characteristics	Intervention/teaching approach and assessment or evaluation tools and methods used	Outcomes
Fox, 2019 Canada	Case study report	Sample size: $n = 15$ students Course: A fourth-year undergraduate course in the Bachelor of Science degree program in Human Nutrition called 'Effecting Change'	Intervention or teaching approach: A case study project utilising problem-based learning Assessment/evaluation: Student feedback on the project	Kirkpatrick-Barr: Unable to determine SDGs, UNESCO and CS guidelines: Not discussed
Navarro et al, 2020 Spain	Quasi-experimental intervention study	Sample size: $n = 76$ students Course: 7 courses in a Human Nutrition and Dietetics degree	Intervention or teaching approach: 10 activities scaffolded across 7 courses. Used active methodologies based on constructivism (problem-based learning), including case studies, role-playing, and group activities Assessment/evaluation: Measured perception of knowledge and knowledge of social responsibility. Pre- and post-test across 1 year of the program.	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS guidelines: Discusses Sustainable Development competencies and knowledge, and includes recommendations made by UNESCO, but does not mention UNESCO or the CS
Pabani et al, 2020 Canada	An exploratory study	Sample size: $n = 5$ students Course: a dietetic placement at FoodARC (not internship)	Intervention or teaching approach: Participatory and experiential learning examining food security Assessment/evaluation: Community-based participatory research using Photovoice and thematic analysis	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS guidelines: Not discussed
Meyer et al, 2021 USA	Intrinsic case study	Sample size: $n = 75$ ($n = 43$ undergraduate students; $n = 15$ graduates; $n = 15$ faculty; $n = 2$ staff) Course: an optional course in a Dietetics program	Intervention or teaching approach: An experiential learning activity embedded into an optional practicum rotation Assessment/evaluation: A food literacy survey and interviews, field notes, observation, materials, documents and reports included	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS guidelines: Not discussed. SDGs referred to in recommendations only
Ruhl and Lordly, 2021 Canada	Descriptive study	Sample size: $n = 46$ ($n = 41$students; $n = 2$ lab instructors; and $n = 3$ student volunteers) Course: an introductory foods course within a nutrition program	Intervention or teaching approach: A community garden using experiential learning explored how the garden influenced students' learning and overall experiences Assessment/evaluation: Qualitative surveys were distributed to participants after the completion of the activity.	Kirkpatrick-Barr: Level 2b SDGs, UNESCO and CS guidelines: Not discussed
Spiker et al, 2021 USA	Pilot intervention study	Sample size: Intervention 1: pre-test $n = 38$; post-test $n = 10$ Intervention 2: pre-test $n = 28$; post-test $n = 5$ Course: Four university sites including dietetics internship and graduate programs	Intervention or teaching approach: Online learning, utilising didactic webinar, problem-based learning, and a synthesis webinar. Assessment/evaluation: Pre- and post-surveys completed, CK also assessed. Identified an increase in confidence. No change in knowledge.	Kirkpatrick-Barr: Unable to determine SDGs, UNESCO and CS guidelines: Refers to SDGs but not UNESCO or CS

Abbreviations: CK, content knowledge; CS, Commonwealth Secretariate; n/a, not applicable; SDGs, Sustainable Development Goals; UNESCO, United Nations Educational, Scientific and Cultural Organization.

articles reported that the learning activity focused on content knowledge,[35–37] problem-based learning techniques were used in four articles,[17,34,43,44] and experiential learning activities were embedded in the curricula in five articles.[38–42]

Of the three articles that focused on content knowledge, the learning outcomes based on the Kirkpatrick-Barr framework varied.[26] Lapp measured a change in knowledge (Kirkpatrick-Barr level 2b),[36] Bonham et al reported a change in confidence and attitude (Kirkpatrick-Barr level 1),[35] whereas Pontikas et al did not address how the students engaged with the learning and so the learning outcome based on the Kirkpatrick-Barr framework could not be determined.[26,37] Four articles reported using a problem-based learning approach; two did not include sufficient information to determine the impact on student learning,[17,34] and two reported a change in knowledge or skill (Kirkpatrick-Barr Level 2b).[43,44] Comparatively, all articles that used experiential learning as a teaching approach were able to either demonstrate a change in knowledge or skill (Kirkpatrick-Barr Level 2b),[38,40,41] or a change in behaviour (Kirkpatrick-Barr Level 3).[42]

Most authors used qualitative evaluation methods to determine the impact of their learning activity.[34,39–42] This ranged from course evaluations and ad hoc feedback,[34,39] to content analysis of blogs,[42] focus groups[40] and qualitative surveys.[41] One research group based their evaluation on quantitative data, using previously validated tools to assess students' knowledge, attitudes and behaviours.[43] The remaining articles appeared to use a mixed-methods approach to evaluating student learning.[17,35,36,38,44] Overall, a wide range of evaluation methods were used.

Of the 12 articles, nine were published after 2015,[17,34,35,38,40–44] following the release of the Sustainable Development Goals.[8,9,27] Seven articles were published after 2017 following the release of the UNESCO and the Commonwealth Secretariat frameworks.[17,34,35,38,40–44] Three referred to the Sustainable Development Goals,[17,38,44] and only Navarro et al reported an intervention that met the UNESCO and the Commonwealth Secretariat scaffolding recommendations,[9,27,44] however, these recommendations were not referenced or mentioned in this study. Although Navarro et al found a significant change in students' knowledge over the 12 months of the study,[44] they did not measure the impact on knowledge or behaviour change over the 4 years during which students would be completing the learning activities. In addition, behaviour did not change during the study period, which the authors attributed to the students already having good sustainable behaviours at the commencement of the study.

4 | DISCUSSION

This study sought to identify how student dietitians learn about sustainability, how their learning is evaluated, and the outcomes of those learning opportunities. Twelve articles met the selection criteria. They reported varying teaching approaches and evaluation strategies, therefore, themes were difficult to identify. Experiential learning activities tended to result in better learning outcomes according to the Kirkpatrick-Barr framework,[26] however, because of the short-term nature of the evaluations, none of the learning activities ranked highly on this framework.[26] The findings showed a growth in studies detailing learning activities on sustainability, where nine of the 12 included articles were published since 2015.[17,34,35,38,40–44] This growth is indicative of the increasing interest in sustainability within the dietetics profession, however, it is unclear of the impact the publication of the Sustainable Development Goals has had on this.

The teaching approaches and evaluation methods (research question 1) varied across all articles included in this review. With a large range of teaching approaches and evaluation methods available for dietetics educators to use to upskill student dietitians, it is unsurprising that with 12 articles found, each used a unique method. This variety in both the teaching approach and evaluation makes it difficult for dietetics educators to choose an approach that maximises the knowledge and skills attained by students. The small volume of literature found may reflect the extent to which sustainability is being embedded into curriculum, which is congruent with the findings by Carino et al.[12] Several previous studies identified barriers to embedding sustainability into curriculum including insufficient leadership and support, competing priorities, and lack of knowledge and understanding of the subject matter.[22,23] With a range of barriers,[22,23] a lack of genuine examples of what sustainability looks like in practice for dietitians,[5] and a vast array of teaching approaches and evaluation techniques, it is understandable that the uptake into curricula has been low.[12]

According to the Kirkpatrick-Barr framework (research question 2), a majority of the articles reported a reaction, a change in attitude, or a change in knowledge/skills.[26] Notably, only the short-term outcomes of the learning activity were evaluated. Given the drive to upskill both students and dietitians alike in this critical area of practice,[3,7,12,13,21,22] longer-term outcomes should be measured. Arguably, the depth and complexity of the knowledge required to develop dietetics students who are competent in this area cannot be taught in one course and requires the development of knowledge and skills to occur over a longer time period. This

aligns with recommendations made by UNESCO and the Commonwealth Secretariate,[9,27] that suggest scaffolding content across multiple courses to develop key competencies.

The learning and teaching methods recommended by UNESCO and the Commonwealth Secretariat (research question 3) align with best-practice teaching approaches.[9,27,45–47] UNESCO recommends that educators embed an action-oriented, transformative pedagogy, that is scaffolded across the curriculum, and not contained in a stand-alone course.[9] However, given the availability of resources to assist academics embedding introductory sustainability concepts such as the Sustainable Development Goals into the curriculum, it is concerning, based on our review, that only three articles referred to the Sustainable Development Goals,[17,38,44] and no articles referred to the UNESCO or Commonwealth Secretariat Guidelines.[9,27] This suggests a delay in translating these goals and guidelines into teaching activities. As curricula is largely driven by the national professional bodies and the competencies they require of graduate dietitians, the limited inclusion of sustainability concepts into competency standards globally could be contributing to this delay, as curriculum decision-makers have limited incentive to include them.

Historically in healthcare, the translation of knowledge to practice has been slow,[48] with barriers to the uptake of knowledge differing depending on the setting.[49]A similarly slow process is apparent with respect to embedding sustainability into competencies and entry-level dietetics curricula. The impact dietitians can have on sustainability is not a new concept to the profession. Concern was raised about the sustainability of the food system as early as 1986,[50] and the American Dietetic Association published a position statement supporting ecological sustainability in 2007.[51] While some resources currently exist to orientate dietitians to sustainability and the roles that dietitians can play within a sustainable food system,[7,13] these resources need to be adapted to the local context with genuine local examples so that they are relevant to students, academics, and the broader profession.[5] Furthermore, without clear competencies from professional bodies and guidance on what to include in the curriculum, academics with an interest in sustainability may add content in an ad hoc manner.[34]

Without the need to meet competencies developed by professional bodies, the delay in translating knowledge to teaching practice can be further compounded in a university setting as changing a program's design and curriculum can have a long lead time due to many courses being delivered on an annual basis.[44] Further impacting universities in recent years has been Coronavirus Disease (COVID-19), taking the focus away from curricula content, to creating remote learning environments and adjusting assessment requirements.[52] While delays in knowledge translation are common and understandable, a commitment has been made to achieve the Sustainable Development Goal targets by 2030.[8]

The findings should be interpreted based on the limitations of this study. While every effort was made to identify all articles which meet the inclusion criteria, there is a risk that some may have been missed despite following a systematic and comprehensive search strategy. Furthermore, while the aim of this study was to identify how student dietitians learn about sustainable development, how that learning was evaluated, and the outcomes of the learning, not all learning interventions may be published either as grey literature or in peer-reviewed journals. Further, each publication measured the learning outcomes differently and despite using the Kirkpatrick-Barr framework to standardise these outcomes,[32] not all publications provided sufficient detail to classify the outcome accurately.

In summary, this study focused on understanding how student dietitians are learning about sustainability, how that learning is being evaluated, and what are the learning outcomes. Based on this review of peer-reviewed and grey literature, there is limited literature to describe how student dietitians are learning about sustainability within their dietetics education programs. The variable teaching approaches and evaluation methods used have resulted in inconsistencies in the reporting of outcomes, and the minimal reference to the Sustainable Development Goals and other published guidelines suggests a slow translation of knowledge to practice in the higher education setting.

The ongoing development and localisation of knowledge, and the sharing of that knowledge, teaching and learning approaches, evaluation methods and outcomes, is critical to the widespread uptake of sustainability into dietetics curricula and preparing our dietetics graduates to engage professionally in a more sustainable world.

AUTHOR CONTRIBUTIONS

JM conducted the literature search. JM, AB, CB, LJR and SR undertook record screening and data synthesis. Any inter-rater discrepancies were resolved by discussion and consensus gained amongst the research team (AB, SR, CB, LJR and JM). JM wrote the manuscript which was reviewed and revised by AB, CB, LJR and SR. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere.

CONFLICT OF INTEREST

The authors declare no conflicts of interest. Dr. Lynda J. Ross is a member of the Editorial Board of Nutrition & Dietetics. They were excluded from the peer review

process and all decision-making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor-in-Chief. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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The origins of hospital food: Where does it come from and what do staff, patients and suppliers think about local food?

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Abstract

Aims: To identify the origin of fresh and minimally processed foods served to hospital patients, and explore the challenges and enablers to local food procurement in hospitals.

Methods: A mixed methods study was conducted in a healthcare network in Victoria, Australia. Packaging labels and product information were used to audit fresh and minimally processed foods purchased in 1 week. Processed food items and meals made offsite were not audited. Interviews were conducted with patients, staff and suppliers to explore their perspectives towards local food in hospitals. Framework analysis was used to identify themes.

Results: Of 105 food products audited, 32% were imported, 25% were 'local' from Victoria and the remaining 43% were from within Australia (excluding Victoria). Qualitative interviews revealed several challenges including: increased cost of local food items, inconsistent supply and variable quality of local produce, difficulty accessing origin information, and lack of autonomy for hospitals to make food procurement choices. Enablers included: conducting a food origin audit to increase awareness, group purchasing organisation prioritising local food suppliers, and suppliers valuing local produce.

Conclusion: A food origin audit and interviews with stakeholders provided a rich understanding of current practices and how to increase local food procurement.

KEYWORDS

food, food supply, food services, hospital, local food, procurement, Sustainable Development Goals

1 | INTRODUCTION

Transforming the food system is essential to meet the United Nations Sustainable Development Goals and the Paris Climate Agreement.[1] The food supply chain in modern food systems has significant and serious effects on the environment.[2,3] Procurement offers one of the first leverage points to address the sustainability of the food

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system. Public food procurement by institutions such as healthcare is a powerful actor in the system because a large volume of fresh and packaged food is procured year round, creating stable and sizable demand. Policies and regulations dictate the way food is procured, what food, from whom, from which location, and from which types of production system.[4] Currently 'value for money' is the priority of healthcare procurement with large group purchasing organisations negotiating price through economies of scale. However, different governance could favour sustainable food systems, and local food procurement is one promising solution to achieve this.[5]

The definition of 'local food' commonly refers to food travelling a short distance from producer to consumer (e.g., within the state).[6] Procuring local food offers environmental, economic and social benefits, addressing the three pillars of sustainability.[5] There are lower emissions and energy use from shorter transport distances and shorter storage durations, and more favourable agricultural practices.[5] Recent findings that emissions associated with global food miles account for 19% of total food system emissions and are 3.5–7.5 times higher than previously estimated have led authors to recommend local food procurement in affluent counties.[2] Purchasing from local farmers and small to medium enterprises can direct money into the local economy, provide job opportunities, reduce inequalities in rural settings, and maintain cultural values of a region.[5] Healthy diets and high quality food are associated with local food, leading to social benefits for populations.[5]

Australian policy makers and advocacy organisations are exploring options for local procurement in healthcare. The 2018 Victorian state government Department of Health established recommendations to 'Develop, implement and monitor a Local (Victorian) Food Procurement Policy and Guidelines for Health Services'.[7] Following this, Nutrition Australia scoped out possible policy options for the Department of Health.[8] While these are positive and useful steps forward, understanding the origins of hospital food and perspectives on the procurement landscape at the current time is necessary to support implementation of policy. To date, one food origin audit has been conducted in an Australian hospital.[9] Faulkner *et al*. found 79% of the total food spend was for products with 75% or more Australian ingredients and only 3% was for local (Victorian) products.[9] Additional studies are beneficial to build a body of literature to better understand food procurement in hospitals. Perspectives towards local food procurement in healthcare have been captured by Carino *et al*. in their broad review of the literature on environmental sustainability in hospital foodservices.[10] They report that although local food procurement is believed to be beneficial, there are multiple barriers to shifting procurement processes and purchasing local food.[10] Importantly, there are no studies that capture the perspectives of patients.

Therefore, the aims of this research were to identify the origin of fresh and minimally processed foods served to hospital patients, and to explore the challenges and enablers to local food procurement in a hospital setting from the perspectives of stakeholders (patients, staff, and suppliers) in foodservice.

2 | METHODS

This mixed methods study included an audit of the origin of fresh and minimally processed foods followed by interviews to explore perspectives towards current food procurement practices among consumers/patients, staff and suppliers. Quantitative and qualitative data were intended to be used for expansion (different methods used to address different questions) rather than for triangulation, complementarity, initiation or development.[11] The research was approved by the Office of Research and Ethics at Eastern Health (Reference number: QA22-013) to be a quality assurance activity, therefore informed consent was not required to be sought from participants. The study was reported according to the Good Reporting of A Mixed Methods Study (GRAMMS) criteria.[12]

The study was conducted at a large public healthcare network in Melbourne, Australia. The food origin audit was completed at two metropolitan hospitals with 23 wards and 11 wards. Both hospitals had the same 28 day cycle menu, although some different brands or flavours of packaged items were used. Both hospitals had a cook-chill foodservice model where meals were produced in bulk at an offsite central production kitchen and plated onsite. They also purchased packaged single-serve food items (e.g., cereal, biscuits, yoghurt, milk) and fresh produce (e.g., cheese, bread, fruit, vegetables, butter and margarine) to make salads, sandwiches, fruit platters and alternative meals (e.g., scrambled eggs) onsite. These products were purchased through a group purchasing organisation that provides supplier contracts to all public hospitals in the state of Victoria.[13]

The food origin audit was conducted in March 2022, with data collected by two researchers following orientation and training. Items included in the audit were fresh and minimally processed foods served to patients as defined by the NOVA classification system by the Food and Agriculture Organization.[14] This included fresh fruit and vegetables, dairy and meat products, as well as single ingredient processed foods such as canned fruit and vegetables, bread, cheese, ham and juice. These foods were often side components to main meals or extra menu items. Meals (soup, main meals, dessert) were excluded

TABLE 1 Interview guides for each stakeholder group.

Patients
Values
• To what extent are you concerned about where you purchase your food from at home?
• To what extent are you concerned about where hospitals purchase their food?
• Explain how important it is to you that hospitals serve local food
• What do you see as the benefits of hospitals purchasing local food?
Expectations
• Do you expect the hospital to use local food? Why is it/is it not important?
• What do you value about local food in hospitals?
• Do you expect the hospital to tell you they purchase local food?
Recommendations
• From your experience as a patient, do you have any recommendations regarding food purchasing or local food in hospitals?
• Is there anything you would like to let us know about food purchased by hospitals?
Staff
Values and expectations
• To what extent are you concerned about where hospitals purchase their food?
• Explain how important it is to you that hospitals serve local food
• Is this something you prioritise in your role?
• What else is important when selecting food that is purchased?
• What do you see as the benefits of hospitals purchasing local food?
Barriers
• From your experience, what do you think are some barriers to increasing the proportion of local food compared to imported food?
Enablers
• From your experience, what would help to increase local food at the health service?
Recommendations
• What recommendations or actions do you think would be beneficial for the health service to improve food procurement practices?
• How important is it that we share with patients where our food is coming from?
• Is there anything else you would like to let us know about food purchasing by hospitals?
Suppliers
Values and expectations
• To what extent are you concerned about where hospitals purchase their food?
• Explain how important it is to you that hospitals serve local food?
• What do you see as the benefits of hospitals purchasing local food?
• Is promotion of product origin something you prioritise in your role?
• How important is it that hospitals share where their food is coming from?
• Do you think there is demand from hospitals?
Barriers
• From your experience, what do you think are some barriers to supplying local food to hospitals?
• What do you think are some barriers to hospitals selecting local foods?
• What information do you provide to hospitals about product origin?
Enablers
• From your experience, what would help to increase local food at the health service or hospitals in general?
Recommendations
• What recommendations or actions do you think would be beneficial for the health service to improve food procurement practices?
• Is there anything else you would like to let us know about supplying food to hospitals?

from the audit as these were produced offsite and data on the origin of the ingredients were not available. Moderately and highly processed foods such as biscuits, crackers, cakes, oral nutritional supplements, etc. were also excluded because future policy directives for local procurement are likely to focus on fresh produce.[7] The audit included items purchased over a 1-week period of the 28 day cycle menu. Fresh and minimally processed ingredients do not change throughout the cycle, only meals do. Eligible items were identified from order forms and invoices. Labels on the products in the cool and dry storage areas, product specification sheets and product origin lists were used to collect the following: name of product, product origin, quantity ordered, manufacturer and supplier details. If data were not available from these sources, websites of manufacturers, suppliers and

retailers were used and suppliers were contacted via email to request information.

