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Systematic literature review of food waste in educational institutions: setting the research agenda

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Abstract

Purpose – In the recent past, academic researchers have noted the quantity of food wasted in food service establishments in educational institutions. However, more granular inputs are required to counter the challenge posed. The purpose of this study is to undertake a review of the prior literature in the area to provide a platform for future research.

Design/methodology/approach – Towards this end, the authors used a robust search protocol to identify 88 congruent studies to review and critically synthesize. The research profiling of the selected studies revealed limited studies conducted on food service establishments in universities. The research is also less dispersed geographically, remaining largely focused on the USA. Thereafter, the authors performed content analysis to identify seven themes around which the findings of prior studies were organized.

Findings – The key themes of the reviewed studies are the drivers of food waste, quantitative assessment of food waste, assessment of the behavioural aspects of food waste, operational strategies for reducing food waste, interventions for inducing behavioural changes to mitigate food waste, food diversion and food waste disposal processes and barriers to the implementation of food waste reduction strategies.

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Research limitations/implications – This study has key theoretical and practical implications. From the perspective of research, the study revealed various gaps in the extant findings and suggested potential areas that can be examined by academic researchers from the perspective of the hospitality sector. From the perspective of practice, the study recommended actionable strategies to help managers mitigate food waste.

Originality/value – The authors have made a novel contribution to the research on food waste reduction by identifying theme-based research gaps, suggesting potential research questions and proposing a framework based on the open-systems approach to set the future research agenda.

Keywords Food waste, Plate waste, School cafeteria, University cafeteria, Out-of-home consumption, Consumer behaviour, Leftovers, Food waste cause

Paper type Research paper

1. Introduction

"Food waste" pertains to the edible and inedible parts of food removed from the food chain, which need to be managed through recycling or disposal (Östergren *et al.*, 2014). Food waste may also be interpreted as the loss of edible food at different stages of the food chain, including harvest, production, processing, distribution and consumption (Ivert *et al.*, 2015; Segrè *et al.*, 2014). Food waste comprises two types based on the kind of waste:

(1) unavoidable food waste: expired or spoiled ingredients, food scraps such as meat scraps (e.g. end pieces of baked ham after slicing, meat pieces after trimming) and vegetable scraps (e.g. tomato ends, outer leaves of lettuce, potato peels, vegetable stems); and

(2) avoidable food waste: meal scraps such as peeling or trimming waste arising from the less proficient handling of food items; overproduction for banquets, events and catering; poor ordering procedures; poor food rotation practices, causing food spoilage; and poor inventory systems, leading to food and plate waste such as unconsumed pasta (Derqui and Fernandez, 2017).

Academics categorize food waste based on the stages of waste generation, such as pre- and post-consumer food waste (Prescott *et al.*, 2019b). Pre-consumer waste occurs at the production level, and post-consumption waste occurs at the consumer level. Scholars argue they associate different factors with food waste generation at these stages. Accordingly, various mitigation approaches perhaps can reduce such waste (Papargyropoulou *et al.*, 2016). Furthermore, thorough diagnoses of food waste generated at various stages are crucial for ensuring the effective management of waste (Dhir *et al.*, 2020).

Food waste is an important concern because it threatens the environment and sustainability. In fact, it is a serious concern in the hospitality and tourism domain (Okumus *et al.*, 2020). Close to 1.3 billion tonnes of edible food is wasted annually, leading to severe financial, environmental and health outcomes (Gustavsson, 2011). Past research has identified several adverse outcomes of food waste, such as threats to food security (Wang *et al.*, 2018), climate change and greenhouse gas emissions (Kallbekken and Sælen, 2013; Katajajuuri *et al.*, 2014) and monetary loss (Hennchen, 2019). For instance, the annual emissions because of food waste in Finland constitute more than 1% of the country's yearly greenhouse gas emissions (Katajajuuri *et al.*, 2014). Similarly, scientists found the ecological impact of food waste in hotels, cafés and restaurants nearly twice the size of the arable land in Lhasa (Wang *et al.*, 2018). Notably, sustainability has come under intense focus in the hospitality industry in the wake of the COVID-19 pandemic (Jones and Comfort, 2020). In addition, studies have underscored the nutritional loss associated with food waste. For instance, Blondin *et al.* (2017) revealed that, in the USA, fluid milk waste results in 27% and 41% losses, respectively, of the vitamin D and calcium required under school breakfast

programme meals. Consequently, scholars argue that reducing food waste is critical from financial (e.g. food cost) and non-financial (e.g. sustainability) standpoints (Okumus, 2019). In fact, research reports suggest that, by saving one-fourth of the food being wasted, we can feed 870 million hungry people (Khadka, 2017). Similarly, the sustainable development goals of the United Nations (UN) have also emphasized responsible production and consumption, underscoring the importance of mitigating food waste (Gustavsson, 2011).

Regarding food waste generation, prior studies have indicated that a large amount of food waste is generated at the consumption stage, which includes both out-of-home and at-home dining (Martin-Rios *et al.*, 2018). Households represent at-home dining, whereas the food service sector represents out-of-home dining. The food service sector includes both non-commercial and commercial establishments (Betz *et al.*, 2015), such as restaurants, hotels, health-care companies, educational institutions and staff catering.

An important subdomain where out-of-home dining takes place is food service establishments at educational institutions. In this context, prior studies have observed that school cafeterias are a major source of unconsumed food (Smith and Cunningham-Sabo, 2014; Adams *et al.*, 2016). For instance, in the National School Lunch Program (NSLP) in the USA, more than 30% of the food served is wasted (Byker Shanks *et al.*, 2017). In fact, food waste in educational settings is a significant issue (Yui and Biltekoff, 2020). What is most worrying in this context is that, in spite of the acknowledgement of such a high quantity of waste generated, the authorities in educational institutions, food service managers in schools and university food service companies' staff are not intent on reducing food waste (Wilkie *et al.*, 2015). Furthermore, the academic research in this area is limited, with most studies in educational settings (particularly in the context of schools) skewed towards using food waste as a measure to estimate the amount of nutrients lost. Food waste does not hold a central place in the existing debate. Other studies have focused on aspects such as the composition of waste generated in the food service operations in schools (Hollingsworth *et al.*, 1995) and the monetary implications of various waste disposal strategies (Wie *et al.*, 2003).

The multiple stakeholders and researchers in this area lack direct attention to food waste. This is quite concerning, given the serious implications of food waste. Deeper insights into food waste at a micro level can help reduce it by documenting the quantity of the food wasted and the causes of such waste. In addition, research inputs concerning possible strategies to reduce food waste without compromising consumer satisfaction can be quite useful for various food service establishments. Correspondingly, we feel academic research on food waste in educational settings must progress beyond an overemphasis on nutrition. More importantly, there is an urgent need to focus on hospitality-related concerns, such as meal production, palatability, dining environment and consumer food choices, as they directly affect food waste at the production and consumption stages. We posit that research investigating various aspects of food waste in educational institutions is important for two main reasons:

(1) the substantial volume of meals that educational institutions handle at a single location (Wilkie *et al.*, 2015); and

(2) the opportunity that such research presents for creating a culture of sustainability and for reinforcing the pro-environment habits of future consumers by making them ecologically aware of the food system and its importance (Derqui *et al.*, 2018).

Consequently, to encourage research in this area, we will review the extant literature and present the accumulated learning on the topic so that future researchers can build upon them and further enrich the field. Specifically, we propose that the following research objectives (ROs) be pursued:

- analyze the research profile of studies on food waste in food service establishments in educational institutions (RO1);
- identify, comprehend and evaluate the thematic foci of the existing research on food waste in food service establishments in educational institutions (RO2);
- critically assess emergent themes to highlight gaps in the extant literature and suggest potential research questions (RO3); and
- develop a framework that multiple stakeholders can use as a reference to understand the contours of food waste in the food service establishments in educational institutions (RO4).