Semi-structured interviews were conducted in March to May 2022 by two researchers. Interviews focused on the origin of food and local food, including expectations, values, challenges, enablers and recommendations. Results of the audit were not known at the time of qualitative data collection. Interviews were conducted with individuals who were stakeholders in food and hospital foodservice. This included patients, healthcare staff (foodservice staff, foodservice managers, senior support services managers, and dietitians), staff from the external health group purchasing organisation and food suppliers. Purposive sampling was used to recruit these participants. Patients were recruited across wards at one site and were selected based on diversity of age and suitability to be interviewed at the time as reported by nursing staff. Staff from the health service and the group purchasing organisation were known to the researcher due to their role and were invited to participate in an interview. Suppliers were identified through the quantitative food origin data collection as they were asked to provide origin information. These suppliers were then also asked to participate in an interview as well. Interviews were managed so that none of the facilitators had an existing relationship with the participants. A series of interview guides (Table 1) were purpose developed by the research team based on a similar interview protocol[15] and refined after initial interviews to enhance the flow. Interviews with patients and some staff were conducted face-to-face, and all other interviews were conducted virtually via Zoom (Zoom Video Communications, Inc., Version 5.10.4). Interviews were audio-recorded and auto-transcribed using Otter (Otter.ai, Inc., Version 2.1.65), with transcripts checked for accuracy against the audio recording. Demographic information was collected for each participant including age, gender, and ward type (for patients) and gender, role, and years in role (for staff and suppliers).

Descriptive data were generated using Google Sheets (Google LLC, Version 1.2022.10201) and Microsoft Excel (Microsoft Corporation, Version 16.59.1) to report on the origin of food products across the two sites. Origin was categorised as: Imported, Australian but origin unknown, Interstate, Victorian and Interstate, and Victorian. This audit defined 'local' food as food originating from the state of Victoria and 'Australian' food as containing >85% Australian-grown ingredients. Items with 'Victorian and Interstate' origin included: (1) a product with multiple ingredients where different ingredients came from different locations (e.g., a loaf of bread with wheat sourced from one state, and salt from another state) or (2) a product that may be sourced from Victoria or interstate depending on season and logistics network issues.

A framework approach was used to analyse qualitative data, following the steps recommended by Ritchie and Spencer.[16] After transcripts were checked for accuracy, two experienced researchers separately read and inductively coded three different transcripts each to generate a coding framework reflecting the key themes identified. This was discussed and modified accordingly to produce the final framework which included 6 categories: importance, values and benefits, challenges, enablers, tensions and action areas. One researcher inductively coded the remaining transcripts and allocated these codes to the relevant categories of the framework.

3 | RESULTS

Across 2 hospital sites, 110 fresh and minimally processed foods were purchased over the 1-week audit period. Food origin data could not be identified for five products ($n = 5$ bakery products) leaving 105 food items to report on. Figure 1 shows that approximately one third of foods (31%, $n = 33$) were imported from overseas and the remaining two thirds were from Australia, with one quarter of these being from Victoria (25%, $n = 26$).

Table 2 shows the origin of different types of food products. All of the juice and meat and seafood products were imported, all of the water and fresh milk products were Australian but origin unknown, and all of the fresh pre-prepared meals/components were from Victoria and interstate. All other products had a range of different origins. Vegetables and yoghurt were the types of foods with the highest proportion of products from Victoria.

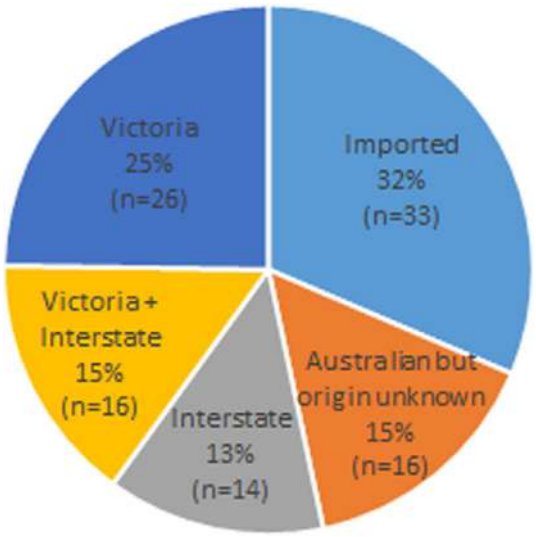

FIGURE 1 Origin of all fresh and minimally processed foods purchased in 1 week by two hospitals ($n = 105$ items).

TABLE 2 Origin of different types of fresh and minimally processed foods purchased in 1 week by two hospitals ($n = 105$ items).

Food group	Food product	Imported, *n* (%)	Australian but origin Unknown, *n* (%)	Interstate, *n* (%)	Victoria + Interstate, *n* (%)	Victoria, *n* (%)
Fruit	Juice ($n = 9$)	9 (100)	0 (0)	0 (0)	0 (0)	0 (0)
	Whole fruit ($n = 21$)	2 (10)	1 (5)	11 (52)	1 (5)	6 (28)
	Processed fruit ($n = 16$)	11 (69)	1 (6)	0 (0)	0 (0)	4 (25)
Dairy	UHT dairy + plant based milk ($n = 8$)	0 (0)	5 (63)	0 (0)	2 (25)	1 (12)
	Cheese ($n = 4$)	1 (25)	0 (0)	0 (0)	2 (50)	1 (25)
	Fresh milk ($n = 1$)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)
	Yoghurt ($n = 6$)	0 (0)	0 (0)	0 (0)	2 (33)	4 (67)
Vegetables	Whole vegetables ($n = 10$)	0 (0)	0 (0)	2 (20)	0 (0)	8 (80)
	Processed vegetables ($n = 3$)	2 (67)	1 (33)	0 (0)	0 (0)	0 (0)
Meat and alternatives	Eggs ($n = 3$)	0 (0)	0 (0)	0 (0)	2 (67)	1 (33)
	Meat and seafood ($n = 5$)	5 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Grains	Bread ($n = 8$)	1 (12)	5 (63)	0 (0)	2 (25)	0 (0)
Other	Butter + margarine ($n = 5$)	2 (40)	1 (20)	0 (0)	1 (20)	1 (20)
	Water ($n = 2$)	0 (0)	2 (100)	0 (0)	0 (0)	0 (0)
	Fresh pre-prepared meals/components (e.g., salad) ($n = 4$)	0 (0)	0 (0)	0 (0)	4 (100)	0 (0)
	Total products ($n = 105$)	33 (32)	16 (15)	14 (13)	16 (15)	26 (25)

Abbreviations: UHT, ultra heat treated.

TABLE 3 Demographic characteristics including patients, stakeholders and suppliers ($n = 23$).

Participants	Characteristics	*n*
Patients ($n = 13$)	Ward	
	General medical	7
	Surgery	4
	Speciality medicine	2
	Age (years)	
	20–30	2
	40–50	2
	50–60	3
	>60	6
	Gender	
	Female	9
	Male	4
Healthcare staff and group purchasing organisation staff ($n = 7$)	Gender	
	Female	2
	Male	5
	Years in role	
	<5	5
	>10	2
Suppliers ($n = 3$)	Gender	
	Female	3
	Male	0
	Years in role	
	<5	2
	>10	1

A total of 23 participants were interviewed (13 patients, 7 staff and 3 suppliers) (Table 3). Staff members were in foodservice management or support services management roles, foodservice dietetics, procurement and from the group purchasing organisation. Three other participants (one staff member, two suppliers) declined to participate. The mean duration of the interviews was 12 min, and ranged from 3:16 to 39:15 min.

One concept explored was the importance, value and benefits of local food procurement by hospitals. The majority of participants believed hospitals purchasing food locally was important. They felt it provides an opportunity for hospitals to support local farmers and the local economy and that it would be better for the environment. Suppliers described that shorter supply chains were more resilient in the face of disruptions. Staff believed it would enhance the hospital's reputation and felt it was something patients wanted. However, the patients had mixed perspectives on the importance of hospitals purchasing foods locally. Some did not see it as

TABLE 4 Stakeholders perspectives on challenges, enablers and action areas for local food procurement by hospitals.

Challenges

- Preference for hospitals to purchase the lowest cost item, while local products are generally more expensive.
- Difficulty for suppliers to consistently source sufficient, high quality local produce.
- Difficulty for suppliers to identify the origin when products and producers change rapidly.
  'Sometimes it's quite difficult to say exactly on what day where that product has come from because we're constantly procuring to maybe fill a gap or fill a quality issue. Sometimes it can be quite difficult to say right, that potatoes that's definitely from down the road in Geelong and that's definitely from down the road in Perth.' (Supplier, participant 19)
- Absence of onsite cooking reducing the ingredients a hospital could procure locally.
- Contract arrangements restricting hospitals from engaging with non-contracted local suppliers.
- Local food procurement being a low priority for hospital foodservice.

Enablers

- New data from this audit providing an understanding of food origin at baseline and perspectives.
- New requirements instigated by the group purchasing organisation for suppliers to provide food origin information to health services.
- Consistent purchasing patterns of hospitals making it worthwhile for suppliers to procure locally if desired.
- Suppliers with values relating to local economies and farmers who are driving change themselves

Action areas

- Provide information about local food items available on the hospital menu
  'Knowing that you're buying local, you know, it's a good feeling, you know, you're going to keep it in the state as much as you can...I mean, it'd be nice to actually glamorise the menus a little bit more than what we do at the moment and say, you know, we get 90% of our food from local suppliers' (Staff member, participant 21)
- Have seasonal menus to allow local, seasonal produce to be procured
- Consider changing to an onsite cook-fresh model to increase opportunities for local procurement.
- Conduct food origin audits regularly to capture differences in seasons and overcome issues with data availability
- Expand food origin auditing to include meals produced by the central production kitchen
- Enhance communication between suppliers and hospitals for greater awareness of produce requirements, produce shortages, seasonal produce availability.

a high priority or had not considered it, while others agreed it was beneficial.

> *'I think it is important from a sustainability perspective, from just the way the world is heading and people's attitudes and things, I think, is quite important. And I think healthcare is definitely trending towards understanding that the consumer perspective is important. So I think it's going to become more and more important.' (Staff member, participant 5)*

Participants identified a number of key challenges limiting hospitals from purchasing local food, as well as enablers that may help this (Table 4). Participants articulated tensions or 'two sides of the coin', where key factors relating to food procurement were beneficial in some ways and at the same time posed challenges. For example, purchasing from suppliers contracted by the group purchasing organisation reduced the autonomy of hospitals to choose suppliers, but also streamlined procurement decisions. Similarly, while hospitals wanted rotating menus with seasonal local produce, there were also benefits to one fixed year-round menu made from ingredients which may not be local. Lastly, there was a tension between whether the priority of procurement is to support local economies and communities or high quality items or cheaper alternatives.

Finally, participants made recommendations for actions that would support local food procurement by hospitals (Table 4).

4 | DISCUSSION

This mixed methods study presents an audit of the origin of food purchased by a Victorian health service and the perspectives of patients, staff and suppliers towards current and local food procurement. These two elements complement each other to present a snapshot of procurement practices, and views of these.

Approximately two thirds of fresh and minimally processed foods were from Australia, with one quarter from Victoria. In comparison, a similar food origin audit in another hospital in Victoria found 3% of the food budget was spent on Victorian products.[9] This indicates that under usual procurement practices where there is no local procurement policy or intention by the hospital to purchase local foods, a portion of products is already from local growers and producers.[9] Changing procurement practices are not occurring from a baseline of zero. It is unclear what the most feasible and impactful target for local food should be. A target of 100% of foods being locally sourced is likely impractical, even if the challenges identified can be overcome, because there are no local industries in Victoria for certain products that are currently staples on an institutional menu and/or in Australian diets (e.g., bananas, tropical fruit, tinned seafood, special dietary products such as gluten free, texture modified, oral nutrition supplements). Re-designing menus to prioritise products that are available locally, and updating menus throughout the year to include seasonal produce will be necessary to increase the proportion of local food. In the healthcare setting, menu change requires contract management, collaboration with chefs and production teams (who may be external companies), consumer testing and feedback, mapping to nutrition standards and specifications for therapeutic and texture-modified diets and updating electronic menu systems. Skilled foodservice dietitians will be key to manage this complex task. Stakeholder perspectives positioned local food procurement as an idealistic future scenario worthy of pursuing, but with many tensions and challenges to overcome first. One issue was the difficulty knowing where a food product has come from and sharing this information with hospitals. Although this seems like a basic task, the audit identified some products ($n = 5$) where origin information was completely unavailable and other items that were ambiguous such as 'Australian but origin unknown' ($n = 16$, 15%). Another audit reported 55% of the food budget was spent on 'Australian but origin unknown' products.[9] The higher proportion of unavailable data is likely because the hospital was a cook-fresh site and a wider selection of food items ($n = 252$) were audited.[9] Recent policy changes by the group purchasing organisation for public healthcare in Victoria have made it a requirement for suppliers to make food origin information available to hospitals, though it is unclear if suppliers will be able to do this. Suppliers interviewed indicated they were willing to share food origin data, but it was not always known because they switch between producers supplying a particular food item as required. Food origin data is more difficult to access reliably for processed food items containing multiple ingredients and/or processing steps compared to fresh/single ingredient foods.[17] A range of traceability methods exist, including novel technologies using artificial intelligence, big data and block chain, which may have multiple benefits of promoting food quality, safety and purchasing decisions based on food origin.[17]

The qualitative results also identified a discrepancy between expectations of patients and hospital staff. There was an assumption from staff there would be patient demand for local food, although in reality this was not the case for all patients. Those who did value local

procurement thought it was more environmentally friendly, better quality or a better alternative to imported food items, consistent with other research on consumer perpectives.[18] Others considered different foodservice issues as more important than sustainable practices, which was also found in research on patient perspectives towards food waste.[15] Making information on origin of hospital food available to patients (e.g., on menus) harnesses hospitals' unique position to educate about sustainable food choices. A review of consumer perceptions and preferences for local food found sustainable food labels influenced attitudes and eventually resulted in behaviour change.[18] Labelling on patient menus is more practical with electronic menu ordering systems than paper menus. Investigation into what information is most important to patients and if labelling is associated with patients' menu selection and attitudes is an area for future research.

While public procurement of local food is an important element of sustainable food systems, there is a need to also consider the types of food purchased. As promoted by the EAT–Lancet Commission, shifting to a healthy and sustainable diet that has more plant based products and less processed and animal based foods than the standard diet may be the most powerful change individuals and institutional food services can make.[19] Menu redesign, menu labelling and service redesign appear to be the most effective strategies to decrease meat, seafood and eggs and/or increase plant-based alternatives in foodservice settings.[20]

This study is the first mixed methods study incorporating a food origin audit and interviews with stakeholders (including patients) from a Victorian health service. It is likely that audit findings are generalisable to other metropolitan Victorian public health care organisations that operate under the same procurement policies and foodservice production model and menu. Differences would be expected in other states reflecting their local agricultural industries, size, transport infrastructure, and policies and governance for food services. While themes from stakeholder interviews reflect general issues about healthcare, supply chain and foodservice bureaucracy and logistics, the single site study design (as opposed to multiple case methodology) does not allow for perspectives from stakeholders at other hospitals to be gathered and compared. It is also possible that individuals who are motivated and passionate about the topic opted to participate in an interview. A larger and more diverse sample of suppliers was sought to promote trustworthiness of findings, but some declined to participate. A key limitation is that not all food items were audited. The fresh and minimally processed ingredients included make up a small quantity of the food purchased by the health service, and there was some missing data. Meals (soups, main meals, desserts), processed foods, special dietary products and serving ware were not included. Future food origin audits should prioritise meals from central production kitchens because their procurement volume is significant, as well as oral nutrition supplements because they are expensive and make up a significant portion of the total food spend, and supplies have been affected by COVID-19. Additionally, data were collected as the number of foods rather than the volume or quantity. Including data on volume or quantity of each product and the proportion of food budget spent on each product would be helpful contextual information for future research.

This audit of fresh and minimally processed hospital food and investigation into stakeholder perspectives of local food provides an interesting overview of baseline procurement practices, and the challenges and enablers associated with increasing local food procurement. Local food is currently used as part of standard practices. There is interest and goodwill from staff, suppliers and some patients to make local food procurement more intentional, but changes to processes and systems and communication would make it more feasible.

AUTHOR CONTRIBUTIONS

SC conceptualised the study. GM, ME and SC collected the data. SC and JC analysed the data. SC and JC drafted the manuscript. GM and ME provided critical revisions. All authors have read and approved the final publication. The contents of this manuscript have not been published elsewhere. Sally Curtis is acknowledged for supervising GM and ME during their placement experience where data were collected. Mina Berlandier is acknowledged for supporting the foodservice student placement and reviewing the manuscript.

CONFLICT OF INTEREST STATEMENT

SC and JC are employed at the health service where the research was undertaken. The remaining authors declare that the research was conducted in the absence of any-commercial or financial relationships that could be construed as a potential conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the authors did not receive consent for sharing data.

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Transformative systemic changes to embed environmental sustainability in foodservices: A grounded theory exploration

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Abstract

Aims: Foodservices are a strong contributor to global environmental impact. Systemic change is required to lead the transformation towards environmentally sustainable foodservices. However, guidance to support foodservices to be more environmentally sustainable is lacking. The aim was to explore food-related environmentally sustainable strategies and their transferability to foodservices in a range of settings, to inform a framework for future application and research.

Methods: A constructivist grounded theory study design was used. Semi-structured interviews with foodservice sustainability consultants, who support foodservice organisations to improve environmental sustainability, were conducted. Interviews were recorded, transcribed, and coded line-by-line. Ten consultants were purposively sampled for diversity in location, organisation type, funding model, and services provided. Codes were collapsed into categories, to inform the development of themes and a framework for the implementation of strategies.

Results: Four sub-themes were created under an overarching theme of 'Transforming the Foodservice System': embedding leadership, shifting perspective, constructing collaborative networks, and fostering momentum. A range of implementation strategies were captured within the sub-themes.

Conclusion: These themes informed the development of a practical application framework for implementing sustainable strategies in foodservices that is useful for practice and future research in the area.

KEYWORDS

climate, environment, food, food services, health, nutrition, Sustainable Development Goals

1 | INTRODUCTION

The global population is estimated to reach about 10 billion people by 2050 and the equivalent of almost three planets would be required to sustain current lifestyles.[1,2] Human activities have warmed the atmosphere, oceans, and land at an unprecedented rate, causing rapid global environmental changes.[3,4] Climate change has now become a worldwide emergency with global emissions of carbon dioxide having increased by almost 50% since 1990 and greenhouse gas emissions having reached their highest level in history.[1] International actions have aimed to address the ecological and climate crisis, such as the Glasgow Climate Pact, 2021 Intergovernmental Panel on Climate Change Report, Paris Agreement, and Agenda 2030: the Sustainable Development Goals.[1,3,5,6] However, their translation to practice, including through effective net zero targets, has been slow.[3,5]

Food systems are a large contributor to this issue and are responsible for 25%–30% of global greenhouse gas emissions and contribute to a range of global environmental changes including deforestation, biodiversity loss, ocean acidification, air, water and soil pollution, and climate change.[7,8] Food systems have the capacity to support the human population within planetary boundaries; however the current trajectory threatens both.[2,9] A food system is sustainable when food security and nutrition meet the needs of the present without compromising the economic and environmental requirements for providing food security and nutrition to future generations.[10,11] As well, sustainable food systems are protective and respectful of biodiversity and ecosystems; culturally acceptable; accessible; economically fair and affordable; nutritionally adequate, safe, and healthy; while optimising natural and human resources.[12] All components of the food system are important to enhance its sustainability, such as agriculture, primary processing, manufacturing, through to retail and foodservice.[13]

Foodservice, by definition, is the serviced provision of food and beverages (meals) purchased out of the home, which may be consumed both in and out of the home.[14] The global foodservice market reached $2.75 Billion in 2021 and is projected to reach $3.629 Billion by 2027.[15] Foodservices are one of the sectors of the food system which interact directly with the public, or consumers, and there is an increasing pressure for foodservices to meet their needs.[2,16] The public are now placing increasing emphasis on the importance of 'eco' or 'green' practices by foodservices and the broader food system.[17–19] This continued pressure is threatening land, soil, and water limits and is injecting a sense of urgency to transform all areas of the food system, including foodservices.[20] In addition, foodservices are increasingly under pressure to implement environmentally sustainable strategies to comply with international agreements which can influence standards, policies, and political changes.[1–3,5,6,21]

While several strategies have been suggested to increase the environmental sustainability of foodservices[22] and leadership has been described as important for pro-environmental change,[23] more information on how foodservices can best manage pro-environmental change is necessary. Frameworks or models are useful, and examples also exist in the areas of business change management and systems thinking/problem-solving for enhancing the sustainability of other sectors or the food system more generally.[13,24,25] One food system example is the food citizenship model, which describes the interaction between food producers, food brands (including foodservices), and the public to create environmental, social, and financial value to support positive change.[16] It recognises the positive role that all sectors and participants in the food system can have in changing their mindset and actions to one of individual responsibility and food citizenship.[16] While some of the components of the framework are not 'new' conceptually, there is a paucity of information on facilitating organisational change specific for environmental sustainability and foodservice. Understanding key strategies and transferability aimed specifically towards foodservices would be useful in supporting systemic change across the food system.

To better understand the food-related, environmentally-sustainable strategies being proposed and their transferability to foodservices, this study focused on the experiences of social enterprise, not-for-profit, and private consultants who support foodservices in enhancing their environmental sustainability to inform a framework for future application and research.

2 | METHODS

Constructivist grounded theory was used for this study.[26] It was grounded in a constructivist-interpretivist position, reflecting the researchers' views that knowledge is constructed and formed through multiple viewpoints being interpreted to form a consensus. Differing from classic grounded theory, constructivist grounded theory allows for personal interpretation, subjectivity among participants, and researcher reflexivity.[27,28] Given the novelty of the topic and paucity of practice or research frameworks previously published on it, constructivist grounded theory as a method aligns with our study aim of constructing, with consultants, a practical application framework to promote environmental sustainability in foodservices. Methods were informed by Charmaz's constructivist

TABLE 1 Demographic data of consultant organisations working with foodservice organisations.

Company	Country	Human development index[a]	Type of company	Strategies implemented to support foodservices
1	Australia	Very High	Not-for-profit	• Recycling
2	Australia	Very High	Not-for-profit	• Non-plastic utensils
3	Canada	Very High	Not-for-profit	• Organic agriculture and sourcing
4	Greece	Very High	Social enterprise	• Waste monitoring • Educational events • Workshops
5	Mexico	High	Not-for-profit	• Sustainable fishing • Seafood portfolio • Public sourcing commitment
6	UK	Very High	Not-for-profit	• Food system transformation strategy • Sustainable food systems strategy
7	USA	Very High	Private	• Brand positioning • Plant-based menus
8	USA	Very High	Private	• Local & organic food • Scratch cooking • Food waste
9	USA	Very High	Private	• Sustainability strategy • Carbon footprint
10	USA	Very High	Private	• Menu design • Recipe development • Food sourcing

[a]The Human Development Index (HDI) measures the achievement of human development in the following areas: a long and healthy life, being knowledgeable, and having a decent standard of living.[30]

grounded theory approach and reported in accordance with the standards for reporting qualitative research.[26,29] Each member of our research team brought their own unique experience to this study, therefore influencing the research aim, data collected, and interpretations developed. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Bond University Human Research Ethics Committee (Approval No. VS03037).

Consultants are recognised as potential leaders and sources of information that support foodservice organisational change management, specific to environmental sustainability. They work with a variety of organisations (e.g., private, public, universities, franchises, government-funded) to create policies, processes, strategy development, reporting, and measuring techniques to promote environmental sustainability. Recruitment was targeted at individual consultants representing social enterprise, not-for-profit, and private organisations from developed countries [Human Development Index (HDI) of High or Very High].[30] They were purposively sampled through a web-based search, identifying organisations that consult with foodservices regarding environmentally sustainable food-related strategies. Individuals who responded to the recruitment email were initially provided with a survey to collect demographic data and short responses regarding their location, organisation type, funding model, and services/strategies provided. Participants who completed the survey were then invited to participate in an extended, semi-structured interview about their experiences working with foodservices. Respondents were also asked to provide suggestions about other potentially eligible organisations to approach. Recruitment ceased when the same themes began reccurring throughout the interviews with no new insights being brought forward by participants, and the final sample was deemed to represent organisations covering a range of locations, types of organisations, and strategies offered. Organisational characteristics are outlined in Table 1.

Data collection from the survey included questions relating to the organisation's structure and operations, as well as free text fields for the optional sharing of an example, related to the research aim, of a strategy that they had previously undertaken to improve sustainability in foodservice practice. These initial stages of data collection allowed the interviews to focus on more extensive questions and conversation and provided a brief overview and understanding of the organisation, which were used as interview prompts. Further data was collected via

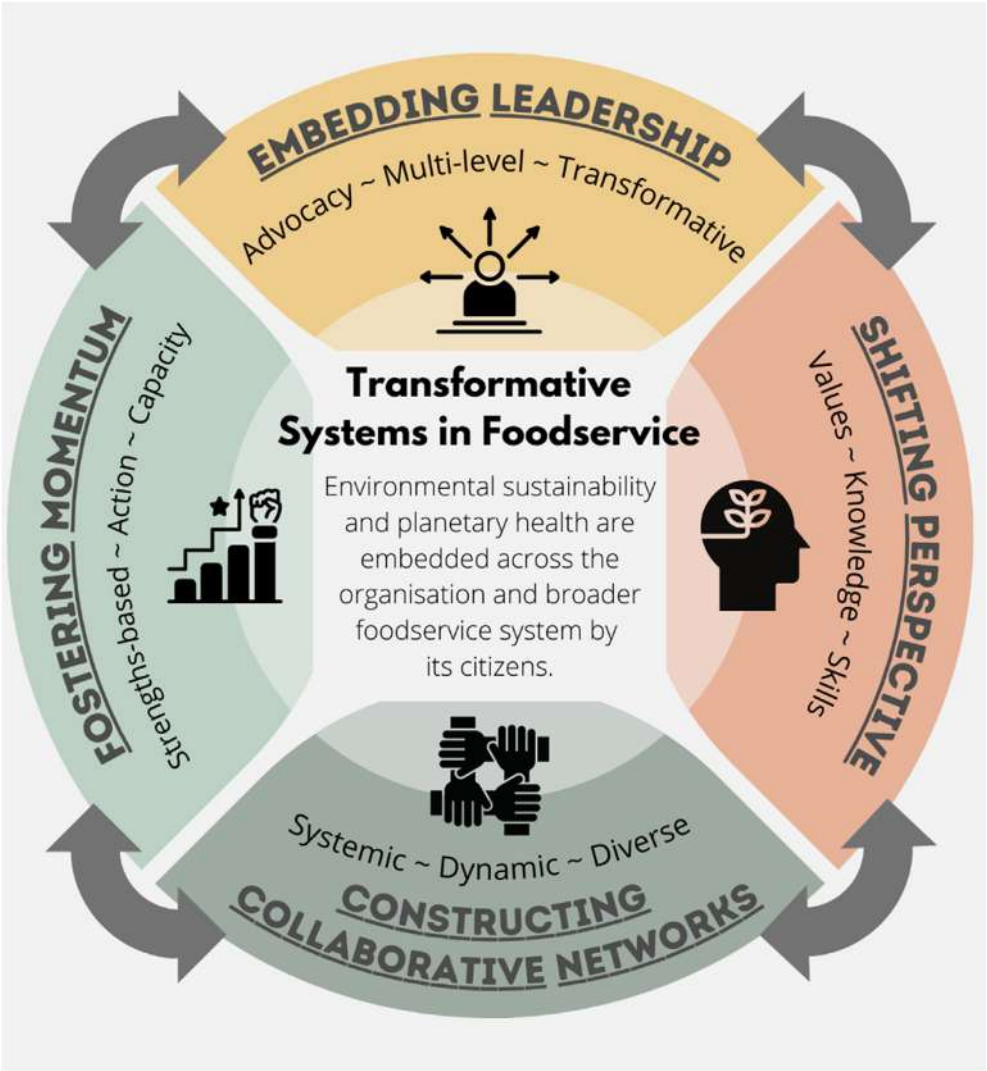

FIGURE 1 Visual framework representing foodservice consultants' experiences of transformative systemic changes required for environmental sustainability in foodservices. This framework includes an overarching theme and four sub-themes that work together to create this transformative system: embedding leadership, shifting perspective, constructing collaborative networks, and fostering momentum.[33]

semi-structured, videoconference interviews conducted by one researcher and a research intern. Interview prompts were developed by the research team and guided by the food citizenship framework due to its powerful insights towards pro-environmental change across the food system (online supplementary material). The interview guide featured information that guided the research team on the application of the food citizenship model in the interview process[16] All interviews were recorded and transcribed verbatim.

Interview transcripts were inductively coded line-by-line. As standard with constructivist grounded theory, analytic memo journals were completed during each phase of the project to aid in data analysis.[26] Following the conclusion of interviews and transcriptions, initial codes were developed, and then axial coding was conducted to group codes and form categories, which were then discussed in research team meetings to conceptualise and refine themes and sub-themes (example provided as online supplementary material).[31] The themes and sub-themes were constructed using implementation strategies and quotes directly from both the survey and interview data. These were selected and agreed upon during the research team meetings. Once the themes and sub-themes were agreed upon, the researchers practised theoretical coding, which broke each theme down into its broader pattern and meaning, linking back to the primary aim of the research.[32] From there, a visual was created to represent the developed framework.

3 | RESULTS

Ten foodservice consultants participated in the survey and a one-to-one interview. As shown in Table 1, representatives from a variety of countries and types of consultancy organisations participated. Strategies implemented by these organisations supported environmentally sustainable practices in foodservices and had a broader reach into other areas of the food system.

TABLE 2 Implementation strategies represented in the data and relating to the sub-themes.

Embedding leadership
• Advocate to higher and/or decision making departments for change in policy
• Challenge companies to think about how change could affect their entire business strategy and what strategies they would have to put into place
• Make employees feel valued
• Understand the company's current practice and/or framework around environmental sustainability
• Advocate internally and externally (e.g., events and campaigns, speaking at conferences, and participating in online forums)
• Support emerging leadership
• Involve senior leadership and executives to influence change
• Encourage behaviour modelling from key stakeholders and senior leadership
Shifting perspective
• Educate on how environmental sustainability is integrated and applied in foodservices, including prioritisation of what will be most impactful for both the business and environment
• Interlink environmental problems with the client's values, beliefs, and motivations
• Engage in practical application and hands-on experiences (e.g., workshops, farm visits, and integrating with other members of the food system)
• Develop personal skills (e.g., leadership and confidence)
• Ensure integrity and transparency of practices across the business
• Introduce modern techniques, such as media and technology
Constructing collaborative networks
• Collaborate with diverse teams locally, nationally, and internationally
• Engage the community through events, workshops, and fundraisers
• Apply already-developed resources and frameworks to enhance knowledge, efficiency, and impact
• Involve the client (organisation) in the change
• Prioritise and build relationships before initiating change
Fostering momentum
• Set goals
• Collect and measure data for progress reporting and accountability
• Use branding, marketing, technology, and media to increase impact
• Develop and/or re-orientate personal skills and values for personal and professional impact
• Prioritise those more willing to change first
• Start with purposive, targeted, strength-based strategies and expand to systemic, impactful, long-term changes

The framework in Figure 1 was developed to represent the theme and sub-themes from the consultants' key considerations for working with foodservices to improve the environmental sustainability of practice. The framework was developed with arrows to symbolise the interlinkages between the elements, which represents the opportunity to focus and address some of those separate, individual components before introducing and interlinking them to the other elements.[33]

An overarching theme, 'Transforming the Foodservice System', emerged from the data and represents how the four sub-themes work together to embed environmental sustainability and planetary health across the organisation and broader foodservice system by its food citizens: embedding leadership, shifting perspective, constructing collaborative networks, and fostering momentum. Table 2 outlines broad implementation strategies linked to each sub-theme and proposed by foodservice consultants.

The first sub-theme was embedding leadership. Within this sub-theme, participants described the importance of transformational change across an entire company, multi-level leadership, and advocating for that change both internally and externally. Participants reported the significance of embedding environmental sustainability into the business model and all areas of the company, as well as breaking hierarchical norms to do so. Contribution and embodied leadership from all areas of the company, including senior leadership and executives, were necessary for this change. It was also desirable for companies to have their employees leading in the area through different forms of advocating (e.g., conferences, education, and events).

'[I] have done some work with foodservice to really embed sustainability across their organisational DNA, so it's not seen as an add-on, but it's really embedded across decision making across those organisations'. *Participant Six: background working on sustainability agendas and using systemic interventions to influence transformational change in foodservices and across the food system.*

The second sub-theme was shifting perspective. Participants emphasised the importance of using systematic approaches to shift employee perspectives and allow for the integration of environmental sustainability initiatives into a foodservice. Raising awareness and knowledge, as well as developing or re-orientating the necessary knowledge, skills, values, and beliefs, were all recognised as key components of making impactful change. Shifting perspective was described as not only required physical and emotional acceptance of environmental sustainability, but also required additional skills and values, such as confidence; a shift to a focus on individual, collective, and organisational responsibility; and the understanding of how environmental sustainability can be economically and impactfully incorporated into a foodservice. Understanding and addressing knowledge and skill gaps and

personal and professional development were all described as necessary to re-orientate and change mindset and behaviours for a more impactful result.

'This tribal knowledge is in direct conflict...it has to be WRENCHED out...this is the hardest part for [kitchen staff] because all of a sudden, they don't know what to do, but there's a lack of accountability and there's a lack of leadership'. *Participant Eight: expertise as a chef combined with systems thinking is used to consult and transition kitchens to environmentally sustainable, locally and organically sourced, zero waste kitchens*.

The third sub-theme was constructing collaborative networks. Participants highlighted the value of collaborating with diverse teams of people locally, nationally, and internationally with a collective goal to enhance environmental sustainability. This included applying a systems approach and involving people across all sectors of the food system, including government representatives and policy makers. Participants recognised that it was crucial to prioritise building relationships and communication with people as a starting point and to not 're-invent the wheel', but to rather build-upon and apply others' work. Although outsourcing support can be beneficial, there should also be a focus on engaging people internally and from all areas of the business, including customers, to support a dynamic organisation that encourages systemic, positive environmental change.

'No one can resolve this problem [of environmental sustainability] alone and it's a huge problem and you need synergies...you need the collaborations to be able to tackle the problem...we don't know everything so we try to bring people on board with us so they can offer the expertise they have...because sustainability—it's about people and it's about humans and it's about how we work together, all of us'. *Participant Four: background of culinary consulting with a focus on food waste management in hotels and restaurants through waste monitoring, educational events, and hands-on workshops*.

The fourth sub-theme was fostering momentum. Participants reported that a company's acknowledgement and recognition of environmental actions to date, willingness to change, and internal and external capacity for environmental change supported a systemic, longer-term impact. These factors were reported as influencing momentum and encouraging organisational development and translational systemic growth. Participants highlighted that it was taking these first steps towards change that were the hardest for foodservices and the individuals within them, and therefore required initial targeted, strength-based, and purposive strategies for change. Commitment, goal setting, accountabilities, progress reporting, and positive reinforcement were described as important and which may be supported by outside consultants, where needed.

'In the sustainability world, we're not good at demonstrating urgency... it's not that sustainability is ever a bad idea, it's that often it just stays in that sort of second tier of priorities – it doesn't have the urgency that gets the time and the attention of the executives... there's a momentum issue that I think makes it quite difficult. My experience is the companies that have the most success are those that have a specific external pressure'. *Participant Nine: background in social sustainability and human rights used to create and implement sustainability frameworks and strategies that address the complexities of environmental sustainability in foodservices and across the food system*.