To achieve the ROs of the study, we used the systematic literature review (SLR) approach to identify, analyze and synthesize past studies in the area in consonance with recent studies (Kushwah *et al.*, 2019; Dhir *et al.*, 2020; Ruparel *et al.*, 2020; Seth *et al.*, 2020). Towards this end, we conducted the following steps. First, we defined the extraction method of congruent studies concerning the conceptual boundary, database identification, keyword choice and actual search and shortlisting of relevant studies. We formulated a robust search protocol based on 18 keywords as well as comprehensive inclusion criteria (IC) and exclusion criteria (EC). We also conducted a peer review of shortlisted studies to finalize the total number of studies to be included in the review (88). Second, we conducted a research profiling of selected studies to present the summary statistics related to publication frequency, publication sources, geographical scope of each study, type of educational institution investigated and theoretical framework. Third, we performed a manual content analysis of the congruent studies to delineate the thematic foci of such studies. This helped us identify seven distinct themes. The emergent themes were critically analyzed to identify the gaps in the extant research and to suggest theme-based potential research questions and future research avenues. Fourth, we developed a framework (the food waste ecosystem) for presenting a systems view of food waste in the food service establishments in educational institutions by building on the key findings of the review that we conducted (i.e. research themes, research gaps and avenues of future research). Fifth, we discuss herein the theoretical and practical implications of the study, followed by the study limitations, which should be kept in mind while implementing the results of this study.

2. Research method

We aimed to conduct a critical and comprehensive synthesis of the accumulated learning related to food waste in food service establishments in educational institutions. We used the SLR method to achieve this broad objective of the study. SLR is a secondary research method that originated in medical science but is now a popular and well-used approach in the social science and hospitality disciplines (Mariani *et al.*, 2018; Bavik, 2020; Seth *et al.*, 2020; Talwar *et al.*, 2020). SLRs should be detailed enough to enable future researchers to replicate or extend a study (Jafari Navimipour and Charband, 2016; Behera *et al.*, 2019). Accordingly, reports should include a well-articulated protocol for the identification and assessment of the congruent studies to be included in the review (Kushwah *et al.*, 2019). In this regard, there are multiple suggestions in the prior literature about the steps to be executed to conduct an SLR (Gomezelj, 2016; Law *et al.*, 2016; Sahu *et al.*, 2020; Sharma *et al.*, 2020). In consonance with the prior studies in hospitality (Bavik, 2020), the current SLR has used an overarching process spanning four steps, as shown below:

(1) Step I. Planning the review: Setting the conceptual boundary and identifying the relevant keywords and databases to identify the congruent studies.

(2) Step II. Specification of the study screening criteria: Defining the IC and EC.

(3) Step III. Data extraction: Using multiple levels of screening to identify congruent studies.

(4) Step IV. Data execution: Presenting the research profile and the thematic foci of the congruent studies uncovered through content analysis.

2.1 Planning the review

We proposed to review studies on food waste in food service establishments in educational institutions. These institutions include pre-schools, schools (primary, secondary and upper secondary), tertiary education centres, colleges and universities. Furthermore, we distinguished between food waste and food loss. Some prior studies used the terms "food loss" and "food waste" interchangeably (Betz *et al.*, 2015). However, many scholars have treated them as two different concepts. They described food loss as food gone to waste in the initial stage of the value-added chain and food waste as food lost at the end of the food supply chain (Parfitt *et al.*, 2010). Our understanding is that "food loss" pertains to food leaving the supply chain initially. "Food waste", though, pertains to the food that is not consumed at the point of food consumption. Therefore, in this SLR study, we treated food waste and food loss as distinct concepts. Accordingly, we identified an initial set of keywords for use in searching the studies to be reviewed, as follows: pre-schools, schools, tertiary education centres, colleges and universities. We searched for these keywords on Google Scholar, and we analyzed the first 100 results to update the keywords list. Afterward, we examined leading journals from the areas of nutrition, food waste and hospitality to confirm if the list of keywords was exhaustive. We selected the final list of 18 keywords after consultation with three experts from the area of hospitality and food waste (two professors and one practitioner; Table 1). Finally, in consonance with Mariani *et al.* (2018), we selected Scopus and Web of Science as the two academic databases from which to retrieve the relevant studies. These two are the most comprehensive databases of social science and hospitality academic studies, with extensive disciplinary coverage (Mongeon and Paul-Hus, 2016).

2.2 Specification of study screening criteria

We specified (Table 2) the IC and EC at this stage to screen the studies found using pre-specified keywords.

2.3 Data extraction

We converted the final set of keywords (Table 1) into search strings using * and Boolean logic, as well as the connectors "OR" and "AND". We then executed the search strings on both databases to search for the title, abstract and author keywords. The search was

Food waste-related keywords	School-related keywords	University-related keywords
Food waste	Early childhood education centre	Higher education
Kitchen waste	School	Tertiary education
School leftover lunch service	Elementary school	College
Plate waste	Middle school	University
	Children's education centre	University dining hall
	School cafeteria	Trayless catering
	Student	
	Special education programme	

Table 1.
Keywords for the literature search

Inclusion criteria	Exclusion criteria
IC1. Peer-reviewed journal articles based on qualitative and quantitative investigations	EC1. Articles not congruent with food waste in educational institutions
IC2. Peer-reviewed journal articles in English published on or before March 28, 2020	EC2. Articles not directly connected with food waste generation in educational institutions (e.g. biogas plants, waste into power, techno-economic evaluation of biogas production, anaerobic digestion)
IC3. Articles explicitly focusing on food waste in educational institutions	EC3. Duplicated articles with matching authors, title, volume, issue number and digital object identifier (DOI)
	EC4. Reviews, thesis papers, editorials, conference proceedings and conceptual articles

Table 2.
Study inclusion and exclusion criteria

conducted from January 1 to March 28, 2020. In Scopus, we found 550 journal articles in English, with 420 articles in Web of Science. We used the pre-specified IC and EC to select studies congruent with the area at hand. First, we screened duplicated articles using Microsoft Excel spreadsheets. We identified articles with the same authors, title, volume, issue number and DOI. Subsequently, we removed 276 duplicated studies from the Web of Science list. After further screening of the joint pool of 694 studies, we excluded 350 studies from the pool.

For the next level of screening of the remaining 344 studies, three researchers with experience in food waste research reviewed the titles and abstracts of the retrieved studies based on the conceptual boundary and IC and EC. To ensure robust screening, the three researchers performed the task individually, after which they shared their shortlists with one another. The researchers discussed any variances in their respective shortlists to arrive at a consensus list that could be further analyzed. This process excluded 230 studies incongruent with the specific area and conceptual boundary of the current study. At the penultimate step of screening, 3 authors analyzed the full texts of the balance 114 articles to reconfirm their eligibility for inclusion in the review. By consensus, we removed 14 articles, as these dealt with issues not immediately relevant to the review, such as sustainability and food insecurity. In the final stage of the study screening process, two professors and a practitioner from the area of hospitality and food waste examined the 100 shortlisted studies and supplied feedback. Based on their observations, we eliminated 12 studies, making the final sample of 88 articles. Subsequent sections of this work will disclose the results of the research profiling and content analysis, which constituted the data execution process.

2.4 Data execution: research profiling

We present the research profile of the retrieved congruent studies concerning descriptive statistics, such as publication year, publication source, educational institution investigated, geographic scope of each study and theoretical framework. The year-wise publications (Figure 1) indicate that there were few studies on food waste in the food service establishments in educational institutions until 2012, after which the studies increased, reaching a peak of 15 articles in 2019. Furthermore, the studies were published in a variety of journals in nutrition and waste management (Figure 2). Figure 3 presents the number of studies that focused on each type of educational institution (e.g. school versus university). Figure 4(a) and (b) presents the countries where the studies were conducted for schools and universities, respectively. Interestingly, the reviewed studies drew upon seminal theories to propose a hypothesis and/or discuss findings (Table 3).