4 | DISCUSSION

This study explored the experiences of participants engaged by organisations as consultants to support foodservices to implement environmentally sustainable strategies. The study aimed to inform a practical application framework and describe sustainability strategies recommended for foodservices. The key findings included the development of an overarching theme, 'Transforming the Foodservice System', with four supporting sub-themes emerging from the data: embedding leadership, shifting perspective, constructing collaborative networks, and fostering momentum. The participants also described broad strategies that supported a paradigm shift towards environmental sustainability and action within these themes, many of which also support international actions, such as The Eat-*Lancet* Commission's important areas for change in the great food transformation and the Paris Agreement goal of 'affirming the importance of education, training, public awareness, public participation, public access to information, and cooperation...'.[2,6]

The overall finding of our research was the need for systematic change overarching all changes within an organisation. The four sub-themes and framework provide a blueprint for action for foodservice stakeholders including, consultancy organisations, government and policy makers, and dietitians[34] to facilitate positive, translational environmental change. Aligning with our study's findings, embedding leadership within organisations has been more broadly recognised as a central component of environmental change.[35–37] Many sustainability challenges are characterised by high complexity, structural uncertainty, resistance to simple solutions, and the requirement for long-term focus, so they are difficult to tackle with management as usual.[38–42] Multi-level management can contribute a more holistic view of individual, organisational, and societal sustainability efforts and performance.[43,44] Social modelling has been shown to promote significant environmental change in

foodservices[45,46] and thus individuals within the foodservice system (food citizens)[16] can feel empowered to be emergent leaders (change champions) and promote positive environmental change within an organisational structure.[36,37]

Similarly, the sub-theme shifting perspective recognises the importance of defying the status quo and removing participant-described 'tribal knowledge' to adapt to new skills and perspectives that will positively promote environmental sustainability. It is clear that consumer attitudes and satisfaction towards environmentally sustainable strategies by foodservices are mostly positive,[46] however there is a widely reported value-action gap in the literature between awareness and pro-environmental initiatives. Literature has addressed these value-action gaps seen across organisations by relating them to groupthink and conformity theories, among other psychological concepts, which describe how hard it is to resist authority or group pressures to make decisions.[47] Engler, Abson, and Von Wehrden review additional human cognition biases, including status quo bias, related to both individual and group settings, alongside mitigation strategies directly related to environmental sustainability.[48] For an organisation to be able to defy the status quo and change, there must be a cohesive commitment to change across the entire organisation. Shifting perspective of all employees can promote positive transformational leadership and change-related communications from top-management through to all employees within an organisation, and will assist in mitigating hierarchical barriers to change.[49]

The sub-theme constructing collaborative networks recognises the importance of adopting practices, resources, and frameworks that are already deemed successful to maximise impact, as well as prioritising relationships that will foster additional impact and momentum. Similarly, Blay-Palmer, Sonnino, and Custot identified common challenges among community-scaled sustainable food initiatives and possible solutions to overcome these shared global pressures experienced by sustainable food system projects around the world.[50] Although this links to the food system as a whole, the strategies identified complement those described within the current framework and are applicable to the challenges and opportunities that our participants reported when working with foodservices across three key areas. First, values-based education for *citizens*: empowering consumers and informing them about the food they consume. Second, networks to connect producers, processors, distributors, retailers, foodservices, and consumers in the shortest food webs possible: technologies to support networks and innovation. Third, economic viability along the food web.[50] It has been identified that although our study focuses on the foodservice sector of the food system, considering all components of the system is relevant for optimal environmental sustainability implementation. Also, implementing learnings and collaboration across various sectors of the food system will promote overall food system transformation.

The sub-theme fostering momentum describes the importance of support and transition management to work towards longer-term and larger impact, that is, the 'ripple effect'.[51–53] Initial targeted, strength-based, and purposive strategies were emphasised as a starting point to pro-environmental change. This component of the framework relates to agency (belief in one's own ability to help, relating to climate change) and actions (pro-environmental behaviours) at an individual through to organisational level. Usual behaviour change approaches can potentially be applied to support change for example, the Com-B behaviour change wheel.[54] Strengths-based approaches are also supported, as they are within individuals' or organisational capabilities and thus support greater agency. This recognises that change is more sustainable when we focus on strengths and possibilities, rather than focusing on challenges. Interestingly, consultancy organisations' funding structures and the impact they had on implementing environmentally sustainable strategies in foodservices was not identified as a common theme or barrier carried by consultants. While other frameworks have acknowledged the role of economy, including the triple bottom line,[21,50,55] this was not distinguished as a priority barrier or enabler for consultancts in our study. This may be due to a majority of consultancy organisations in our study working in line with the Sustainable Development Goals, which have commonalities with an updated conceptualization of the triple bottom line, where all dimensions (social, environmental, economic) overlap and the distinction between economy and human society are removed, with both confined together within environmental limits.[1,55]

Participants engaging in consultancy to foodservices were recruited as they were identified as leaders working with foodservices; however, as custom with grounded theory research design, it became evident that they were not only focusing on foodservice-specific strategies, but also on strategies supporting the broader food system, as these are indistinguishable. Therefore, organisational or systems change frameworks can be applied to support change, of which there are many,[24,56] including some specifically for health promotion and food systems. For example, similar themes have emerged from The I+ PSE conceptual framework for action,[25] World Health Organization,[57] and Sustainability Victoria,[58] including strengthening individual knowledge and skills, promoting community engagement and education, and facilitating partnerships and multi-sector collaborations.

Our research referenced the food citizenship model, which was reinforced by participants as all sectors of the food system were identified as important to promote positive change within foodservices.[16] Facilitating organisational change specific for environmental sustainability and foodservice has now been determined through applying a constructivist grounded theory approach.

Due to purposive sampling, a potential limitation to our study is that only select foodservice consultants were recruited. Consultants from key businesses with different experiences may not have been interviewed. The minimal results relating to consultancy organisations' funding structures could suggest that the interview may have not gone into enough depth on the funding structure of the consultancy organisations and its effects on consultants' experiences. One last limitation is that no countries categorised as low on the HDI scale[30] were included in this study. Including low HDI countries would have provided unique differences in experiences.

It is recommended that consultancy organisations, individuals that consult to foodservices, and potentially foodservices themselves apply the developed framework when implementing environmentally sustainable strategies in foodservices. Foodservice dietitians can enhance their dietetics practice by implementing, or supporting the implementation of, the sustainable strategies that fit within the developed framework. Applying the individual components of the framework, and organisation-appropriate strategies, in collaboration both within and external to the organisation, will support dietitians to foster momentum, support and implement pro-environmental change.

This study created a framework for consultants to use when working with foodservices to promote a fundamental shift towards pro-environmental change. Through embedding leadership, shifting perspective, constructing collaborative networks, and fostering momentum, foodservices will be actively involved in the long-term, systemic change and impact that is crucial to transform the foodservice system. The developed framework will inform research and company environmental performance.

AUTHOR CONTRIBUTIONS

MS recruited participants, collected data, performed data analysis, developed the themes and framework, wrote the manuscript, and had primary responsibility for the final content; KMS designed the research, reviewed the data collection and analysis, contributed to the theme and framework development, reviewed the manuscript, and had primary responsibility for the final content; AD contributed to the methodology, theme and framework development, and reviewed the manuscript; and DPR designed the research, contributed to the methodology, theme and framework development, and reviewed the manuscript. All authors are in agreement with the manuscript and it has not been published elsewhere.

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CONFLICT OF INTEREST STATEMENT

Dianne Reidlinger is Editor of Nutrition & Dietetics. This manuscript has been managed throughout the review processby the Journal's Editor-in-Chief. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. All other authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL RESEARCH

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Packaged hospital food appears safe and feasible to reuse

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Abstract

Aim: To determine the safety, operational feasibility and environmental impact of collecting unopened non-perishable packaged hospital food items for reuse.

Methods: This pilot study tested packaged foods from an Australian hospital for bacterial species, and compared this to acceptable safe limits. A waste management strategy was trialled ($n = 10$ days) where non-perishable packaged foods returning to the hospital kitchen were collected off trays, and the time taken to do this and the number and weight of packaged foods collected was measured. Data were extrapolated to estimate the greenhouse gasses produced if they were disposed of in a landfill.

Results: Microbiological testing ($n = 66$ samples) found bacteria (total colony forming units and five common species) on packaging appeared to be within acceptable limits. It took an average of 5.1 ± 10.1 sec/tray to remove packaged food items from trays returning to the kitchen, and an average of 1768 ± 19 packaged food items were per collected per day, equating to 6613 ± 78 kg/year of waste which would produce 19 tonnes/year of greenhouse gasses in landfill.

Conclusions: A substantial volume of food items can be collected from trays without significantly disrupting current processes. Collecting and reusing or donating non-perishable packaged food items that are served but not used within hospitals is a potential strategy to divert food waste from landfill. This pilot study provides initial data addressing infection control and feasibility concerns. While food packages in this hospital appear safe, further research with larger samples and testing additional microbial species is recommended.

KEYWORDS

food safety, food waste, health service, recycling

1 | INTRODUCTION

Waste is an unavoidable outcome of healthcare provision, yet dealing with waste is a complex task. Waste management programs must take into consideration health services' legislative obligations, corporate responsibility to the community, and operational limitations as well as the environmental impacts, costs, and health risks to patients, staff, and the public which are associated with waste, its handling, and disposal. The waste hierarchy is

a guiding principle for making decisions on how waste should be managed, with avoidance the most preferred approach followed by reuse, recycling, recovery of energy, treatment, and finally disposal.[1]

In the context of food, if waste cannot be avoided the waste hierarchy recommends first reusing food waste onsite, followed by feeding hungry people (donation), and then feeding animals.[1] Food waste includes unplated food (bulk trayline waste), meals that are plated and taken to the ward but not served, and packaged food items that have been served to patients but not eaten, which may be fit for human consumption. Shelf-stable single-serve packaged food items (e.g., packets of cereal, packets of biscuits, coffee sachets, long life milk) (Figure 1) are suited to being reused because they are staple food items, they do not need to be kept refrigerated, and they are used in high quantities widely across healthcare. A recent comprehensive systematic literature review[2] reported how food and food related waste is managed in hospitals internationally and how this compares to the waste hierarchy. The review found out of 85 examples of food waste management, the most common strategy was composting ($n = 34$) which is low on the waste hierarchy, followed by donating food ($n = 21$) which is high on the waste hierarchy.[2] Despite being the most preferred approach, there were no examples of reusing food items onsite found in the literature.[2] The likelihood is that most hospitals across the world are sending food waste to landfill or incineration as part of their general non-hazardous waste stream.

The absence of reusing packaged food is problematic because in some hospital settings, food contributes to up to 50% of the total waste stream and is the next largest component of the total combustible waste following plastics.[3] The large scale of hospital food waste emphasises the importance of foodservice being part of the conversation and action plan for sustainable health care. Finding feasible alternatives to disposing food waste in landfill is essential because food waste contributes 3.5% of total greenhouse gas emissions in Australia.[4] In addition, there are costs associated with transporting large quantities of food to landfill.[5]

FIGURE 1 Examples of unopened non-perishable packaged food items used in healthcare.

Safety concerns relating to infection control and physical risks from tampering present a barrier to the reuse of hospital food items.[6] Interviews with patients about their perspectives on food waste identified they see a dilemma between the risk of contamination and the solution to food waste presented by reusing food.[7] It is purported that pathogens may colonise on the surface of packages that have been handled by patients or in the patient zone, and then be transferred to other people if they were reused. However, there are many examples of common practices in healthcare where similar infection risks exist but are managed and tolerated such as items in patient fridges in common areas, coffee stations or ice machines that may be handled by many people, or food from outside hospital brought in by visitors that is not cleaned or sterilised. It is recognised and accepted by Food Standards Australia New Zealand (FSANZ)[8] and the Institute of Medicine (US)[9] that potential pathogens may be present on packaging, but at low levels that do not pose a risk to health. In the broader community FSANZ Food Standard 3.2.2 allows a business to sell food to a customer that has already been served to another customer, provided the food was completely wrapped when served and remains wrapped.[8]

Risk management approaches are important in any scenario in healthcare where adverse outcomes (e.g., safety risks) must be weighed up against benefits to patients, staff or the community.[10] Such mitigation strategies may include isolation, behaviour controls, engineering/design controls, personal protective equipment, cleaning programs and monitoring/testing programs that are all explicitly set out in hospital policy. Additionally, understanding the likelihood of an adverse event occurring and the severity of its consequences is important for preventing and managing risk.[10] In the context of reusing food items, such decisions can be informed by gathering data to identify risks, testing potential solutions, and considering legislation and best practice guidelines that pertain to risk management in the hospital environment (e.g., Five Moments of Hand Hygiene) or food safety in the hospital setting (e.g., FSANZ Standard 3.3.1 Food Services to Vulnerable Persons).[11,12]

If safety concerns of reusing food items in hospital setting can be managed appropriately, operational feasibility may present another barrier. A new process to collect unopened packaged food items must be integrated

into current hospital food service operations without disrupting the flow and timing of an efficient meal service cleanup. This study aims to determine the safety, operational feasibility and environmental impact of collecting packaged hospital food items for reuse.

2 | METHODS

The study was approved by the health network Human Research and Ethics Committee (application numbers QA19/064 and LR19/086). This study was conducted in two parts. First, an observational design was used where samples of packaged food were collected and the level of microorganisms present on the outside of packaged food items from different locations in a hospital were measured and compared to safety standards for surfaces set out by a National Association of Testing Authorities accredited food safety laboratory (Omic Australia, Victoria). This aspect was reported using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement.[13] The second part involved trialling a waste collection strategy, and assessing the operational feasibility along with determining the environmental impact.

This study was carried out at a 621-bed tertiary hospital located in suburban Melbourne, Australia. The hospital uses a cook-chill, cold plating food service model. Soups, main meals and desserts are produced offsite at a central production kitchen and breakfast, snacks, drinks and accompaniments are pre-packaged portion-control items. Patients' meals are plated cold and other items are assembled onto trays and loaded into trolleys where they are rethermalised or kept chilled prior to distribution to patients. After meal service, patient trays and waste is collected from wards, loaded into trolleys and returned to the hospital kitchen where it is separated into recycling (e.g., plastic) and rubbish/landfill streams, and serving ware is washed. Under usual circumstances, all unopened packaged food is considered rubbish and disposed of via landfill.

Samples of unopened food packages were collected from eight locations along the hospital food distribution chain (Figure 2). The ward pantries (accessed by clinical and support staff, patients and visitors), kitchen store room (accessed predominately by foodservice staff and food deliverers) and kitchen plating line (manned by foodservice staff) were included as controls as food items in these areas are perceived to be safe, and readily eaten. To collect food items that had been served to patients but not eaten, additional food items were placed on patients' trays at the plating line in the kitchen with the expectation that since they were in excess to those ordered by the patient they would return to the kitchen as waste. Trays of patients who were on diet codes not compatible with the sample food items (e.g., nil by mouth, fluid only diets) were excluded. The ward and bed number listed on the tray ticket was noted when items were placed on trays, and when they were returned to the kitchen and samples collected. Food items that had been opened and those from trays missing a tray ticket were excluded. To identify if a tray had returned from a patient in isolation or not, we cross checked ward and bed numbers of trays with a list of patients in isolation provided by the infection control team each morning, and verified by visiting the ward to cross check the patient with the list and

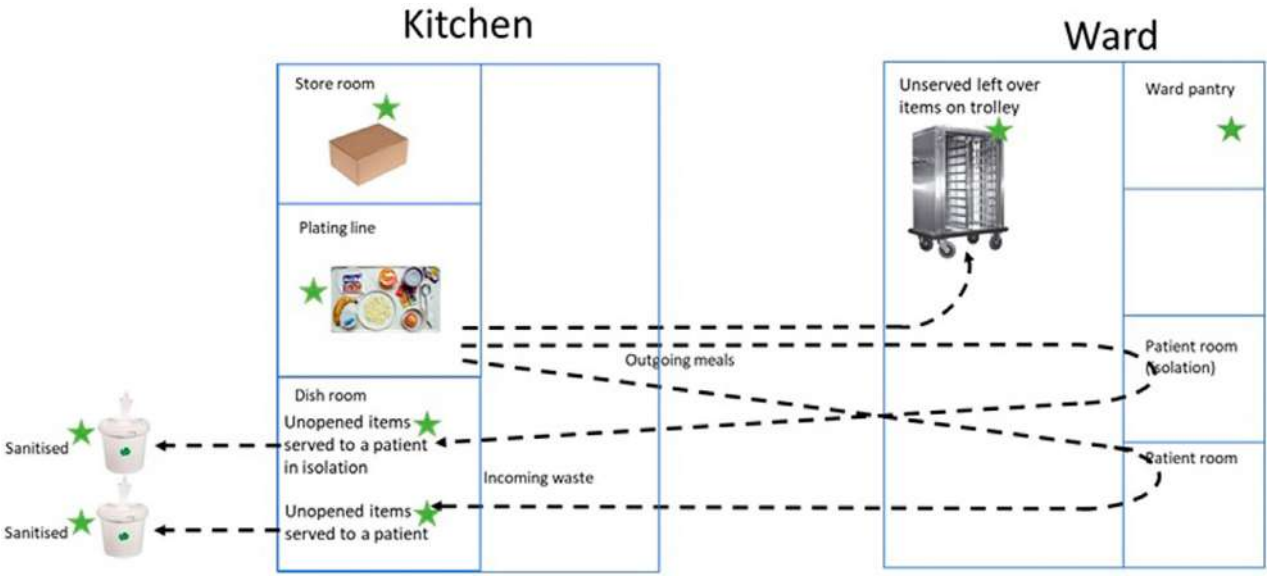

FIGURE 2 Locations in the hospital where non-perishable packaged food items were collected for microbiological testing.

observe that isolation measures were still in place prior to the meal.

The items collected as samples used a range of packaging materials including paper (i.e., salt or pepper sachet), lined plastic (i.e., coffee sachet) and hard plastic (i.e., cup of thickened fluids) (Figure 1). Sample size was driven by feasibility and logistical factors, with a minimum of three items per location as the target, as the authors were not aware of prior data or industry resources to inform sample size.

Two researchers completed sample collection and swabbing following the guidelines provided by the food safety testing laboratory (Omic Australia, Victoria) and were trained by laboratory staff in these processes. Researchers wore disposable gloves and sanitised their hands and changed gloves between collecting each sample, and performing each swab. Samples of packaged food items were collected from the various locations (Figure 2) and placed in an individual, labelled zip lock bag. Samples were taken to a dedicated, cleaned work space in the hospital where information was logged in a spreadsheet, a portion were sanitised per the procedure below and they were swabbed for microbiological analysis.

The authors were interested in whether sanitising the outside of food packets altered the microbiological safety, as sanitising items before reuse is an accepted risk management practice in healthcare. Hence, we used a standard hospital sanitising wipe (Tuffie 5 hospital grade disinfectant wipe) to thoroughly wipe over the entire surface (~3–5 s) of a portion of the samples served to patients that were lined plastic or hard plastic. Food items in paper packets were not sanitised as we expected this to ruin the integrity of the packaging.

Swabbing involved rubbing a cotton swab (NRS II™ Transwab provided by the laboratory) held at 30° angle slowly and thoroughly three times over the entire surface of the outside of the food packet. Each swab was put in an individual, labelled zip lock bag stored at 4°C until microbiological testing, which occurred within 24 h.

Analysis of microbiological species and number were carried out by a National Association of Testing Authorities accredited laboratory (Omic Australia, Victoria). Swabs collected from the surface of packaged food items were used to measure the number of colony forming units (CFU) per swab for standard plate count and the bacterial species Enterobacteriaceae, *Escherichia coli*, Coagulase positive staphylococci, *Bacillus cereus*, *Listeria monocytogenes* and *Salmonella sp*. These species were selected following advice from a clinical microbiologist working in healthcare, and as they are the most common strains associated with food borne infections from packaged ready-to-eat foods and food preparation areas.[14]

To assess the operational feasibility and environmental impact, a waste collection strategy was implemented for a 2-week period whereby all unopened non-perishable packaged food items returning to the kitchen from the ward (excluding isolation rooms) were taken off meal trays. This included breakfast cereal, UHT milk, spreads, coffee, sugar, salt, pepper, sweetener, biscuits, fruit cups, salad dressing, oral nutrition supplements and thickened fluids (Figure 1). Perishable packaged food items (e.g., yoghurt), opened food items or items with observable damage to packaging were not collected. One trained person was responsible for collecting the packaged items off the tray and separating it into containers. The other foodservice staff members completed the clean up as per usual.

Outcome data were collected at breakfast and lunch over 10 weekdays by two trained researcher students. Food items were sorted by type and the number of items collected at each meal period were counted and weighed using calibrated digital platform scales with a graduation interval of 0.01 kg (Wedderburn, New South Wales). In the absence of data from the dinner service, the number and type of food items collected at lunch was assumed to be the same as dinner, given the menu options are similar. Thus, Breakfast + Lunch + Lunch data was used to calculate values per day. Annual values were estimated by multiplying daily values by 365 days. Estimation of the amount greenhouse gas that could be produced from the weight of the collected packaged food items was calculated using a factor of 2.89 $kgCO_2$-e per kg generated through the US EPA's Waste Reduction Model (WARM V15).[15]

Researchers observed the clean-up process to gather information on the time required and the scope of waste collection that was possible for one additional dedicated person to do within the time allocated for clean-up. The time taken to collect the unopened packaged food items from each tray was timed and recorded, together with the time taken to clear an entire trolley of waste. To determine if collecting packaged food items disrupted breakfast and lunch meal service, the total duration of the whole clean-up was measured and compared to the allocated time. The number of 'uncollected trolleys' per meal service that could not be included in the waste collection without slowing down the pace of clean- up were counted.

All statistical analyses, including descriptive statistics and power calculations, were completed using SPPS version 26 (IBM). Data are presented as mean ± standard deviation or mean ± variance (range). The level of bacterial species present on packaged food items from different locations within the hospital was compared to safe levels (colony-forming units (CFUs) per swab) for satisfactory cleaning and sanitation of surfaces

in contact with food set out by the food safety laboratory (Omic, Victoria Australia) which were informed by guidelines from the American Public Health Association.[16] These are listed in Table 1. FSANZ does not set out acceptable limits for environmental monitoring, and hence guidelines used by the laboratory who regularly assess samples were followed.[14] Microbiological data had a skewed distribution (Kolmogorov–Smirnov); thus, comparisons between the average standard plate count for samples from each location and the safe limit (1000 CFU) used a Kruskal–Wallis test with pairwise comparison and Bonferroni correction for multiple tests. p Values <0.05 represented a significant difference.

3 | RESULTS

Data from microbiological testing of 66 packaged food items from various locations in the hospital compared to safe limits for surfaces are shown in Table 1. The level of Enterobacteriaceae, *E. coli*, Coagulase positive staphylococci and *B. cereus* on the surface of food packages was below the safe limit for all samples ($n = 66$ samples) and *L. monocytogenes* and *Salmonella sp* were not detected on any samples ($n = 66$ samples). The average standard plate count was statistically significantly lower than the safe limit (1000 CFU) for food items from each location except for those from the kitchen plating line or the kitchen store

TABLE 1 Bacteria present on packaged food items from various locations within the hospital.

	Colony forming units per swab								
	n	Enterobac.	*E. Coli*	Coag. + Staph	*B. Cereus*	Listeria	Salmonella	Standard plate count	*p*
Acceptable levels for satisfactory cleaning and sanitation of surfaces in contact with food set out by the food safety laboratory (Omic, Victoria Australia)		<10	<10	<100	<100	0	0	<1000	
Unserved leftover food items on trolley	3	<10	<10	<100	<100	0	0	12 ± 0.5 (0–39)	0.096
Unopen items served to a patient	14	<10	<10	<100	<100	0	0	37 ± 8 (0–160)	0.004
Unopened items served to a patient in isolation	10	<10	<10	<100	<100	0	0	45 ± 4 (0–300)	0.013
Sanitised unopened items served to a patient	9	<10	<10	<100	<100	0	0	0–9**	<0.001
Sanitised unopened items served to a patient in isolation	6	<10	<10	<100	<100	0	0	0–9**	<0.001
Items in the kitchen storeroom	3	<10	<10	<100	<100	0	0	12 ± 0.5 (0–39)	0.096
Items plated on a patient's tray in the kitchen	12	<10	<10	<100	<100	0	0	18 ± 8 (0–50)	0.002
Items in the common ward pantry	9	<10	<10	<100	<100	0	0	12 ± 5 (0–39)	0.001

Note: Data presented as the number of colony forming units (CFUs) per swab or total count mean ± variance (range) of CFUs per swab.
**There was no variation, all observations were 0–9 CFUs/g. p Value from Kruskal–Wallis test with pairwise comparison and Bonferroni correction for multiple tests compared to safe level of CFUs <1000.
Abbreviations: *B. Cereus*, *Bacillus cereus*; Coag. + Staph, coagulase positive staphylococci; *E. coli*, *Escherichia coli*; Enterobac., Enterobacteriaceae; Listeria, *Listeria monocytogenes*; Salmonella, *Salmonella sp*; total count, total plate count.

room. Although the average standard plate count for the small sample ($n = 3$, $n = 3$) of food items from these two locations was not statistically different to the safe limit, the average standard plate count (12 ± 0.5 CFU) and the standard plate count of each individual sample was well below the safe limit (<1000 CFU). The average standard plate count for packaged food items served to a patient (37 ± 8 CFU) and packaged food served to a patient in isolation (45 ± 4 CFU) were higher than control samples from the kitchen storeroom, ward pantry and kitchen plating line, however it was not possible to test the statistical significance of this difference. The highest standard plate count (300 CFU) occurred for a packaged food item from a patient in isolation.

Data from this pilot study was used to complete a post hoc power calculation. Table 2 shows the number of packaged food items (sample size) required to detect if there was a significant difference in the microbiological safety for a range of bacterial species between packaged food items from various locations within the hospital (2 tailed estimation $p < 0.05$). 'Safety' is the presence/absence of pathogens (e.g., listeria, salmonella) or CFUs below/above the safety threshold (e.g., Enterobacteria, *E. coli*, coagulase + staphylococcus, *B. cereus*, standard plate count). While the sample size for each location varied, a sample size of 12 replicates is recommended as a conservative estimation. This sample size estimation is based on the variance in safe vs unsafe results (i.e., categorical outcome) generated in the pilot study. It is likely that more than 12 samples per location would be required if the intention was to quantify and compare the average number of CFUs (i.e., continuous outcome) as greater variability is possible when quantifying rather than categorising the outcome. Furthermore, it is unknown if the variance observed in the samples in this pilot study reflects the 'true' variance occurring in another hospital setting or generally in the population.

The amount of unopened packaged food items collected off the trays at breakfast and lunch is reported in Table S1, and the daily and annual results are reported in Table 3. An average of 1768 ± 19 packaged non-perishable food items were served to patients each day, never opened, and then returned to the kitchen to be disposed of in landfill. The weight of this waste was 18.0 ± 0.2 kg/day on average which equates to 6613 ± 78 kg/year, which has the potential to produce 19 110 CO_2-e (kg) total per year. The highest number of wasted items were sugar sachets (482 ± 67/day), pepper sachets (363 ± 81/day) and salt sachets (323 ± 73/day), however the weight of these items made up less than 10% of the total waste. Conversely, small numbers of thickened fluids (12 ± 1/day), supplement bottles (6 ± 1/day) and diced fruit cups (32 ± 13/day) were wasted but they made up almost half of the total waste by weight. Ultra heat treated (UHT) milks made substantial contribution to total waste by number (208 ± 44/day) and by weight (20% of total waste).

Time in motion analysis revealed taking packaged non-perishable food items off each tray during the clean-up process in the kitchen took an average of 5.1 ± 10.1 sec per tray or 2.7 ± 2.4 mins for a trolley full of trays ($n = 32$ trays). The total length of the whole clean up (including collecting food items off trays) took 57 ± 5 min on average, indicating when this extra task was completed by a dedicated staff member the whole clean up could be completed within the allocated time period of 1 h for clean up. However on average, items on 2.3 ± 1.3 out of 12 trolleys of trays per meal time were not collected in order for the staff member to keep pace with the whole clean up.

4 | DISCUSSION

This pilot study is the first of its kind to explore whether it is feasible and safe to collect unopened, non-perishable

TABLE 2 Estimation of sample size of food items required to achieve statistical significance for microbiological testing of packaged food items from all locations within the hospital.

		Power (V0 = 0.1)	
	Variance	**1 tail**	**2 tail**
Unserved leftover food items on trolley	0.5	11	12
Unopen items served to a patient	7.9	3	3
Unopened items served to a patient in isolation	3.7	4	4
Sanitised unopened items served to a patient	0		
Sanitised unopened items served to a patient in isolation	0		
Items in the kitchen storeroom	0.5	11	12
Items plated on a patient's tray in the kitchen	8	3	3
Items in the common ward pantry	4.5	4	4
Mean	3.14	4	4

TABLE 3 Average daily number of non-perishable food items collected over the study period, estimated number of items returned annually and estimated annual contribution to greenhouse-gas production when packaged food items were disposed of in landfill.

Item	Number of unopened food items collected per day	Number of unopened food items collected per year	Mass (kg) of unopened food items collected per day	Mass (kg) of unopened food items collected per year, annual (kg)	Estimated volume of CO_2-e emissions (kg) produced from unopened food items in landfill per year
Breakfast cereal	48 ± 5	17 520 ± 1933	1.7 ± 0.2	601 ± 64	1738
UHT milk	208 ± 44	76 030 ± 16 000	3.8 ± 0.7	1369 ± 265	3956
Honey	4 ± 2	1570 ± 663	0.1 ± 0.03	27 ± 11	77
Jam	83 ± 6	30 222 ± 2229	1.2 ± 0.1	444 ± 33	1284
Vegemite	6 ± 3	2226 ± 1003	0.1 ± 0.03	23 ± 10	68
Coffee sachet	67 ± 7	24 528 ± 2589	0.1 ± 0.01	349 ± 5	142
Sugar sachet	482 ± 67	175 784 ± 24 292	1.4 ± 0.2	527 ± 73	1524
Sweetener sachet	76 ± 17	27 667 ± 6360	0.2 ± 0.03	55 ± 13	160
Biscuits	15 ± 2	5548 ± 560	0.2 ± 0.03	65 ± 10	188
Diced fruit cup	32 ± 13	11 680 ± 4601	4.1 ± 1.7	1601 ± 630	4627
Salt sachet	323 ± 73	117 713 ± 26 545	0.2 ± 0.05	88 ± 20	255
Pepper sachet	363 ± 81	132 568 ± 29 474	0.04 ± 0.01	13 ± 3	38
Salad dressing	33 ± 7	12 118 ± 2436	0.7 ± 0.1	238 ± 50	688
Supplement bottle	6 ± 1	2044 ± 202	1.4 ± 0.1	514 ± 49	1485
Supplement sachet	3 ± 1	949 ± 149	0.2 ± 0.03	54 ± 10	156
Thickened fluid	12 ± 1	4271 ± 309	2.3 ± 0.2	852 ± 62	2463
Total	1768 ± 19	645 284 ± 7047	18 ± 0.2	6613 ± 78	19 110

Note: The values for an 'average daily number' are calculated from values for breakfast + lunch + lunch, as data were not collected for dinner. Data are presented as mean ± standard deviation. Annual values were estimated by multiplying average daily values by 365 days. Estimated greenhouse gas production expressed as CO_2-e (kg) if items were disposed of in landfill was calculated by using a factor of 2.89 kgCO_2-e per kg generated via the US EPA's Waste Reduction Model (WARM V15).[15]
Abbreviations: UHT, ultra heat treated.

packaged food items in a hospital. The level of six common bacterial species and the standard plate count present on the surface of all food packages from various locations in the hospital was less than the standards for surfaces in contact with food set out by the food safety laboratory (Omic, Victoria Australia). While this suggests that the infection risk posed by the surface of unopened food packages of food is low, further research is required to draw firm conclusions. When a food waste collection strategy was implemented, it took an average of 5 seconds per tray to collect unopened food packages and it was possible to clear, on average, all but two trolleys within the allocated time period for clean-up. A total of 1768 (18 kg) packets of unopened non-perishable food items were collected each day when they would otherwise be sent to landfill. Further investigation to build on this research is essential to inform and translate practical solutions for dealing with food waste in hospitals and reducing its environmental impact.

If unopened packets of non-perishable food are collected instead of sending them to landfill, how should they be repurposed? A preferred option in the waste recovery hierarchy is to reuse food items.[1] Food items can stay within the hospital and be reused by re-serving them to patients. Items collected from patient trays returning to the kitchen would be returned to the storeroom or pantry where they are combined with new items that arrive via the supply chain, and used according to standard inventory control measures (e.g., first in first out). The second option is food items are made available for staff to use. The advantage of reusing packaged items within the hospital is the financial outlay is recuperated. Food items could also be reused by being donated to food rescue organisations to be distributed for people needing food relief. Donation of food to food banks, emergency shelters, food pantries, and soup kitchens would be an ideal use of packaged items.[17] Case studies of hospitals in the United States that donate left over food reveal that one of the outcomes

is that it positively portrays the hospital to the broader community.[18] However, critics of the donation approach as a food waste management strategy point out it is only a short-term solution and does not address the underlying cause of why people need to access food relief.[19]

While the data from this pilot suggests the presence of bacteria on the surface of packaged food items is low, in the absence of a stronger evidence base, excluding food items that have been in rooms of patients in isolation from being collected and reused may be a preferred risk management strategy. Additionally, a conservative approach may be more palatable to organisations, staff and patients who are acutely aware of the consequences of disease transmission and outbreaks due to COVID-19. Food items served to these patients would be discarded in the room as clinical waste, rather than returning to the kitchen. Although sanitising food packets is theoretically another useful risk reduction approach, this requires time, labour, creates waste and is not appropriate for all types of packaging (e.g., paper packets). Our data does not present conclusive evidence that sanitising packaged food items has a safety benefit, as food items that had been in the room of a patient in isolation were within safe limits, irrespective of whether they had been sanitised or not.

Any approach to repurpose food items requires the items to be collected in the first place. In this pilot, an additional staff member was employed to collect food items off the trays however, if a waste collection strategy were to be implemented in practice, it is expected that collecting and separating items would be integrated into the duties of the existing foodservice staff members. These additional hours, and the associated costs, would need to be absorbed by the organisation. A targeted strategy that focuses on collecting food items that are lower risk (e.g., not from rooms of patients in isolation and/or taken to the ward but not served), high weight, easy to grab and/or expensive (e.g., oral nutrition supplements) will require less labour than a broader strategy and may be preferred.

While reuse of packaged items is better than landfill disposal, the best option is to avoid food waste being created in the first place.[1] One way this can be achieved is with a food service system that uses technology for meal ordering and menu management. An electronic system is agile in responding to changes in patient admissions, discharges and dietary needs which may result in less default meals and less surplus meals. It also allows patients to order closer to the time of eating so they are better able to select a meal they want to eat. A systematic review reported that electronic meal ordering systems increase patient intake and decrease plate waste compared to traditional systems.[20]

Dietitians are recognised as professionals with the qualifications and skills to provide expert nutrition and dietary advice and interact with the food system more broadly to bring about change.[21] Environmental sustainability issues apply to all aspects of nutrition and dietetics practice from the individual through to the systems level.[21] Dietitians in the hospital setting regularly measure and explore food waste and implement a plan to address it. However, this occurs through the lens of individual patient management where food waste is a surrogate measure for nutrition intake. There is an opportunity for dietitians to work upstream to find solutions to food waste at the system or organisation level. Carino et al.[22] present a case study of a sustainable food systems dietitian in a hospital, where activities included food waste audits, food waste education sessions, and food waste awareness campaigns.

Further research is required to build on the results from this pilot study. The microbiological safety analyses should be repeated with a larger sample size of food items to be adequately powered to detect a statistical difference. Specifically, the number of samples of unserved leftover food items on trolleys and items in the kitchen storeroom were not sufficient to reach statistical significance. Our data suggests 12 food items per location may be appropriate, while a minimum of five samples is recommended by industry guidelines.[14] Advice was sought from a clinical microbiologist and the infection prevention and control team on the types of bacteria to test for, however the species analysed was not an exhaustive selection and did not include *Clostridium difficile* or any viral pathogens such as COVID-19 (which emerged after the study data collection was completed). Future research should include these. Repeating the safety analyses in other hospitals is recommended to establish if the results are reproducible when there are different policies and practices around infection prevention and control. A limitation of the waste collection strategy and the evaluation of its outcomes was that dinner service was excluded for logistical reasons. Separately weighing organic (food) and non-organic (packaging) waste to calculate greenhouse gas emissions of food items may provide a more accurate reflection on the emissions avoided, as packaging waste is still generated even if food products are consumed.

To achieve food waste reduction targets by 2030, hospitals must address the volume of waste they create and how they dispose of it. Collecting unopened packets of non-perishable food that have entered the patient zone to reuse within the hospital or donate to food relief organisations is an innovative solution. The current pilot study is the first to provide empirical preliminary evidence addressing infection control risks and feasibility

concerns, and we invite further research repeating safety analyses and translating a waste collection process into practice.

AUTHOR CONTRIBUTIONS

PAL analysed the data and prepared the manuscript. LAB critically reviewed the manuscript. AH conceived the study, collected data and critically reviewed the manuscript. JC conceived the study, collected data, critically reviewed the manuscript and led the research.

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CONFLICT OF INTEREST STATEMENT

Antony Howard and Jorja Collins are employees at the healthcare service where this research was undertaken. Jorja Collins has received financial support for travel to conduct and present research relating to environmental sustainability in hospital foodservices.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL RESEARCH

Quantifying waste and its costs in hospital foodservices

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Abstract

Aim: To measure the amount of different types of food and food packaging waste produced in hospital foodservice and estimate the cost associated with its disposal to landfill.