3. Thematic foci

The studies included in the review examined food waste from different perspectives and investigated distinct aspects of it. To synthesize such diverse studies systematically, we attempted to identify the common themes within the studies. The key themes in the selected studies were identified through content analysis, in consonance with the recently published SLR literature (Seth *et al.*, 2020). To ensure that emergent themes would present an unbiased

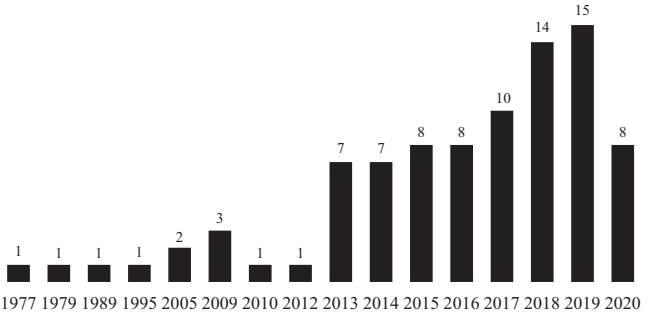

Figure 1.
Year-wise publications in food waste in food service establishments in educational institutions

Notes: Other journals that each published one study include American Journal of Public Health; Annals of Nutrition and Metabolism; Applied Economics Letters; Australasian Journal of Management; Behavioural Sciences; Childhood Obesity; Clinical Pediatrics; Eating and Weight Disorders; Ecology of Food and Nutrition; Food, Culture and Society; Infant, Child, and Adolscent Nutrition; International Journal of Environmental Research and Public Health; Journal of Agriculture Food Systems and Community Development; Journal of Consumer Behaviour; Journal of Culinary Science and Technology; Journal of Foodservice Business Research; Journal of Hospitality and Tourism Research; Journal of Nutritional Science; Nutrition and Dietetics; Nutrition Research; PLoS ONE; Preventive Medicine; Renewable Agriculture and Food Systems; and South African Journal of Clinical Nutrition

Figure 2.
Publications on food waste in the food service establishments in educational institutions, by journal

view of the literature, we followed a three-step process. First, three researchers performed the open coding. Later, the deductive and inductive methods of axial coding identified relationships among the open codes. Second, to ensure consensus and inter-rater reliability, the three researchers discussed the identified codes and aligned their thought processes. As food waste is a universally understood phenomenon, there were no disagreements except in the sequencing and presentation of the themes. Third, two professors from the hospitality and food waste areas commented on the identified themes. Finally, seven themes

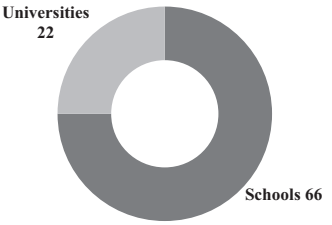

Figure 3.
Food service establishments examined by the studies

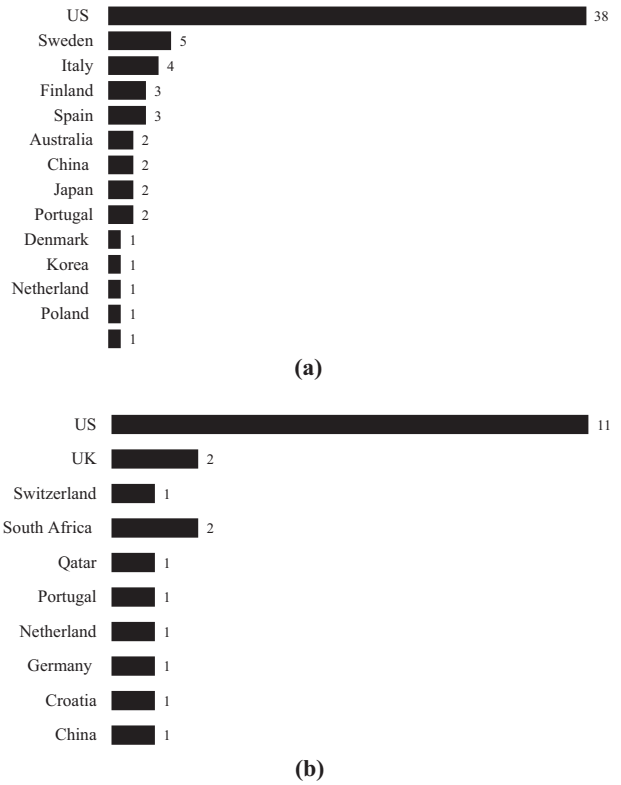

Figure 4.
Geographic scope of the studies

Notes: (a) Schools; (b) universities

synthesized the existing literature. These were the drivers of food waste; quantitative assessment of food waste; assessment of the behavioural aspects of food waste; operational strategies for reducing food waste at the pre- and post-consumer levels; strategies and interventions for inducing behavioural changes to mitigate food waste; food diversion and food waste disposal processes; and the barriers to the implementation of food waste reduction strategies. A mind map of the emergent themes and the related subthemes is showcased in Figure 5.

3.1 Drivers of food waste

Two perspectives can assess food waste at food service establishments in educational institutions: pre- and post-consumer waste (Prescott *et al.*, 2019a). "Pre-consumer waste" is kitchen waste arising at the time of storage, preparation and production, whereas "post-consumer waste" consists of leftovers or plate waste (Burton *et al.*, 2016; Bean *et al.*, 2018b; Zhao and Manning, 2019b). Scholars have also used the term "serving waste" or "display waste" (especially regarding buffet meals) to represent waste at the point of consumption (Abdelaal *et al.*, 2019). Prior scholars examining food waste at the pre-school, elementary and middle school levels have discussed uneaten meals, representing post-consumer waste, to a large extent (Smith and Cunningham-Sabo, 2014; Adams *et al.*, 2016; Zhao *et al.*, 2019). Most studies focused on food waste measurement as a tool to assess the nutritional aspects of leftovers from meals consumed in schools (Getts *et al.*, 2017).

Table 3. Theoretical framework used in food waste in food service establishments in educational institutions

Theory	Author(s)
Inventory theory	Costello *et al.* (2015)
Practice theory	Laakso (2017)
Prospect theory	Jagau and Vyrastekova (2017)
Social cognitive theory	Abe and Akamatsu (2015), Deavin *et al.* (2018)
Social practice theory	Yui and Biltekoff (2020)
Theory of planned behaviour	Abe and Akamatsu (2015), Lorenz-Walther *et al.* (2019); Wu *et al.* (2019), Visschers *et al.* (2020)
Theory of psychic numbing	Jagau and Vyrastekova (2017)
Theory of food waste	Knezevic *et al.* (2019)
Theory of self-determination	Prescott *et al.* (2019)

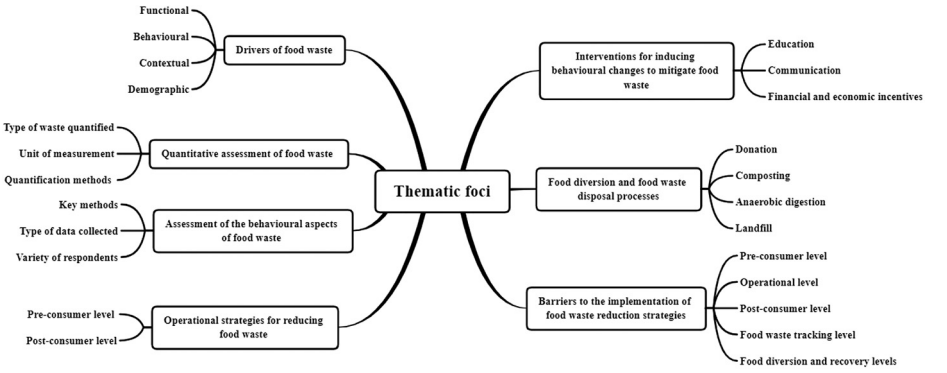

Figure 5. Thematic foci of studies on food waste in educational institutions

Pre-consumer waste: It is generated based on various functional, behavioural and contextual factors, as presented in Table 4. A key driver of food waste in school food service establishments at this stage is production waste, which can also increase because of various regulatory requirements and contractual obligations. For instance, food safety guidelines may prevent food service establishments from re-using the extra amount of food prepared for a particular meal (Derqui *et al.*, 2018). As such, serving an agreed-upon variety of food offerings as per a contract may force kitchen staff to prepare and serve food that ultimately may not be consumed (Derqui *et al.*, 2018).

Post-consumer waste: The drivers of post-consumer waste comprise behavioural, contextual and demographic factors, as Table 4 presents. Within post-consumer waste, the key drivers of wasted, edible food at both the school and university levels are taking a portion size larger than required as per one's age and satiation level (Thorsen *et al.*, 2015; Huang *et al.*, 2017; Zhao and Manning, 2019a); and the time allowed for eating (i.e. recess; Cohn *et al.*, 2013; Abe and Akamatsu, 2015). Students' dietary habits (Liu *et al.*, 2016) also influence the amount of food waste generated in the school dining halls. Other factors that contribute to food waste at

Type	Stage	Driver	Author(s)
Functional	Pre-consumer (production waste)	Menu composition, availability of competitive foods, substandard foods, meal plan, overproduction, food service quality, inadequate meal planning, regulatory requirements, contractual obligation, food service regime, serving style, meal presentation, procurement issues, perishability of certain food items, low attention to the dietary habits of consumers	Boschini *et al.* (2020), Templeton *et al.* (2005); Prescott *et al.* (2019a); Marais *et al.* (2017), Costello *et al.* (2017); Derqui *et al.* (2018), Liu *et al.* (2016); Pinto *et al.* (2018), Wilkie (2015); Blondin *et al.* (2018), Falasconi *et al.* (2015)
Behavioural	Pre-consumer (production waste) and post-consumer (consumption waste)	Self-efficacy, tendency to consume fast foods, attitude towards food waste, personal norms, social emotions of guilt and shame, staff's perceptions of keeping track of food wastage	Abe and Akamatsu (2015), Baik and Lee (2009); Wu *et al.* (2019), Knezevic *et al.* (2019); Visschers *et al.* (2020), Jagau and Vyrastekova (2017); Burton *et al.* (2016)
Contextual	Pre-consumer (production waste) and post-consumer (consumption waste)	Dining environment, duration of eating time, food quality and palatability, timing of recess, portion size	Steen *et al.* (2018); Davidson (1979); Cohen *et al.* (2016); Niaki *et al.* (2017), Cohn *et al.* (2013); Abe and Akamatsu (2015); Cohen *et al.* (2016), Chapman *et al.* (2017); Zhao and Manning (2019b)
Demographic	Post-consumer (consumption waste)	Child characteristics, age, gender, ethnicity	Nicklas *et al.* (2013), Niaki *et al.* (2017); Huang *et al.* (2017); Zhao and Manning (2019b); Ellison *et al.* (2019), Izumi *et al.* (2020)

Table 4.
Drivers of food waste in food service establishments

the university food services were incorrectly labelled food items (which led to the choice of wrong food items), differences in appetite and diet-related choices (Wu *et al.*, 2019; Yui and Biltekoff, 2020).

Prior literature has also offered insights into the associations between the drivers of food waste at the post-consumer level and the sociodemographic profile of the consumers. For instance, some studies observed gender-based distinctions in waste generation:

- Low self-efficacy in finishing one's meal if it does not taste good is a significant predictor of plate waste only among boys (Abe and Akamatsu, 2015).
- Male students tended to waste staple food less compared to females (Wu *et al.*, 2019).
- Male consumers were more likely to finish their meal compared to females (Zhao and Manning, 2019b).

Studies have also revealed age-related disparities:

- Young consumers tend to waste more food than adults on average (Ellison *et al.*, 2019).
- Within the student groups, younger students wasted more food than older ones (Dillon and Lane, 1989; Huang *et al.*, 2017; Niaki *et al.*, 2017).

However, contradictory findings exist concerning the association of age with waste generation. For example, some scholars observed that plate waste increased with an increase in the student's age (Steen *et al.*, 2018). Variances in plate waste also traced to the student's financial condition. Key observations were as follows:

- Individuals with more disposable incomes waste more food (Wu *et al.*, 2019).
- Middle-income students generated more food waste compared to students with poorer backgrounds (Dillon and Lane, 1989).

3.2 Quantitative assessment of food waste

A key aspect of food waste studies is the quantification of the waste generated. In this regard, the reviewed studies have discussed the following:

- the type of waste quantified;
- the unit of measurement used; and
- the method used for quantification.

The key concerns covered by each of these aspects are described below.

Type of waste: Some studies have measured all waste, edible or avoidable as well as inedible or unavoidable (Langley *et al.*, 2010; Costello *et al.*, 2015). In comparison, many studies quantified only edible or avoidable food waste (Whitehair *et al.*, 2013; Thorsen *et al.*, 2015). The items considered edible or avoidable food wastes are meat protein, soy protein, fruits, rice, potatoes, bread, pies, juice, beverages, milk, vegetables and salads (Langley *et al.*, 2010; Thiagarajah and Getty, 2013; Blondin *et al.*, 2017, 2018; Eriksson *et al.*, 2018b). Conversely, the inedible or unavoidable food wastes are fruit or vegetable peels and spines, eggshells, bones and skins and seeds (Langley *et al.*, 2010; Whitehair *et al.*, 2013; Derqui and Fernandez, 2017). The greatest amount of food waste is derived from vegetables, fruits, salads, main entrées and milk (Carmen *et al.*, 2014; Smith and Cunningham-Sabo, 2014; Blondin *et al.*, 2015; Silvennoinen *et al.*, 2015; Wu *et al.*, 2019).

Unit of measurement: In this regard, the reviewed studies collected wastes for quantification at different stages of food services. Accordingly, the serving waste, plate waste and production waste (prepared food left over after service) were quantified (Gase *et al.*, 2014; Eriksson *et al.*, 2017; Boschini *et al.*, 2020). Hence, scientists measured the entire mass of food waste generated at every meal (Carmen *et al.*, 2014; Painter *et al.*, 2016); the aggregated discarded food at the pantry, kitchen, service station or plate level (Derqui *et al.*, 2018); or the individually/aggregately weighed plate waste (Chapman *et al.*, 2019). The most commonly used unit of food waste quantification is plate waste, which is the quantity/percentage of edible food served on a plate but left unconsumed (Huang *et al.*, 2017). In schools, where the focus is nutrition, plate waste is the quantity of edible vegetables and fruits students did not consume during lunch (Adams *et al.*, 2016; Capps *et al.*, 2016). In this context, studies have revealed that students waste 40% and 30%, respectively, of the fruits and vegetables they receive (Templeton *et al.*, 2005; Carmen *et al.*, 2014). Most of the studies included in the review used plate waste as a unit of quantification of food waste (Cohen *et al.*, 2013; Liz Martins *et al.*, 2016; Chapman *et al.*, 2017; Hudgens *et al.*, 2017).

Methods of quantification: There are multiple methods of quantifying and measuring plate waste, and one can observe method variations in the plate waste quantification approach that selected studies used, such as direct physical measurements and indirect visual observations (Eriksson *et al.*, 2018b). Plate waste can be weighed in grams per portion served (Eriksson *et al.*, 2018a) or as aggregate plate waste per meal (Eriksson *et al.*, 2017). Although weighed plate waste is considered the gold standard for determining the quantity of plate waste, scientists have also applied visual assessment approaches such as the quarter-waste method, which is considered reliable (Derqui and Fernandez, 2017; Getts *et al.*, 2017; Niaki *et al.*, 2017). In fact, the three visual waste measurement methods (photograph, half-waste and quarter-waste) have been found to be as accurate as the plate weighing method (Hanks *et al.*, 2014). Visual methods are appealing, as they offer advantages such as convenience, time savings and ease of using a larger sample size to monitor plate waste (Liz Martins *et al.*, 2014). Within visual methods, many studies have used photography (Smith and Cunningham-Sabo, 2014; Yoder *et al.*, 2015; Bean *et al.*, 2018a; Katare *et al.*, 2019; Prescott *et al.*, 2019a; Serebrennikov *et al.*, 2020). Moreover, scholars have discussed the use of rubbish analysis to quantify food waste (Dresler-Hawke *et al.*, 2009; Derqui and Fernandez, 2017).