Method: A foodservice waste audit was conducted over 14 days in the kitchens of three hospitals (15 wards, 10 wards, 1 ward) operating a cook-chill or cook-freeze model with food made offsite. The amount (kg) of plate waste, trayline waste and packaging waste (rubbish and recycling) was weighed using scales and the number of spare trays and the food items on them were counted. Waste haulage fees ($AU0.18/kg) and price per spare tray item were used to calculate costs associated with waste.

Results: On average there was 502.1 kg/day of foodservice waste, consisting of 227.7 kg (45%) plate waste, 99.6 kg (20%) trayline waste and 174.8 kg (35%) packaging waste. The median number of spare trays was 171/day, with 224 items/day on them worth $214.10/day. Only 12% (20.4 kg/day) of packaging waste was recycled and the remaining 88% (154.4 kg/day) was sent to landfill along with food waste at two hospitals. Overall 347.3 kg/day was sent to landfill costing $62.51/day on waste haulage fees, amounting to 126.8 tonnes and $22 816.15 annually.

Conclusion: A substantial amount of waste is generated in hospital foodservices, and sending waste to landfill is usual practice. Australia has a target to halve food waste by 2030 and to achieve this hospital foodservices must invest in systems proven to reduce waste, solutions recommended by policy advisors (e.g., waste auditing) and waste diversion strategies.

KEYWORDS

food, food services, health economics, health services, sustainability, waste

1 | INTRODUCTION

The 2021 National Food Waste Baseline reports that Australia produced 7.6 million tonnes of food waste per year at a cost to the Australian economy of AU$36.6 billion.[1] Approximately 250 000 tonnes of food waste is generated annually in institutional foodservices like hospitals and 99% of food waste from institutions is sent to landfill which is higher than any other stage and sector.[1] Promisingly, a comprehensive feasibility study has identified it is possible to achieve the target of halving food waste by 2030 set out in Australia's National Food Waste strategy,

but it will require 'unprecedented action' from households, businesses, commercial and institutional foodservices and governments.[1] Institutions like hospitals have power to create sizeable, meaningful change due to the scale and repetition of their foodservice operations. Furthermore, they can set a standard to inspire and influence other organisations, and educate and nudge behaviour of staff and patients to create a flow on effect in their households.

In the healthcare setting, providing food to patients while avoiding food waste is a delicate balancing act. Malnutrition affects a third of hospital patients in Australia and the role of dietetic and nutrition care is to provide adequate food to patients to meet their nutritional needs, which are often increased because of illness.[2] Yet at the same time, 56% of patients report not feeling hungry as the reason for not consuming their meals.[2] Other patient-related factors that may reduce intake include cognitive and physical impairment, changes in taste, smell and swallow or pain.[3] At an organisational level, the diverse food preferences and characteristics of patients make it difficult for a single menu to cater to their needs, and poor food quality and presentation may be other factors contributing to plate waste.[3] Foodservice systems for producing and plating meals and taking orders at scale are not responsive enough to accurately predict the amount and types of food required, leading to surplus waste.[4]

Historically, research on food waste in healthcare has focused on plate waste (food served but not eaten by patients) as an indicator of nutritional status and satisfaction among patients.[3] More recently, attention has turned to the environmental, economic, and societal implications of food waste in healthcare in recognition and response to food system and planetary health challenges. A recent systematic review reported that food waste generally makes up 20%–30% of total hospital waste, ranging from 17% to 74%.[5] Thiel et al. reported that the annual carbon emissions associated with food and packaging waste from foodservices in one New York hospital (294 466 kg CO_2e per year) was equivalent to the emissions produced by 64 standard US passenger cars.[6] Another recent study has compared the emissions associated with food waste produced in healthcare with other foodservice sectors, finding greenhouse gas emissions, land use, and eco-points were highest for hospitality followed by healthcare and then business.[7]

Measuring waste is important to provide a baseline to understand the current situation, model the impact of different waste reduction strategies, and monitor progress. Attempts to measure food waste have been the focus of recent government policy directives at the national, state and local levels in Australia. These have largely provided a broad picture of waste (e.g., National Food Waste Baseline[1]) or focused on household food waste (e.g., Food Waste Australian Household Attitudes and Behaviours National Benchmarking Study[8]). Two systematic reviews that have captured aggregate food waste audits occurring in healthcare show none have been conducted in Australia to date.[5,9] Therefore, the aim was to measure the amount of different types of food and food packaging waste produced in hospital foodservice and estimate the cost associated with its disposal to landfill.

2 | METHODS

An aggregate audit of the amount of food and food packaging waste generated in or returning to the kitchen of patient foodservices at three hospitals was conducted over 14 weekdays in 2018. An estimate of the daily and annual cost of sending waste to landfill was calculated. Ethical approval for this quality assurance activity was obtained from the Human Research and Ethics Committee at Eastern Health (QA84-2018). Permission and support were sought from support services and dietetics, informed consent was not required.

The waste audit was conducted concurrently at three hospitals within a publicly funded healthcare organisation in Victoria, Australia. The hospitals differed in regard to their size, location, services provided and foodservice systems (Table 1). All hospitals served food made offsite at a central production kitchen and pre-packaged single-serve items (e.g., yoghurt, cereal, biscuits), with minimal items prepared onsite. The majority of their organic and non-organic food waste at all three hospitals were disposed of to landfill, with waste management handled by a contracted waste hauling company.

Data were collected Monday to Friday for seven breakfasts, 14 lunches and seven dinners in the kitchen at each hospital. Data were collected by student researchers working in small teams for a morning shift (breakfast–lunch) or an afternoon shift (lunch–dinner), leading to double the amount of data points for lunch than other meals. It was not possible to capture breakfast trayline at hospital A as breakfast was cold plated the evening prior and this was outside of researchers' hours. Student researchers received a comprehensive 1 day training session on the research objectives, audit protocol and orientation to the foodservice processes, hospital kitchen and staff members. The foodservice and support services staff were aware the audit was occurring and were instructed to keep waste aside and communicate with the student researchers to minimise the chance of missed data.

Food and food packaging waste from hospital patient foodservice was included in the audit. This included trayline waste (food left over once plating has finished or prepackaged items reaching their expiry date), plate waste (food served to patients but not consumed) and food packaging waste (e.g., plastic and paper containers from

TABLE 1 Characteristics of three hospitals participating in a foodservice waste audit

	Hospital A	Hospital B	Hospital C
Size	15 wards	10 wards	1 ward
Location	Metropolitan	Metropolitan	Regional
Health services provided	Emergency care, general and specialist medicine, general and specialist surgery, intensive care, maternity care, mental health inpatient services for children, adolescents and adults	Emergency care, general and specialist medicine, general and specialist surgery, intensive care, mental health inpatient services for adults	General medicine, palliative care, Geriatric Evaluation and Management
Food production	Hot meals, soup, desserts, hot breakfast items produced offsite at the CPK, chilled (combination of short and long-term chilled) and delivered in bulk. Sandwiches and salads made fresh onsite. Other foods are single-serve packaged items (e.g., milk, yoghurt, cereal, biscuits).	Hot meals, soup, desserts, sandwiches produced offsite at the CPK, chilled (combination of short and long-term chilled) and delivered in bulk. Hot breakfast items and salads made fresh onsite. Other foods are single-serve packaged items (e.g., milk, yoghurt, cereal, biscuits).	Hot meals, soup and sandwiches produced offsite at the CPK, meals plated into individual 'smartpaks', frozen and delivered. Hot breakfast items and salads made fresh onsite. Other foods are single-serve packaged items (e.g., desserts, milk, yoghurt, cereal, biscuits).
Food plating and distribution	Meals are plated cold and other items are added to the tray 4–5 h before lunch and dinner and the night before breakfast. Meals are rethermed in a trolley. Trays are taken to the ward in a trolley for distribution.	Meals are heated in bulk and plated hot and other items are added to the tray immediately before the meal service. Trays are taken to the ward in a trolley for distribution.	Individual meals are heated and plated hot and other items are added to the tray immediately before the meal service. Trays are taken to the ward in a trolley for distribution
Meal ordering system	Paper or electronic menu (maternity ward), order 1 day ahead for both systems	Paper menu, order 1 day ahead	Paper menu, order 1 day ahead
Foodservice operation	Contracted catering company	In house catering staff	Contracted catering company
Waste management	Organic waste sent to landfill. Food packaging from patient trays not recycled. Recycle large packaging (e.g., tins, carboard boxes).	Organic waste disposed to waste water via two insinkerators. Food packaging from patient trays recycled at breakfast only. Recycle large packaging (e.g., tins, carboard boxes).	Organic waste sent to landfill. Food packaging from patient trays recycled at all meals. Recycle large packaging (e.g., tins, carboard boxes).

Abbreviations: CPK, central production kitchen.

patient trays, single-use plastic servingware and plastic, paper, cardboard and tins from the kitchen). Preparation waste (e.g., crusts and vegetable peel) was collected but data could not be collected consistently across sites due to types and timing of food production so these data were excluded from analyses.

Waste was collected in bags in rubbish bins, containers or buckets and weighed using 40 cm × 60 cm calibrated general purpose floor scales (Wedderburn®, New South Wales) and reported to the nearest 0.1 kg. Trayline waste was collected at the end of plating for each meal and expired items were set aside by staff to be weighed when fridges were checked each day. Packaging waste from around the kitchen was collected at four set time points in the day (7:00 a.m.–10.00 a.m., 10.00 a.m.–1.00 p.m., 1.00 p.m.–4.00 p.m., 4.00 p.m.–7.00 p.m.), with waste destined to be recycled or sent to landfill collected separately. When patient trays were returned to the kitchen on trolleys after each meal, the waste was sorted and separated to capture packaging waste and organic plate waste. If there was food remaining in a package (e.g., unopened or half-eaten fruit puree in a container), the food was removed to be counted as plate waste and the empty package was weighed. Liquids (e.g., milk, soup, juice, tea, coffee) were discarded and not captured as spills presented a health and safety risk.

TABLE 2 The quantity of different types of waste generated in three hospitals participating in a foodservice waste audit

		Hospital A	Hospital B	Hospital C	All hospitals
Plate waste, kg/day (mean ± SD)	Breakfast	24.5 ± 6.5	10.2 ± 1.1	0.5 ± 0.2	35.2
	Lunch	56.7 ± 8.3	37.3 ± 3.9	1.3 ± 0.8	95.3
	Dinner	59.6 ± 5.1	36.0 ± 3.3	1.6 ± 0.4	97.2
	Daily total	140.8	83.5	3.4	227.7
Trayline waste, kg/day (mean ± SD)	Breakfast	–	7.1 ± 2.6	0.2 ± 0.4	7.3
	Lunch	14.3 ± 3.1	20.4 ± 5.2	0.0 ± 0.0	34.7
	Dinner	24.3 ± 11.0	21.4 ± 5.9	0.0 ± 0.0	45.7
	Expired	8.8 ± 6.6	2.0 ± 2.1	1.1 ± 1.4	11.9
	Daily total	47.4	50.9	1.3	99.6
Packaging waste, kg/day (mean)	Rubbish	122.7	28.6	3.1	154.4
	Recycling	9.1	10.5	0.8	20.4
	Daily total	131.8	39.1	3.9	174.8
Overall waste, kg/day (mean)	All waste, daily total	320.0	173.5	8.6	502.1
	Organic waste, daily total	188.2	134.4	4.7	327.3
	Non-organic waste, daily total	131.8	39.1	3.9	174.8
	Waste sent to landfill, daily total	310.9	28.6	7.8	347.3
	Waste sent for recycling, daily total	9.1	10.5	0.8	20.4

Note: All waste = plate waste + trayline waste + packaging waste; organic waste = plate waste + trayline waste; non-organic waste = packaging waste; waste sent to landfill = plate waste + trayline waste + rubbish at hospitals A and C or rubbish only at hospital B as plate waste + trayline waste were disposed of via insinkerator; waste sent for recycling = recycling.

In addition, spare trays that were taken to the ward but not used and the specific items on the spare trays were counted as they returned to the kitchen on the trolleys after meal service. As data were collected in the kitchen, food and food packaging waste disposed of on the wards or in other areas of the hospital (e.g., hospital cafeteria) was not included. This included waste from mid meals which were pre-packaged food items distributed via a trolley service.

To estimate the cost of sending food waste to landfill, a waste haulage fee of $0.18/kg (AUD) was calculated based on the bin fee for a 7000 kg dumpster plus the charge per kg using data supplied by support services at the time of data collection. It was not possible to determine the value of the food and packaging waste itself as waste was collected at the aggregate level and the composition was not known. However, the cost of spare tray items was determined using the purchase price per single food item (AUD) based on purchase order data supplied by support services staff.

Hard copy forms created by the research team were used to record the amount of waste generated for each data collection period, and it was entered into Microsoft Excel (Microsoft Corporation, Redmond, WA) the next day. Descriptive analyses were completed in Microsoft Excel. Data were reported for each hospital site and totalled to give the overall amount of waste across the three hospitals. Data for spare trays and spare tray items was not normally distributed so the median number and inter-quartile range were reported, while the mean and standard deviation were generated for the weight (kg) of plate waste, trayline waste and packaging waste. The mean or median amount of waste per meal time was calculated from seven breakfast, 14 lunch and seven dinner periods, and daily total was calculated as the sum of the mean or median from each meal period. The cost of sending food and packaging waste to landfill was calculated by multiplying the amount (kg) of waste sent to landfill by $0.18/kg.

3 | RESULTS

Table 2 reports the amount of food and food packaging waste generated at each meal service and each day in three hospitals. Differences in the amount of waste were observed across meal times, with the least amount of waste produced at breakfast. Similarly, there were differences in the amount of waste occurring at each hospital, which is likely reflective of the size of each hospital, acuity and complexity of care, and their foodservice models (Table 1). Across all hospitals, 327.3 kg/day of organic

TABLE 3 Costs associated with sending foodservice waste (organic waste and rubbish) to landfill

	Hospital A (per day)	Hospital B (per day)	Hospital C (per day)	All hospitals (per day)	All hospitals (per year)
Amount of waste sent to landfill, kg	310.9	28.6	7.8	347.3	126 764
Cost of sending waste to landfill, AU$	55.96	5.15	1.40	62.51	22816.15

Note: Costs calculated by multiplying amount of waste by waste haulage fee of $0.18/kg.

TABLE 4 The number of spare trays plated, sent to the ward but not consumed by patients in three hospitals participating in a foodservice waste audit

		Hospital A	Hospital B	Hospital C	All hospitals
Spare trays, number/day (median (IQR))	Breakfast	23 (18–30)	6 (6–7)	0 (0–0)	29
	Lunch	50 (49–54)	33 (28–35)	0 (0–0)	83
	Dinner	29 (28–33)	30 (25–32)	0 (0–0)	59
	Daily total	102	69	0	171

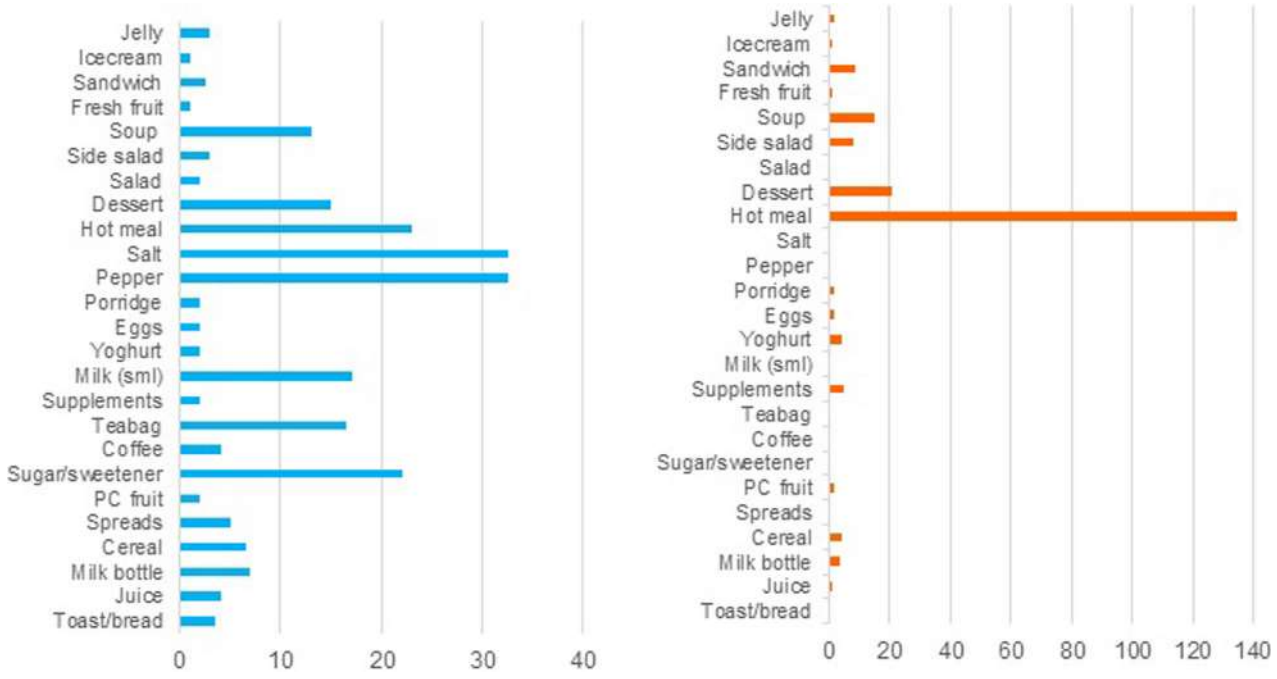

FIGURE 1 The (a) number per day and (b) cost per day (AU$) of food items occurring on spare trays across three hospital sites

food waste was generated consisting of 70% plate and 30% trayline waste. As a proportion of the total waste (502.1 kg/day), 45% (227.7 kg) was plate waste and 20% (99.6 kg/day) was trayline waste. Preparation waste data were excluded, but is another source of organic food waste in hospital foodservice. As the hospitals only prepared a few items onsite, the amount of preparation waste anticipated to be generated is minimal in comparison to preparation waste that would occur at the central production kitchen supplying meals to the hospitals. There was 174.8 kg/day of food packaging waste across all hospitals, making up 35% of total waste. Of this, 12% was put in the recycling bin while 88% was put in the rubbish bin although it included potentially recyclable packaging waste that was not sorted and separated.

Across all hospitals, 347.3 kg (69%) of the total 502.1 kg of waste per day was sent to landfill which cost $62.51/day. This included packaging waste put in the rubbish bin at all hospitals and organic waste (plate waste and trayline waste) at hospital A and C, but excluded organic waste at Hospital B which was

discarded via the insinkerator. Assuming that waste patterns were consistent throughout the year, these findings equate to 126 764/kg (126.8 tonnes) per year of combined food and food packaging waste disposed into landfill and $22 816 per year spent on waste haulage fees (Table 3).