Prior scholars have also tried to ascertain the efficacy of different methods of plate waste quantification. For instance, Bean *et al.* (2018a) compared a weighed and digital imagery-based assessment of plate waste and confirmed the accuracy of the digital imagery method in terms of plate waste estimation. However, Liz Martins *et al.* (2014) contended that the visual estimation method is not as accurate as the weighing method in assessing nonselective aggregated plate waste. Previous studies have used food waste audits to quantify the amount and type of food waste generated (Wilkie *et al.*, 2015; Costello *et al.*, 2017; Derqui and Fernandez, 2017; Derqui *et al.*, 2018; Schupp *et al.*, 2018; Prescott *et al.*, 2019a). Figure 6 depicts an overview of the stages of waste generation, the types of waste quantified and the key methods of quantification.

3.3 Assessment of the behavioural aspects of food waste

The reviewed studies primarily focused on measuring quantities of food waste, but some prior scholars have applied a mixed-method approach by not only quantifying food waste but also collecting qualitative information related to it through a variety of methods and involving a variety of stakeholders (Cohn *et al.*, 2013; Marais *et al.*, 2017; Derqui *et al.*, 2018; Prescott *et al.*, 2019a, 2019b). The discussion under this theme finds its basis on three factors:

(1) key methods;
(2) type of data collected; and
(3) variety of respondents.

Key methods: The methods used for assessing food waste include direct observation (Marshall *et al.*, 2019), field notes (Yui and Biltekoff, 2020), cross-sectional questionnaire (Abe and Akamatsu, 2015), semi-structured interviews (Zhao *et al.*, 2019), non-structured interviews (Falasconi *et al.*, 2015), structured interviews (Burton *et al.*, 2016), focus group discussion (Blondin *et al.*, 2015), experiments (Kim and Morawski, 2013) including randomized controlled experiments (Katare *et al.*, 2019), quasi-experiments (Visschers *et al.*, 2020), longitudinal studies (Lagorio *et al.*, 2018; Marshall *et al.*, 2019) and pre- and post-test-based intervention studies (Kowalewska and Kołłajtis-Dołowy, 2018; Kropp *et al.*, 2018; Lorenz-Walther *et al.*, 2019; Visschers *et al.*,2020). Figure 7 presents a snapshot of the methods.

Type of data collected: Scientists use self-reporting questionnaires quite frequently to identify the key factors influencing food waste, the reason for plate waste and preferences (Thorsen *et al.*, 2015; Liu *et al.*, 2016; Huang *et al.*, 2017; Kowalewska and Kołłajtis-Dołowy, 2018; Derqui *et al.*, 2020). In addition, questionnaires gathered eating behaviour-related information and food preferences (Baik and Lee, 2009). Notably, prior scholars have made limited qualitative attempts to assess consumer behaviour concerning food waste generation. For instance, Jagau and Vyrastekova (2017) conducted a study to observe the differences

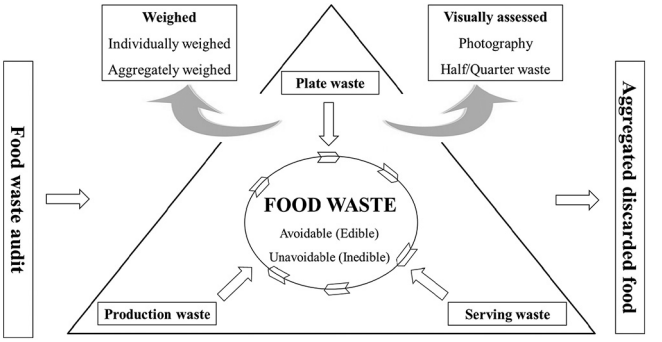

Figure 6.
Methods of food waste quantification

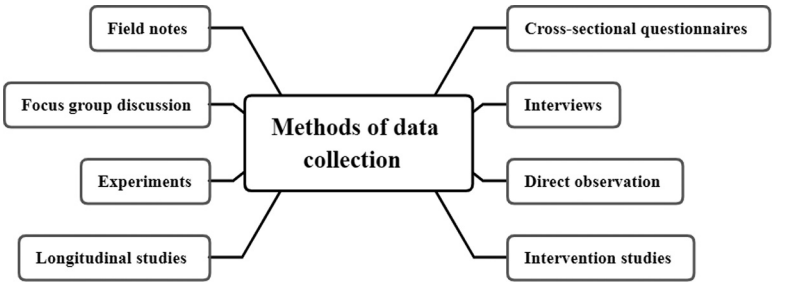

Figure 7.
Methods of data collection

between the intention to prevent food waste and the actual waste that consumers generated. Similarly, researchers examined staff and students' insinuated intentions related to food waste (Zhao and Manning, 2019b). A few studies have also analyzed the changes in behaviour with regard to food waste and its reduction (Whitehair *et al.*, 2013; Pinto *et al.*, 2018; Boulet *et al.*, 2019; Visschers *et al.*, 2020). Along the same lines, fewer studies have focused on the ethnic background of students or other demographic factors. For example, only two studies using a mixed-method approach have undertaken ethnographic investigations (Lazell, 2016; Izumi *et al.*, 2020). Similarly, a limited number of researchers (Nicklas *et al.*, 2013) have used a demographic questionnaire (e.g. age, ethnicity). Langley *et al.* (2010) acknowledged the effect of gender-based differences in food consumption and waste; they selected dining areas for the study based on gender composition.

Regarding the variety of respondents, qualitative studies have taken place with many stakeholders, such as kitchen managers, nutrition service directors and sustainability staff (Prescott *et al.*, 2019b), professionals engaged in food recovery (Prescott *et al.*, 2019a), stakeholders along the supply chain (Liu *et al.*, 2016), school head teachers (Derqui *et al.*, 2020), managers and staff in schools and catering firms (Derqui *et al.*, 2018), key informants about stakeholder accountability (Cohn *et al.*, 2013), food service managers, catering personnel, students (Marais *et al.*, 2017), teachers (Prescott *et al.*, 2019a) and parents (Baik and Lee, 2009).

3.4 Operational strategies for reducing food waste

The studies included in the review had given some attention to waste reduction strategies that could help food service establishments. Prior studies have made some useful recommendations on how to control or mitigate food waste (Kim and Morawski, 2013; Blondin *et al.*, 2015). The proposed strategies pertained to the multiple stakeholders in food service and consumption at both the school and university levels. These stakeholders were food service managers, kitchen staff, school and university authorities and students (Baik and Lee, 2009; Marais *et al.*, 2017; Prescott *et al.*, 2019a, 2019b; Derqui *et al.*, 2020). Broadly, one can dichotomize the operational strategies to reduce food waste into:

- strategies to reduce food waste at the pre-consumer level; and
- strategies to reduce food waste at the post-consumer level.

This work will explore both strategies in what follows.

Pre-consumer level: The reviewed studies discussed several operational strategies to reduce waste at the pre-consumer level. The main objective of these strategies was to reduce food waste at the kitchen level. Waste at this level occurs largely because of overproduction, mishandling, staff inefficiency and the quality of food prepared. Accordingly, strategies largely target these issues (Table 5). *Post-consumer level*: The operational strategies to reduce waste at the post-consumer level largely relate to avoiding serving food that would not be consumed. With plate waste being the focus of waste quantification, many previous scholars have discussed strategies to reduce plate waste. Most of the suggestions relate to the serving portion size based on age, going trayless and making better food choices, as Table 5 illustrates.

3.5 Interventions for inducing behavioural changes to mitigate food waste

Previous studies have emphasized the importance of interventions for bringing about behaviour change at both the pre- and post-consumer levels to mitigate food waste (Whitehair *et al.*, 2013; Wilkie *et al.*, 2015). In this context, prior scholars have discussed three broad types of intervention:

Level	Food waste reduction approaches (operational strategies)	Author(s)
Pre-consumer level	Pricing by portion	Zhao and Manning (2019b)
	Improvement of taste and quality	Kowalewska and Kołłajtis-Dołowy (2018); Abe and Akamatsu (2015), Zhao *et al.* (2019)
	Lunchtime extension	Silvennoinen *et al.* (2015), Steen *et al.* (2018); Abe and Akamatsu (2015)
	Improvement of the atmosphere of the dining area	Byker *et al.* (2014)
	Stability of tenure of the kitchen staff	Prescott *et al.* (2019a); Sarjahani *et al.* (2009)
	Accurate prediction of the No. of consumers and better food production planning	Prescott *et al.* (2019a); Steen *et al.* (2018)
	Minimizing buffet service	Silvennoinen *et al.* (2015)
	Hiring well-trained cooks	Wu *et al.* (2019)
	Using locally grown and in-season foods	Sarjahani *et al.* (2009)
	Batch cooking	Sarjahani *et al.* (2009), Yui and Biltekoff (2020)
	Menu revision	Falasconi *et al.* (2015)
	Matching portion sizes with age	Huang *et al.* (2017)
Post-consumer level	Going trayless	Kim and Morawski (2013), Thiagarajah and Getty (2013); Babich and Smith (2010)
	Teaching younger children to self-select	Nicklas *et al.* (2013), Zhao *et al.* (2019)
	Supervising meal consumption	Blondin *et al.* (2014)
	Allowing sharing and saving of leftovers	Zhao *et al.* (2019); Blondin *et al.* (2014)
	Taste testing for better food choices	Yui and Biltekoff (2020)

Table 5.
Operational strategies for food waste reduction

- education;
- communication; and
- financial and economic incentives.

Education and communication have been suggested to be the most effective approaches for behaviour change (Whitehair *et al.*, 2013).

Education: Past studies have recommended a holistic approach to decrease food waste, which involves multiple stakeholders in society, including parents and catering staff (Marais *et al.*, 2017; Wu *et al.*, 2019; Izumi *et al.*, 2020). Studies also have indicated the need to identify and increase the engagement levels of families that have the lowest level of engagement in food waste reduction behaviour (Boulet *et al.*, 2019). Students can receive education, as an intervention, through lectures on morals, sustainability and related environmental issues, or through a hands-on experience such as visiting landfill sites or segregating their plate waste themselves by putting the leftovers in separate bins (Wu *et al.*, 2019). Curricula should integrate student engagement and social norms related to eating without waste into food-waste-related discussions, along with nutrition education (Izumi *et al.*, 2020). Table 6 presents the key educational interventions introduced at the pre- and post-consumer levels. Besides discussing the interventions, some prior studies also tested their efficacy. For instance, Kowalewska and Kołłajtis-Dołowy (2018) revealed that students' exposure to film was more effective in reducing food waste among students than giving an informational leaflet to parents or guardians. Similarly, Whitehair *et al.* (2013) reported that a to-the-point prompt-type message effectively reduced food waste by 15%.

Communication: Interaction among varied stakeholders is essential to reducing food waste (Cohn *et al.*, 2013; Marais *et al.*, 2017; Derqui *et al.*, 2018). Clear and continuous

Level	Food waste reduction approaches (interventions)	Author(s)
Education		
Pre-consumer	Displaying posters with educational messages	Pinto *et al.* (2018)
	To-the-point prompt-type messages	Whitehair *et al.* (2013)
	Increasing the awareness and education of the catering staff	Marais *et al.* (2017)
Post-consumer	Distribution of information leaflets related to food wastage education for parents or guardians	Kowalewska and Kołłajtis-Dołowy (2018)
	Exposure to films on related topics	Kowalewska and Kołłajtis-Dołowy (2018)
	Providing nutrition education to children	Liz Martins *et al.* (2016)
	Displaying banners to motivate individuals to "ask for less" according to their hunger level	Jagau *et al.* (2017)
Communication		
Pre- and post-consumers	Continuous communication	Prescott *et al.* (2019a); Derqui *et al.* (2018)
Financial and economic incentives		
Post-consumer	Financial and economic incentives	Sarjahani *et al.* (2009)
	Rewards in the form of small prizes and emoticons can ensure a better selection	Hudgens *et al.* (2016)

Table 6.
Interventions for food waste reduction

communication among kitchen managers, kitchen staff, students and school authorities boosts the success of food waste reduction efforts (Prescott *et al.*, 2019b; Zhao and Manning, 2019b).

Financial and economic incentives: These incentives encourage consumers to finish their meals (Sarjahani *et al.*, 2009). However, there is a challenge here. Providing financial incentives to motivate food waste reduction behaviour among students is effective. However, a non-intended adverse outcome of such incentives for finishing the food on one's plate could be overeating and obesity. Therefore, any intervention related to food waste in food service establishments in educational institutions should be integrated with healthy eating policies (Katare *et al.*, 2019).

3.6 Food diversion and food waste disposal processes

The processes related to the diversion and disposal of the daily waste of food service establishments in educational institutions are important aspects of food waste reduction and control efforts. The primary objective at this stage of handling food waste should be to divert it from landfills through recycling (Wilkie *et al.*, 2015). Such diversion processes are a way of reducing food waste, as they decrease the actual amount of scraps destined to be

buried in landfills (Prescott *et al.*, 2019a). The reviewed studies discussed the following approaches to handling food waste: reuse (e.g. staff meals), recycling (e.g. composting) and disposal (Derqui and Fernandez, 2017).

Food diversion implies the following:

- the redistribution of edible, non-perishable and perishable food by donating it to food banks, shelters and other food-insecure groups (Burton *et al.*, 2016); and
- the recovery of food waste through anaerobic digestion and composting, which are the processes of converting leftovers into useful end products, such as nutrient-rich soil amendments and bio-energy (Sarjahani *et al.*, 2009; Wilkie *et al.*, 2015; Burton *et al.*, 2016; Wu *et al.*, 2019).

The key disposal method discussed by the past studies is the landfill. The approaches discussed by the extant studies range from pulping waste for landfilling to lunchroom food-sharing programmes and leftover lunch service in the form of redistributing leftovers (Babich and Sylvia, 2010; Laakso, 2017; Prescott *et al.*, 2019a).

Although a limited number of studies have discussed the food diversion and disposal processes in detail, most seem to agree on the donation of edible recovered food as a feasible option to redistribute waste. For instance, Deavin *et al.* (2018) revealed the popularity of a novel breakfast programme based on donated food to increase food security. Schupp *et al.* (2018) discussed a "backpack programme" where food-insecure students were to carry temperature-controlled leftovers home. Many other studies have discussed food donation to reduce food waste but emphasized that it is possible only through the collaborative efforts of food service establishments and the beneficiaries of such donations (Hackman and Oldham, 1974; Sarjahani *et al.*, 2009; Blondin *et al.*, 2015; Marais *et al.*, 2017; Balzaretti *et al.*, 2020; Derqui *et al.*, 2020). The results of our study indicate that much of the generated food waste is landfilled, even though landfilling represents a missed opportunity to recover food and promote sustainable behaviour (Prescott *et al.*, 2019b). Finally, prior studies have contended that the sustainability initiatives of diversion, recovery and redistribution can be made successful and effective through proper waste sorting and waste audits by food service establishments (Prescott *et al.*, 2019a).

3.7 Barriers impeding the implementation of food waste reduction strategies

Scholars have discussed various factors that impede the successful implementation of strategies to reduce food waste and the general efforts to achieve such goals. Some studies have referred to certain competing priorities and objectives (e.g. customer satisfaction, concern for food safety, diet quality) that may restrict efforts to reduce waste (Blondin *et al.*, 2015; Prescott *et al.*, 2019b). These impediments and conflicting priorities act as barriers to the implementation of food waste mitigation plans and exist at the:

- pre-consumer;
- operational;
- post-consumer;
- food waste tracking; and
- food diversion and recovery levels.