Table 4 and Figure 1 report the number of spare trays and the number of spare tray items and their cost. Overall, the median number of spare trays was 171/day, with the highest number occurring at lunch (Table 4). Spare meals were rarely observed at hospital C ($n = 5$ across the 14-day data collection period), resulting in a median number of 0. Across the three hospitals the median number of items on spare trays was 224/day, which were valued at $214.10/day, equating to $78146.50 per year. The items most frequently on spare trays were pepper sachets (median 33/day, $0.29/day) and salt sachets (median 33/day, $0.17/day) followed by hot meals which had the highest cost (median 23/day, $134.78/day; Figure 1).

4 | DISCUSSION

This food and food packaging waste audit provides a snapshot of the amount of plate waste, trayline waste, rubbish, recycling and spare trays generated in patient foodservice, and the costs associated with sending waste to landfill across three public hospitals in Australia. Hospitals with different foodservice systems to the cook-chill or cook-freeze model with offsite production observed in the current audit may introduce other types of waste, altering the waste profile of foodservice. For example, food and packaging waste was also generated from unpacking deliveries and preparation in a New York hospital with a cook-fresh kitchen producing meals for patients, catering and staff cafes.[6] The current audit revealed approximately 500 kg of waste was generated each day, with plate waste making up the largest component (45%, 227.7 kg/day). Other literature report high rates of plate waste, with approximately 30% of food served not eaten.[4] Another key finding was that the majority of food and packaging waste was sent to landfill costing the organisation ~$22 000 per year on waste haulage fees. Within this healthcare network there were no systems in place for organic waste management (e.g., compost, anaerobic digestion, donation, animal feed) and minimal separation and sorting of waste streams to recycle packaging waste.

The Food Waste Hierarchy[1] can be used to guide waste management practices. Avoiding food waste at its source is the best solution. The current audit identified a high number of spare trays generated each day (102/day 15 ward hospital, 69/day 10 ward hospital) due to completing menus 1 day ahead, and the patient discharges and dietary changes that occur in this time which are not responded to by cancelling or updating orders. Spare trays were infrequent at Hospital C (1 ward) as the smaller size simplified communication of changes between the ward and kitchen. The paper menus used across all three hospitals drive the time lag, as manual tasks of printing, distributing and collecting menus and checking and tallying orders by hand need to be scheduled. These time consuming manual tasks can be eliminated by embracing digital technology such as electronic bedside meal ordering systems (e.g., using tablets handled by staff or patient entertainment systems) and an Electronic Medical Record, and an electronic menu management system connected by a live interface, and must be a priority for healthcare. There is consistent evidence ($n = 5$ studies) that electronic bedside meal ordering systems have favourable outcomes on food intake, plate waste and satisfaction compared to paper menus.[10] However, data on their impact on spare trays, trayline waste and tray accuracy are lacking and is an area for future research.

Similarly, high levels of trayline waste seen in the current audit (47.4 kg/day 15 ward hospital, 50.9 kg/day 10 ward hospital) may be associated with the food production model and a lack of forecasting. Hospitals A and B use cook-chill food made at an offsite central production kitchen that arrives the day before the meal service. Consequently, at Hospitals A and B in the current study, food is produced before the amount needed is even known. Data from previous menu cycles can forecast requirements, but this is a best estimate only. 'On demand' foodservice systems such as room service prepare or heat meals only once they have been ordered by the patient, eliminating surplus meals. In a cook-fresh system, raw ingredients are usually prepped ahead of time, but monitoring par levels and smart menu design where one ingredient is used in multiple ways may prevent leftovers. Neaves et al. report plate waste decreased from 40% to 15%, trayline waste decreased from 15% to 5.6% and satisfaction, meal quality and food costs improved after transitioning from a cook-freeze, hot plating model with set meal times to room service.[11] Single-serve chilled or frozen ready meals such as 'Steamplicity'[12] or 'smartpak'/'toruspak®'[13] used in Hospital C offer another solution to 'on demand' foodservice without requiring kitchen facilities, equipment and staff necessary for a cook-fresh operation. However, while these may reduce trayline waste, they introduce packaging waste and their items and size cannot be customised to meet patient preferences. Therefore, recycling pathways and monitoring of plate waste are essential to ensure one waste problem is not replaced with another.

In addition to avoiding food waste, diverting it from landfill by using it to feed animals, reusing it,

repurposing it into new products or donating it to food rescue and food relief organisations are approaches that will help meet the 50% food waste reduction target.[1] However, sending food waste to landfill is currently standard practice in institutional foodservices, including the hospitals in the current audit.[1] One hospital in this study used a food waste disposer (insinkerator), however, a recent review was unable to draw conclusions about the benefits of solid waste entering waste water systems.[14] Positive and negative implications should be considered by hospitals using these devices.[14] Exemplar hospitals using more preferred strategies do exist locally and internationally. Cook et al. searched grey and published literature and found 85 examples of hospitals using waste diversion strategies, including donation ($n = 21$ internationally, $n = 1$ in Australia) and feeding animals ($n = 2$ internationally, $n = 1$ in Australia) which are most preferred.[15–17] These serve as case studies of 'best practice' for other hospitals to learn from. Cook et al. found the most common enabler of change in these hospitals was dedicated leadership.[15] While additional tasks associated with waste diversion (e.g., sorting, separating and transporting waste, maintaining equipment, coordinating vendors) and the associated time to complete these tasks were barriers.[15] As resource constraints are common in healthcare, costing the savings (e.g., waste haulage fees), expenses (e.g., increased labour) and return on investment will help to understand the financial implications of alternate waste management approaches. Qualitative interviews with patients and staff report they have concerns about infection control which makes them question the appropriateness of reusing hospital food.[3,18] Trayline waste (cooked surplus food), items approaching expiry and spare tray items (particularly packaged non-perishable items) are most suitable for donation as they have not entered the patient zone, and the current audit indicates they are plentiful.

Solutions to packaging waste may depend on the type of material, size of the item, and cleanliness. Recycling streams for large, clean paper, carboard, hard plastic and glass are established, but soft plastics and single-use food packages with food residue are more difficult to manage. Shifting from single-serve portion controlled food items to decanted items will reduce packaging waste, but they are often preferred for being a consistent product, requiring less labour and having a longer shelf life.

Waste tracking in food businesses and waste audits in hospitality and institutions are two of 25 recommended solutions to food waste set out by the Victorian Government, with the potential to reduce food waste by 25% and 9%, respectively.[19] Similarly, data analytics and waste audits are the strategy predicted to have the second greatest impact on waste reduction at a national level.[1] Foodservice staff in university dining facilities have described that measuring food waste improved awareness, conscientiousness, accountability and prompted corrective action.[20] Meanwhile, challenges were logistical concerns (space, equipment), increased time, communicating with and training staff.[20] COVID-19 has introduced additional barriers including difficulty prioritising quality improvement tasks over day-to-day activities and insufficient manpower.[21] An evidence-based consensus tool for conducting waste audits in hospital foodservice has recently been developed by Australian researchers.[9] It provides guidance on the considerations and steps to follow when planning, conducting and analysing a waste audit. Future food and food packaging waste audits would benefit from using this tool to design a fit-for-purpose protocol.

Dietitians are ideally positioned to influence environmental change across the food system, including specifically in hospital food services.[22] Future new practice areas for dietitians include roles as 'Sustainable food systems analysts for institutions' and 'Environmental impact consultants of food production and consumption using life cycle and economic assessments'.[23] Such roles are already being developed in hospitals highlighting how the role of a dietitian can provide linkages between senior management, environmental teams and foodservice staff.[24]

In the current study differences in the characteristics of each hospital, in particular differences in hospital size, preclude direct comparison of waste between hospitals. Future research expressing waste as a function of the number of meals produced and per patient bed day would be beneficial. Some data were not able to be included in the results due to missing data (e.g., preparation waste not able to be reported, breakfast trayline waste at site A) or occupational health and safety risks (e.g., omission of liquid food waste) and collecting food waste from mid meals was out of the scope of the study. It is likely that capturing these additional data points would have increased the amount of waste identified further. Daily waste values were generated by combining waste from breakfast, lunch and dinner services on different days. While this would have been overcome with 1-day meal audit, day-to-day variability is not captured by this approach.

This study quantifying food and food packaging waste in hospital foodservices reinforces the substantial amount of food wasted and sent to landfill in Australia, and some of the associated economic consequences. Policy advisors have identified and modelled solutions to show that national targets for halving food waste by 2030 are possible, though require collaboration, commitment and action.[1,19] In healthcare, improvements in

foodservice systems including electronic bedside meal ordering systems and 'on demand' models have been shown to reduce food waste, and reuse, donation and feeding animals are recommended to divert waste from landfill. Measuring food waste is a key strategy to reducing food waste. This current audit describing the quantity of waste generated in food services and some of the associated costs may inspire and instruct others to audit waste in their foodservices.

AUTHOR CONTRIBUTIONS

JC and JP conceived the study, provided training to data collectors and supervised data collection. JC liaised with foodservice staff, analysed the data and prepared the manuscript. JP critically revised the manuscript. Eastern Health dietitians Mina Berlandier and Brooke Pinsent are acknowledged for supervising the student researchers. Monash University Master of Dietetics student researchers Emily Clarke, Chloe Swiney, Ann Cheung, Hollea Goninon, Li Ming Lim, Ho Sum Yeung, Jamie Tze-Yan Yeung, Jessica Xi and Alice Mika are acknowledged for collecting the data.

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CONFLICT OF INTEREST

Jorja Collins is an employee at the healthcare service where this research was undertaken. She has received financial support for travel to conduct and present research relating to environmental sustainability in hospital foodservices. Judi Porter is Editor-in-Chief of Nutrition & Dietetics. She was excluded from the peer-review process and all decision making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ORIGINAL RESEARCH

'It's a constant changing environment, and we're just playing catch up': Hospital food services, food waste, and COVID-19

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Abstract

Aims: Hospital food service operations have been affected by the COVID-19 pandemic, particularly resulting in increased waste. The aim of this research was to explore the impact of the COVID-19 pandemic on hospital food services, particularly on food waste and the completion of food waste audits.

Methods: A qualitative interview research design was used. Semi-structured interviews were completed and recorded via Zoom, focusing on the barriers and enablers towards the completion of hospital food waste audits. Twenty-one participants were interviewed from 12 hospitals. No questions were related to the COVID-19 pandemic and its impact on hospital food services, however this issue frequently emerged during interviews. Data were coded following inductive thematic analysis.

Results: Five themes were generated from the interviews related to COVID-19 and hospital food services; impacts on practice, labour, change, technology and post-pandemic expectations. Participants reported COVID-19 negatively affected food service operations. Changes included increased food waste, contact restrictions, and labour shortages. Nonetheless, hospitals embraced the challenge and created new positions, trialled different food waste data collection methods, and utilised technology to support food service operations around COVID-19 restrictions.

Conclusions: Despite the impact COVID-19 had on hospital food services, including their ability to audit food waste and increased food waste generation, the response from food services has demonstrated their adaptability to change. Sustainable healthcare, including the aggregate measuring and reduction of food waste in hospital food services, is an essential transition post-pandemic, and may be facilitated through the operational changes forced by COVID-19.

KEYWORDS

COVID-19, food, food services, hospitals, sustainability, waste

1 | INTRODUCTION

The COVID-19 pandemic continues to have an unprecedented impact on the world's systems including transport,[1] economics, food, and healthcare.[2] At 16 March 2022, 460 280 168 cases and 6 050 018 deaths[3] have been reported globally. Many of these individuals and their families would have interacted with the healthcare system, emphasising the stress placed on healthcare during this time of crisis. The healthcare system relies on secure supply chains,[4] a large workforce, and funding to function,[5] however these areas have been severely reduced or altered during the pandemic, contributing to increased pressures on healthcare delivery. An area of healthcare which has been inundated with pressure as a consequence of the pandemic is waste management.[6]

Healthcare waste has been exacerbated due to the infection prevention measures required to reduce the spread of COVID-19.[6] Pandemic associated waste includes face masks, testing kits, personal protective equipment (gowns, gloves), disinfectant items, plastic packaging[7] and other provisions which come into contact with isolated patients such as food. After the initial outbreak in Hubei Province China, medical waste increased by 370%.[8] As a result, healthcare services have had to produce innovative storage, handling, and management strategies to adapt to the unparalleled output of infectious waste.[9] Unfortunately, this waste is disposed of via high temperature incineration or sanitary landfill after treatment,[9] reversing progress in reducing and managing waste in line with the UN Sustainable Development Goals of 'responsible production and consumption'.[10] Hospital food services is one department whose operations have been impacted by the COVID-19 pandemic and its resulting increase in waste.

Historically, hospitals experience high levels of food waste, with food waste making up 50% of the total waste by volume in some hospitals.[11] Reasons leading to this volume of waste include; patient appetite, food quality and quantity, and food service model limitations such as ordering meals 24-h prior to consumption.[12] This large amount of food waste is concerning as it contributes to the already significant volume of food waste disposed of to landfill, which results in the generation of significant greenhouse gas emissions (3% of Australia's annual emissions).[13] During heightened times of COVID-19 outbreaks, rising patient numbers have created challenges for hospital food services to guarantee food supply and usual menu options, to forecast expected meal numbers, and measure waste levels accurately. Furthermore, anecdotal reports suggest regular food service practice has been significantly impacted by reductions in staff, cessation of quality improvement projects, dissolved production and distribution systems, and increases in food waste. In contrast, the acceleration and modernisation of other areas of hospital nutrition practice have occurred, including care delivery via telehealth,[14] the installation of electronic menu systems and intake assessment tools,[15] as well as the rapid development of nutrition guidelines for management of COVID-19 patients.[16] Despite these solutions, the pandemic has correspondingly highlighted the requirement for reliable food procurement systems, and exposed the continued need for sustainable waste management within hospital food services.[17]

Healthcare services are obliged to deliver food and nutrition care to patients to support their recovery and hospital food services are at the core of this necessity. However, the importance of this department's contribution to healthcare may be overlooked. While there has been a focus towards understanding the increased demand on overall healthcare waste management due to COVID-19,[6,8,9] there has been limited documentation discussing its impact within hospital food services. Therefore, the aim of this research was to explore the impact of the COVID-19 pandemic on hospital food services, particularly on food waste and the completion of food waste audits.

2 | METHODS

A qualitative research design was used, from the philosophical positioning of interpretivism as the researchers were exploring participant's subjective perspectives around the research matter.[18] Interpretivism assumes a relativist ontology whereby there are multiple realities which are constructed by the meanings and interpretations individuals give their previous experiences.[18,19] Conducting this research from an interpretivist paradigm was appropriate as interpretivism considers knowledge to be socially or co-constructed from the interactions between the researcher and the participants,[18,20] and is why interviews were selected as the data collection method.[19] This approach aligns with interpretivism because the research questions focus on asking participants how and why something occurs, which facilitates the researcher to build a new understanding on the investigated topic in addition to their previous knowledge, as an outcome from valuable discussions with participants.[19]

This research is a secondary analysis of a dataset originally generated to explore food waste audits in hospital food service. The original research questions were to identify the perspectives of staff involved in the operation of hospital food services on (1) the barriers and enablers to conducting routine food and food-related waste audits, and (2) how an evidenced based consensus pathway food

waste audit tool is perceived to translate into practice within hospital food services. Conducting semi-structured interviews from an interpretivist view allows researchers to accept the existence of multiple realities, focus the conversation on complete experiences, prompt to explore unexpected outcomes and seek a deep understanding of the topic.[21] As it unfolded, this research about food and food-related waste audits provided a launchpad to explore COVID-19 and its impact on food waste and food waste auditing. This study was approved by the Monash University Research Ethics Committee (Project ID: 28908) and was developed and reported using the Consolidated criteria for reporting qualitative research (COREQ) guidelines.[22]

The setting for this research was hospital food service. Through the allocation of a random number[23] to a list of all the public hospitals in Victoria,[24] 10 hospitals were contacted fortnightly. This technique of maximum variation sampling was intended to provide a widespread and varied sample of hospitals with a diverse range of characteristics (e.g. size, location, COVID-19 site), food service models and organisational structures and values which were anticipated to influence the phenomenon of waste management under study.[25] From these hospitals, individuals who worked within, or governed, hospital food service operations and had knowledge relating to hospital food service operations were purposefully sampled[26] (e.g. food service workers, food service managers, waste management staff, financial officers and sustainability officers). Their real world experiences 'on the ground' during COVID-19 made them a valuable information-rich data source. Snowball sampling was also used whereby participants were asked to reach out to any colleagues within their health service who they thought may be suitable participants and request that they contact the research team via email.[27] Justification for the appropriate sample size was guided by evidentiary adequacy,[28] meaning the researchers needed to collect an adequate amount and variety of evidence, and the evidence must be interpretive, disconfirming and discrepant. These conditions were considered satisfactory in the collected dataset by the research team.

Hospital administrators were contacted by phone to request contact details of operations managers. Operations managers were contacted via email and asked to identify and provide contact details of key informants who met the eligibility criteria. Operations managers were contacted due to their position in the hierarchy of hospital food services, their assumed understanding of research value, email accessibility, and connection to the desired participants. When recommended participants contacted the research team, more details were shared by the primary researcher via email including an explanatory statement, consent form, organisational permission letter, and further information on the interview topic. Interviews were scheduled once participants returned both a signed consent form and organisational permission letter.

Prior to data collection, the interview guide was piloted with food service dietitians and other researchers, with refinements made as needed. The interview was designed for the primary study and consisted of semi-structured questions related to the barriers and enablers towards the completion of hospital food waste audits, and the use of a consensus tool to support food waste audits.[29] The interview guide included six key questions which centred on understanding participant perspectives on the following topics: participant role in the food service, barriers to audit completion, enablers to audit completion, strategies to incorporate audits in practice, thoughts on the consensus tool, and how the consensus tool could support their practice. Prompting was used as needed to enable participants to elaborate in greater depth for four of the questions, for example '*What else may support this process further?*'. There were no specific questions relating to the COVID-19 pandemic and its impact on hospital food services, however this issue frequently emerged.