Pre-consumer level: The barriers to mitigating food waste exist at the pre-consumer level, even though the food service establishment is the one that will benefit financially if waste is reduced. Silvennoinen *et al.* (2019) identified three barriers at this level:

(1) a lack of willpower and a negligent attitude;
(2) the pressure to quickly finish one's work; and
(3) less experienced and incompetent personnel.

Prescott *et al.* (2019b) revealed that limited storage capacity for dry/cold storage also acted as a barrier to success in reducing food waste by impacting the inventory management plans of kitchen managers.

Operational level: The barriers to the implementation of operational strategies to reduce food waste include the following:

- short lunch breaks and too few kitchen staff to allow the adoption of the batch cooking approach as a waste mitigation strategy (Prescott *et al.*, 2019b);
- the increased breakage of meal utensils and the need to wipe dining tables more frequently, which made it challenging to use the strategy of going trayless to reduce waste (Thiagarajah and Getty, 2013);
- parents scolding their children for bringing home leftovers and providing bins at school, which presents an easy way to dispose of unconsumed food through the reuse of leftovers (Boulet *et al.*, 2019); and
- the timing of recess (Chapman *et al.*, 2017).

Post-consumer level: The behavioural and perceptual aspects at the post-consumer level also help impede efforts to reduce food waste. In this context, Zhao *et al.* (2019) cited the differences in satiation level and social influences as key barriers. Consumers tended to throw away food that they disliked but found it unacceptable to waste the food that they liked. Similarly, Prescott *et al.* (2019b) argued that factors such as weather, changing tastes and preferences, and seasonal changes also acted as barriers to the success of the efforts to reduce food waste. Other barriers to food waste reduction also stemmed from consumers' intention–behaviour gap (Lazell, 2). In addition, unsupportive school policy in terms of not allowing students to share food they did not want with others or take leftovers home also hampered food waste reduction efforts (Zhao *et al.*, 2019).

Food waste tracking system level: Barriers to implementing food waste tracking systems also exist. Burton *et al.* (2016) identified logistical issues in this context:

- the time devoted to weighing and keeping a record of food waste;
- difficulties in weighing certain items, such as soups;
- the ongoing training required for the weighing of waste because of employee turnover; and
- spatial constraints.

Food diversion and recovery levels: Barriers to food diversion and recovery also exist. Prescott *et al.* (2019a) identified four significant factors that act as barriers to successful food diversion and recovery:

(1) food safety concerns and food quality standards, which impose limits on the donation of edible leftovers for human and animal consumption;
(2) the prohibitive cost of transportation, heat treatment of waste for making it safe for animal consumption and setting up onsite composting units compared with the low cost of landfilling waste, making redistribution a financially unviable solution;

(3) adverse publicity for the effectiveness of nutrition programmes, highlighted by the waste generated and where legal liability also acts as a disincentive; and

(4) the lack of a clear understanding of the kinds of recovery activity the law permits.

4. Research gaps and potential research questions

We critically assessed the emergent themes to identify the gaps in the literature on food waste reduction measures. We mapped the identified gaps onto the seven themes to present theme-based gaps. We also suggested potential research questions that future researchers can address to close these gaps. The multiple gaps in the literature concerned the seven themes. Table 7 demonstrates potential research questions.

5. Framework development

Based on our content analysis, we identified the key themes on which the extant research on food services in educational institutions focused. The learning emerging through these themes has helped us develop a deeper understanding of the area. Our review has revealed that the entire food service–food waste debate represents a complex ecosystem consisting of different stakeholders and processes that interact but are driven by diverse priorities, as some of the reviewed studies also have argued (Prescott *et al.*, 2019b). Consequently, we have built on this learning to apply the systems approach.

We adapted our approach from the open-systems approach of Katz and Kahn (1966). According to them, the open-systems approach consists of the following:

- a repeated input–process–output–feedback cycle; and
- the influence of the external environment.

We adopted the systems approach to develop a framework that presents various aspects of food waste in the food service establishments in educational institutions as an open system that provides a holistic view of food waste in educational settings (Figure 8). We call the framework developed by us the "food waste ecosystem (FWE)". FWE consists of the following:

- the internal and external environment;
- inputs;
- transformative processes;
- competing forces;
- output; and
- feedback loop.

FWE posits that food waste generation and mitigation in educational institutions depend on the interaction of various subsystems that are interdependent and integrated into an organized whole.

To begin with, the food waste system is conceptualized as an open system influenced not only by cues from the internal environment but also by cues and stimuli from the external environment. The internal environment represents the environment within the food service establishment in educational institutions and includes factors such as school policies and methods of food production. It impacts how transformative processes are executed. The

Theme	Gaps	Potential research questions (RQs)
Drivers of food waste	Food waste in university food services is under-explored both at the pre- and post-consumer stages Food waste in school food services is under-researched at the pre-consumer level. The behavioural aspects helping increase or reduce food waste have remained confined mainly to norms regarding and attitudes towards waste, with various factors (e.g. preferences, willingness to take home leftovers, the tendency to over-order, shopping routine and table manners) remaining ignored by scholars The focus of school food service studies has been the nutritional aspect of meal consumption, with food waste just serving to assess nutritional loss There is very little information about the number and types of food service establishments in educational institutions or about the level of importance of such establishments in schools/universities, which limits the contextual insights about food waste Limited studies have delved into the role of parents in controlling the food waste of young children	Does the lack of a system for tracking food waste increase the same at the production level? Does the food service establishment under consideration consider the gender and age of consumers when deciding fixed portion sizes versus serving meals buffet style? To what extent do faulty inventory planning, procurement practices and menu composition contribute to food wastage in school catering? Does the availability of competitive foods such as fries, fast food and sodas affect the shopping routine and consequent waste in the pay-and-eat food service establishments in educational institutions? Does the number of food service establishments or their type affect the food waste generated in educational institutions? What are the differences between the antecedents of food waste by children in school and the antecedents of food waste in food service establishments outside schools in the presence of parents?
Quantitative assessment of food waste	In spite of their cost-effectiveness, visual plate wastage methods are not used as much as the weighed plate waste method Most prior studies have measured food waste for a limited duration, ranging from three days to two weeks Food waste audits are an important way of assessing food waste, but only a few studies have conducted food waste audits Limited studies have discussed the methods of quantifying food waste that are being used by educational institutions, which limits the insights about the ground realities concerning the efforts to quantify and control food waste	Is there a substantial difference between the food waste measurement using visual methods (photograph, half waste and quarter waste) and the weighted plate waste method? Does the quantity of food waste in school and university food service establishments change with the change in seasons? What is the difference in the quantity of food wasted at the production, serving and plate levels after the introduction of food waste tracking systems in food service establishments in educational institutions? Will measuring plate waste in grams present a better picture of plate waste, or is it better to express it in percentage terms (meaning serving size)? Are educational institutions effectively using existing food waste quantification methods to provide inputs for food waste control?