Interviews were conducted with the video communications program Zoom (Version 5.5, Zoom video communications, California) during Victoria's second wave of the COVID-19 Delta variant and the 6th lockdown period[30] between August and November 2021. They were facilitated by the primary researcher who was a PhD candidate and Accredited Practising Dietitian with prior experience working in hospital food service as a Dietitian Assistant and who has conducted research in hospital food waste auditing. Interviews were audio recorded. At the beginning of the interview the primary researcher introduced himself, explained his relationship to the research, and collected demographic data for descriptive purposes. Participant data collection included their age, gender, position, years in their current position and previous food service experience; hospital data collected were size and food service model. Interviews were not repeated and transcripts were not returned to participants for verification (member checking) to minimise research burden at a busy time. However, additional email exchange to clarify or share information occurred for up to 2 weeks post interviews. Field notes were not taken so the interviewer could dedicate their focus to the conversation to facilitate rich information sharing, however to facilitate reflexivity the interviewer discussed the data and debriefed fortnightly with two members of the research team (senior researchers with experience in qualitative methods and the topic area).[26]

TABLE 1 Participant ($n = 20$ participants) and hospital ($n = 11$ hospital sites) demographics

Demographics	Response	*n* (%)
Gender	Male	8 (40%)
	Female	12 (60%)
Age	20–30	3 (15%)
	31–40	6 (30%)
	41–50	4 (20%)
	51–60	5 (25%)
	61–70	2 (10%)
Position	Food service dietitian	4 (20%)
	Hotel service coordinator	2 (10%)
	Support services manager	1 (5%)
	Food service project officer	1 (5%)
	Special projects coordinator	1 (5%)
	Food safety supervisor	1 (5%)
	Food service manager	1 (5%)
	Store person	1 (5%)
	Head chef and food service coordinator	1 (5%)
	Group management support services	1 (5%)
	Sustainable food systems dietitian	1 (5%)
	Catering team leader and dietitian	1 (5%)
	Catering manager	1 (5%)
	Dietetics department manager	1 (5%)
	Chief sustainability officer	1 (5%)
	Facilities services manager	1 (5%)
Length of time in current work role (years)	<1	6 (30%)
	<5	9 (45%)
	5+ to 10 years	2 (10%)
	10+	3 (15%)
Hospital size (bed numbers)	0–100	3 (15%)
	101–300	4 (20%)
	301–500	2 (10%)
	500+	2 (10%)
Food service type	Cook chill	5 (45%)
	Cook fresh	2 (18%)
	Cook chill and cook freeze	1 (10%)
	Cook freeze	1 (10%)
	Cook fresh and cook freeze	1 (10%)
	Cook chill and cook fresh	1 (10%)

Demographic information was collated and analysed using descriptive statistics in Microsoft Excel version 16.0. Interviews were transcribed using artificial intelligence software, Otter.ai (Version 2.1.52, Otter.ai, California), and were checked in full to ensure accuracy, whereby the interview recording was reviewed simultaneously while errors in transcription were changed. A six-phase inductive thematic analysis was then utilised for data analysis.[31] This process included the primary researcher importing each transcript into NVivo (NVivo, QSR International, Victoria) to read and iteratively code. Concepts that represented an important idea

in relation to the research questions were identified and coded, and as new codes were identified from the data, previous transcripts were re-examined. One researcher (with extensive qualitative research experience) reviewed 10% of the coded transcripts alongside the primary researcher. Codes that shared meaning or when combined told a story were then collated into themes and shared with the research team for discussion and consensus.

3 | RESULTS

Seventy hospitals were contacted to participate in this research. The most common reasons for hospitals not accepting the invitation to be included were hospitals not sharing participant contact information, lack of response from contacted individuals, or invitations being declined as a result of priority and time pressures. A total of 21 participants (Table 1) were interviewed across 12 different hospital sites. One participant (data not included) retracted their consent to participate and their data were removed from the analysis.

Eight participants were male, the average (± standard deviation) age of all participants was 44 ± 11 years. There were 16 different position titles, however crossover was evident between the reported participant responsibilities. The mean period of employment at the current health service was 5 ± 6 years. Participants reported a plethora of previous experience in hospitality, food service and the healthcare system. Hospital size ranged from 18 to 600 beds and cook chill was the most common food service type used. The mean interview time was 64 min (range 50 to 94 min).

The following results describe the major themes identified from participant interviews relating to the COVID-19 pandemic and its impact on hospital food services, food waste levels, and their ability to complete a food waste audit. The five major themes were: impacts on practice, labour, change, technology and post-pandemic expectations.

Participants reported that infection prevention measures presented by COVID-19 led to increased prepackaged single serve food items and disposable utensils and crockery being placed on patient trays; these were not returned to the kitchen if unconsumed or unused. Because waste was disposed of in patients' rooms, this limited the ability for hospitals to visualise or measure plate waste or aggregate food and food-related waste from COVID wards and isolation rooms.

> *In our [COVID-19] suspect rooms, here in the hospital, and any isolation room, we send up disposable crockery, cutlery, everything. So, everything gets disposed of in the room in the infectious waste … So, the only thing we get back out of that room is the tray, which we then clean properly. So as far as their food waste goes, we've got no idea on that side, because it just goes into the infectious waste.* (Participant 6, Food service manager)

At some hospital sites, where pre-pandemic usual practice was to re-use, keep, or donate unused suitable food items, this was no longer permitted. One participant (Participant 18, Dietetics department manager) gave the example of unused Enteral Feeds and Oral Nutrition Supplements being sanitised and sent back to wards, but reported that these practices would never be endorsed during COVID-times.

The increase in waste was perceived as a negative outcome from the pandemic by numerous participants. Food waste, disposables and personal protective equipment used throughout the hospital, including the food service, were visibly obvious to participants and were not previously considered usual practice. A food service dietitian elaborated on how they were creating new policies and practices to attempt to feed patients and permit staff to enter their rooms. These frequent changes to hospital protocols and procedures were reported to impact the ability of staff to focus and conduct standard responsibilities.

> *It's just a constant changing environment, and we're just playing catch up, and it's very hard to think of doing anything other than just getting through the day at the moment.* (Participant 12, Food service dietitian)

Another change to the working environment at one paediatric hospital was the regular daily influx of 30 patients and their parents for COVID-19 testing. The hospital had to provide additional meals for these patients and families, meaning a consistent overproduction of food to ensure everyone received a meal, which impacted forecasting and led to increased food waste.

Staffing challenges was a major theme that emerged from the interviews. Participants reported difficulty recruiting staff during the COVID-19 pandemic, others transferred into new roles, higher than usual sick leave occurred, and fewer students were allowed onsite to contribute to quality and research projects.

> *The last 18 months has been insane as far as recruiting into health services, and I think we're not the only industry that's been affected. But it's been, I think I've conducted*

> *300 interviews over the last 12 months and I don't have any staff I've employed out of those 300 interviews ... Our sick leave is up, we're looking at 10 EFT (equivalent full time hours) out of a week, on average, that were due to sick leave. So that's as a result of COVID. Obviously, we're not going to be in COVID for the rest of our lives, I hope .... But the things that you know, when you've got that sort of sick leave coming out of any part of the organisation, it does put stress on managing processes. So sometimes things have to give*. (Participant 11, Group management support services)

A Food service manager (Participant 6) described how their hospital was a COVID-19 hot spot, which required staff members to be furloughed. Another participant (Participant 10, Food service dietitian) described how they were developing a contingency plan in case a similar scenario were to happen at their facility, which would leave no staff to cook meals for patients. Prioritising this plan was viewed as more urgent than completing a food waste audit, regardless of its importance.

When asked how to overcome the barrier of high sick leave, one participant (Participant 17, Food service dietitian) suggested that if food service staff could be more involved with individual patient stories, it may enhance their profile and their understanding of the importance of their role. The rationale behind this idea was that because food service staff are often located in the basement of the hospital or offsite, they are often disconnected from the reasoning for patient nutrition requirements. However, COVID-19 was a barrier to rationalising this strategy.

One participant (Participant 15, Catering team leader) reported losing staff members due to the vaccine mandate laws,[32] which created more work for remaining staff. Furthermore, there appeared to be a cumulative pressure on food service staff as a result of working in healthcare during the pandemic.

> *Because like I said, it's something I'm working with myself trying to get the staff motivated a little bit more, but it's just been definitely really hard this past year with the COVID restrictions. Everybody's just worked to the bone, everything's, everybody's struggling pretty hard and just trying to get by at the moment*. (Participant 15, Catering team leader)

Due to the COVID-19 pandemic hospital food service practices were forced to adapt and change. In some cases, these changes were immediate, while others took time to take effect. Participants reported different changes such as a decrease in the number of clinical recycling waste audits, disruption to the introduction or continuation of surplus food charity collections, a reduction in catering services, ingredient suppliers being out of stock, and the extension of an external food service provider contract.

> *People don't really like change. So as far as the past 18 months, COVID has bought, I've never seen so many changes in my professional career as far as COVID has bought to us. So, I think staff have, well, they've had no other reason, and no other choice but to, to accept change*. (Participant 11, Group management support services)

A positive example from one hospital was the creation of a new role, the 'ward host'. The responsibilities of this position were to collect patient orders on the wards and notify the kitchen of changes to patient menu choices. This role had a significant impact on food waste and generated time savings for food service, who previously would unknowingly cook meals for discharged, fasting, or deceased patients.

Additionally, COVID-19 was believed to be an excuse for not changing practice or completing a food waste audit, even if it was specified in a mandated document.

> *Because, you know, even if it [food waste auditing] does get into some sort of internal document, it could just not be achieved. People could just not do it. It can just, you know, there'll be an excuse, like, COVID or whatever. We didn't get around to it, and that'll be fine*. (Participant 13, Food service dietitian)

Technology was viewed as an obvious solution to the contact restrictions and food service delays presented by COVID-19. Implementation of an electronic plate waste measurement strategy was being trialled at one hospital, whereby students used visual estimation to estimate and enter patient food waste percentages into a device attached to the collection trolley before it reached the kitchen. The dietitian from this hospital (Participant 10) said that she could observe changes in patient intake after just 3 days of data. Other hospitals who were aware of this strategy praised its practicality, while those who were not, explained (without mention of an electronic plate waste measurement strategy by the interviewer) that using an identical strategy such as an electronic application across multiple devices, would support them to collect patient intake data and measure food waste.

> *... we really need to have it all sort of like electronics, so it's easy just to go. It's a percentage of what's left on the plate. So, let's say they've eaten 10% of the plate, if you have an input of what the meal is, like casserole and mashed potato, peas and carrots, you can just go on an overall, you know, like there's 40% of the casserole eaten and x amount of veg and the starch. Or you can actually do it as a whole meal, but it was 60% or 20% of the meal, it's easy just in percentages, because once people get used to it, and you actually take a few photos along the way, you get a good visual of what is actually eaten. And that would be simple to do, you can actually do it. You can actually almost get, the whole hospital audited instead of just one ward at a time*. (Participant 20, Facilities services manager)

Participants described how the benefits of electronic menu systems were supportive in managing and collecting data that streamlined food service operations, however this technology was not available at all health services interviewed. One participant (Participant 14, Hotel services manager) explained that they did not have an electronic menu system due to the high financial outlay required, so they relied on staff to manually collect and recall data, and speculate meal numbers needed. Another participant (Participant 20, Facilities services manager) commented that the electronic menu system they used did not have the capacity to input food waste data. Conversely, a number of participants reported the positive outcomes experienced from having an electronic menu system in operation, such as the opportunity to retrospectively obtain information from past food services, instantly share patient intake data, and accurately forecast meal numbers.

> *Data that gets entered into our food system, that's then accessible by dietitians, speech pathologists, it's also accessible by food service management. That gives us insights, and maybe as a way of accessing quality or understanding quality of our meals. We may think we're producing a great meal, but plate waste is coming back consistently at 50%. What's wrong with the meal? How do we improve quality? So, those sorts of things come into play, as well.* (Participant 11, Group management support services)

Moreover, participants also mentioned that changing the food service delivery model to a room service design could possibly reduce waste and stagger food waste collection throughout the day.

> *... because they've got that centralised breakfast, lunch and dinner plating, collecting all at the same time which makes it very time driven, something like a room service on demand model where you are taking up smaller: a) the patient's order what they want, when they want it, so they're more likely to eat more of it, but b) you're probably collecting less meals at a time. So therefore, the staff probably have more time to be able to look at that waste because they're not having to collect hundreds of meals. They're just collecting a smaller trolley of meals*. (Participant 17, Food service dietitian)

Some participants were looking towards the end of the COVID-19 pandemic. They explained that '*once COVID moves on*' the changes to food service operations will return to normal. However, one health service was expecting an increased workload focussing on sustainability projects post-pandemic and were therefore planning to hire two more sustainability professionals. The Chief Sustainability Officer (Participant 19) for this health service commented that once these positions were appointed, if a food waste audit were deemed a priority, they would then have the resources to complete one.

4 | DISCUSSION

It is evident that the COVID-19 pandemic has had a considerable impact on hospital food service operations. Changes experienced by individual hospital food services in Melbourne comprised of labour duties, routine procedures and the recruitment of staff and students, whereas broader variations to the entire healthcare food system such as technology requirements and alterations in the food supply chain were experienced by the whole state of Victoria. Further, the COVID-19 pandemic has resulted in increased food waste and a reduction in the workforce's capacity to prioritise and complete food waste audits. The response of food service staff has been to modify their practice, demonstrating their resilience, creativity and adaptability.

The large variations in the global healthcare system due to the pandemic triggered downstream involuntary change to all hospital departments, including food services. This pressured hospitals to rapidly change practices that would guarantee the safety of their staff by limiting virus transmission, including physical distancing, and

increased hand hygiene precautions.[33] The reduced capacity to place nutrition and dietetics students in hospital food services to complete food waste audits as part of these changes exposed food services' reliance on these students to complete this task. However, perhaps the increased use of technology-focused solutions found in the current study, in the form of electronic plate waste measurement systems and electronic menu ordering systems, which were trialled and implemented, or included in business cases, to support COVID-safe food service operations will reduce this reliance. It is noted that electronic plate waste measurement systems only capture food that patients do not eat.[15] Measuring aggregate hospital food waste which includes preparation and plating line surplus is useful in understanding waste on a higher level. There is technology available that addresses this issue,[29] but this was not mentioned by participants in this study. Recent research has investigated and validated the benefits of integrating technology into hospital food service operations, including functional efficiencies, reductions in food waste and cost.[15] COVID-19 has accelerated the need for, and integration of, these tools to support hospital nutrition care amid contact restrictions and staff shortages. The success of these technologies may see them remain as 'standard procedure' in food services post-pandemic. The future may see a reallocation of resources to further implement these technological advancements in other areas of hospital food service operations that were stressed by the extremities of the pandemic, such as food waste auditing.

Despite the global impact of COVID-19 on the health system, climate change still remains the number one threat to the provision of healthcare.[34] COVID-19 has delayed and disrupted the health system's response to the growing danger of climate change and has highlighted the enormous, as well as rapid, change required when disaster strikes.[34] The global healthcare system contributes 4.4% of total greenhouse gas emissions, which effects human and planetary health.[34] Unfortunately, the green recovery from COVID-19 to this point has not been prioritised in Australia, although 50 other countries at the recent United Nations Climate Change Conference (COP26) committed to building health systems which can withstand climate change impacts.[35]

Globally, many lessons were learnt once the frailty of the current food system was exposed, including the disruption of supply chains from paddock to plate,[36] that led food services to question the sustainability of their food supply. The 2021 United Nations Food Systems Summit[37] aimed to generate action and identify progress towards the United Nations Sustainable Development Goals.[38] If the Sustainable Development Goals are to be met by 2030, transforming food systems to be more resilient and sustainable must be a high priority for the nutrition and dietetic profession. This has been recognised as the third most needed theme of nutrition research,[39] and one of six emerging roles for dietitians in the future.[40] Additionally, a recent position paper from Dietitians Australia endorsed the need for a food systems transformation to support healthy and sustainable diet-related practices, including institutional food services.[41] Despite the negative impact of the COVID-19 pandemic on the progression of the Sustainable Development Goals,[10] organisations are still committing to meet them. For instance, International Service System Facility Services (who were represented by participants in this study), have announced they are aiming to halve food waste in all their United States branches by 2024.[42] Furthermore, 78% of Practice Greenhealth affiliates (a membership for sustainable healthcare) are reducing food waste.[43] These examples demonstrate that some institutional food services are acting to improve their operations, and attempting to build back better after the COVID-19 pandemic, which may support their response during the next emergency.

Interviews were completed in the Australian state of Victoria, which contains the city of Melbourne, the most locked-down city in the world during the COVID-19 pandemic.[30] As a result, this made hospital and participant recruitment for this study challenging, as managing COVID-19 was a higher priority. In addition, this led to a low participation of food service staff who complete kitchen tasks such as cleaning, preparing food, and washing up after service as they were either preoccupied with service or not approached by their manager to participate. These individuals may have provided important insights for informing the research questions. Completion of interviews with hospital food services located in Victoria and no other Australian state may be viewed as a limitation of this study, however this was a practical approach to recruitment. Qualitative interviews were conducted via Zoom (Version 5.5, Zoom video communications, California) which reduced the exposure of subtle in- person cues that aid interview questioning, as well as caused minor technical difficulties, interruptions and delays. The pandemic has led to an increase in the acceptability and popularity of video communication to complete previous face-to-face interactions, consequently participants were familiar and comfortable with this format. A strength of this study is its internal coherence, which enhances its quality.[20] This was demonstrated by the chosen philosophical paradigm of interpretivism (a relativist ontology and subjectivist epistemology)[18] aligning with the researcher's axiology of placing value in participants' social context and their perspectives, that led to a qualitative descriptive study design (methodology) and semi-structured interview data collection

method.[20] Declaration of the researcher's position to the participants at the start of the interview, regular peer-debriefing and a collaborative analysis approach supported reflexivity.

This research demonstrated the effects of the COVID-19 pandemic on hospital food services, specifically in the areas of food waste auditing and on the generation of food waste. Although COVID-19 created a 'tug of war' scenario between the use of resources and individual safety, hospital food services showed resilience in their practice. Forced changes in resource allocation and usage allowed food services to adapt and learn to work with COVID-19 restrictions, potentially beginning the path to post-pandemic services. While this study describes the impact of COVID-19 on hospital food services, food waste and audits, complementary future research should measure the impacts of COVID-19 on other metrics including patient intake, staff turnover, and food costs. Further research focussing on measuring aggregate food waste and the outcomes of strategies to reduce or divert food waste from landfill are also desirable. The advancement towards sustainable healthcare will then support and potentiate the green recovery from COVID-19.

AUTHOR CONTRIBUTIONS

NC conducted the interviews, collated, analysed and interpreted the data and wrote the manuscript. DG, JC and JP supervised this process and critically reviewed the manuscript. All authors contributed to the conceptualisation and design of the study and have read and approved the final publication. The contents of this manuscript have not been published elsewhere.

CONFLICT OF INTEREST

Prof. Judi Porter is Editor-in-Chief of Nutrition & Dietetics. She was excluded from the peer-review process and all decision making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. All authors are in agreement with the manuscript and declare that the content has not been published elsewhere. Other authors declare that there is no conflict of interest to report. The scholarship funders had no role in the design, analysis or writing of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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