(*continued*)

Table 7.
Theme-based gaps and related potential research questions

Theme	Gaps	Potential research questions (RQs)
Assessment of the behavioural aspects of food waste	Few studies have tried to understand the behaviour of consumers, even though behaviour is a major cause of food waste, particularly in developed countries Demographic inputs, particularly ethnographic insights on the propensity to waste food, are limited in the past literature, even though researchers consider them important	What are the pro-environmental drivers of food waste reduction behaviour that may help with the formulation of effective food waste reduction strategies? What is the relationship between the cultural practices of a place/nation and food waste? How important are hedonic enjoyment, personal norms, guilt, social influence and greed in promoting/reducing food waste-related behaviours?
Operational strategies for reducing food waste	Few studies have discussed the mapping and assessment of the potential benefits of initiating waste reduction measures at the micro level of the food service establishment Few studies have discussed food waste in terms of the emission costs associated with the consumption of food items and the consequent effect on food waste-related emissions Limited studies have tested the efficacy of the introduction of waste reduction approaches such as tasting, allowing food sharing, caretaker supervision and younger consumers' self-selection of food items Limited case studies have observed the practical measures schools and universities have used to reduce food waste and to report the observations of these	Apart from the apparent implication of obtaining cost savings through reduced food waste, what are the other potential benefits of food waste reduction that can motivate food service establishments to reduce their food waste at the pre-consumer level? What is the likely effect of reducing the content of relatively high-emission foods such as proteins and meats in a meal and compensating for these with a higher amount of low-emission foods on the nutrition and satisfaction of consumers in educational institutions? How useful and effective are food waste reduction strategies based on saving leftovers and sharing food during lunch in educational institutions? What is the efficacy of the food waste reduction measures that educational institutions currently use?
Interventions for inducing behavioural changes to mitigate food waste	Most of the studies that have discussed interventions have tested the efficacy of only one or two interventions and have not compared the effectiveness of the different interventions discussed There is a limited understanding of how financial incentives to reduce food waste should integrate with ways of promoting healthy eating behaviours to avoid obesity and non-nutritional calorie intake	Are informative and educational posters more effective in reducing food waste in schools than a nutritional and educational course offered once a year? What are the practical approaches to offering financial incentives to reduce food waste without promoting obsessive cleaning of the plate and the resultant obesity issues?
Food diversion and food waste disposal processes	There are very few studies that have discussed the waste sorting systems used in food service establishments in educational institutions Very little knowledge is available in the literature about edible food recovery approaches and the diversion of recovered edible food to consumption through charity and donation Leftover lunch service appears a viable food	What are the operational and functional issues in implementing a waste-sorting system in food service establishments in educational institutions? What are the enablers and barriers that food service establishments may encounter in their efforts to divert food waste to food-insecure students? What is the feasibility of initiating a

Table 7. (*continued*)

Theme	Gaps	Potential research questions (RQs)
	diversion option in an educational setting, yet only one study has examined it, and in a limited context, at that	leftover lunch service in school and university cafeterias daily?
Barriers to the implementation of food waste reduction strategies	There is a lack of understanding of the intention–attitude gap that may act as a barrier to the success of food waste prevention interventions	What are the moderating influences that are likely to increase or decrease the attitude–intention gap?
	No study has discussed the behavioural aspects of food waste in terms of the resistance offered against strategies initiated to mitigate such waste	What are the roles of health consciousness, hygiene consciousness, food safety concerns and habits in increasing consumer resistance to food waste reduction strategies?

Table 7.

external environment represents the environment outside the educational institution and includes factors such as government regulations, composting facilities and food banks.

Inputs are the first block in FWE. Inputs represent the first step in a systems model, and represent the decisions at the beginning of the process that finally result in waste generation. Typically, at this stage, they include decisions such as what is to be served per meal, the food service regime that mandated a particular type of meal to be served, dietary guidelines (particularly in the context of schools), the dining facility and the number of consumers. These decisions affect the amount and type of food prepared, the use of local produce, the storage facilities required, the beverages served, the use of temperature-controlled food items, the portion size, the method of service (self-serve, tray system or trayless system) and the ambiance of the dining area. The decisions at this stage set the tone for the extent to which food waste is generated in the next step in the systems model: the transformative process.

The four key transformative processes at this stage are food production, food service, food consumption and food diversion. Each of these processes presents a potential point of food waste generation. As discussed in the themes, food production is a part of the pre-consumer phase, where the kitchen staff's role is important. Food service represents serving food for consumption. The food consumption stage is where consumers enter the picture. Food diversion is a process that takes place after the consumption phase is over.

These four activities are the subsystems of the transformative process that is a chaotic tradeoff of competing forces and conflicting priorities. FWE identifies seven broad competing forces based on the reviewed literature: functional issues, behavioural factors, demographic influences, contextual issues, interventions, waste tracking systems and supportive policies. For instance, the functional issues that can generate food waste are overproduction, a lack of trained staff, the mishandling of ingredients and the lack of awareness of the seriousness of food waste among the staff and consumers. Similarly, the size of the portion in staff-served meals, the amount of food added to serving dishes, meal presentation and spillage during handling can generate food waste. Functional issues associated with the donation of edible waste for human consumption, the treatment of waste for animal consumption, composting, anaerobic digestion or landfills also affect the amount of waste generated.

Regarding behavioural factors, the negligent attitude of a kitchen and service staff, the lack of willingness to prevent waste, food preferences, level of satiation, the influence of the social group and family, and the inherent intention–behaviour gap may lead to food waste. Demographic influences in terms of age, gender, household income and ethnic background also influence the amount of food consumed or left unconsumed,

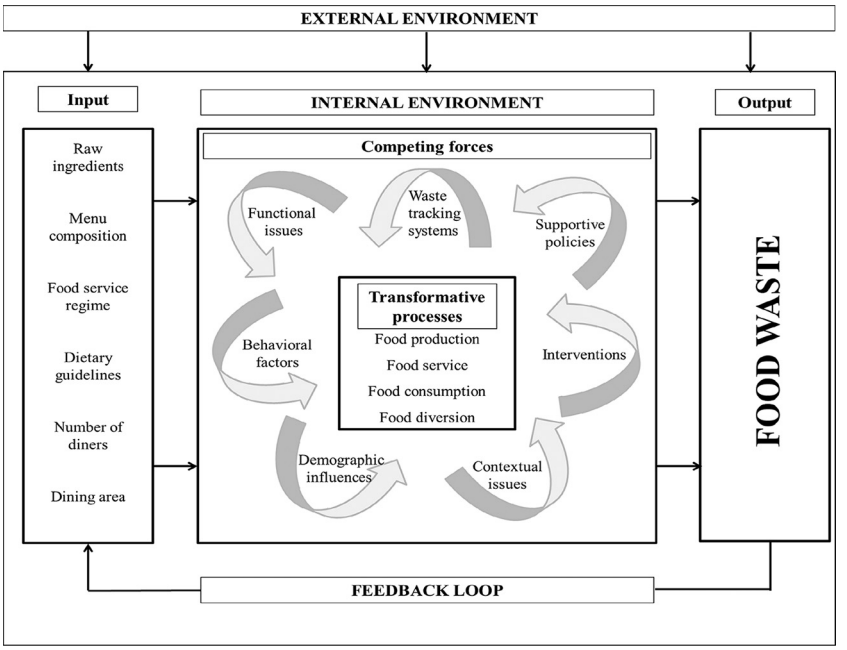

Figure 8.
Systems approach to food waste mitigation: The food waste ecosystem (FWE) framework

contributing to food waste. Contextual factors such as the quality and taste of meals, the unpleasant ambiance of the dining room, the extent of supervision (for younger consumers) and the eating duration can potentially increase food waste.

The four competing forces (functional, behavioural, demographic and contextual) represent the reasons behind the increased food waste in the food service establishments in educational institutions. However, interventions, robust waste tracking systems and supportive policies can reduce food waste. The challenge is that most of the interventions require some expense and effort in terms of time and money. For instance, offering financial incentives may reduce food waste, but for food service establishments, such food waste savings will make economic sense only if the money saved from less food going to waste is more than or at least equal to the financial incentive. Similarly, interventions such as education campaigns may cost money, and whether they are worthwhile will depend on the money saved from less food going to waste. One way of compensating for costs is for a government's support policy to make the expenses incurred for food waste mitigation efforts tax-deductible. In addition, the initiatives for food diversion, such as food donations, have an associated legal liability that suitable policy guidelines can reduce.

The supportive policy of educational institutions can help by granting permission to take home leftovers, share food, provide better dining areas and make provisions for adequate eating time between academic commitments. In the case of the food tracking system, the immense effort required for sorting, weighing and training the staff to operate such a system represents a cost that must be offset by balancing the savings in food costs. In this way, the food waste ecosystem is an interdependent mass of competing forces that interact to increase or decrease the quantity of food generated, and the food waste mitigation decisions at the micro level are a trade-off between costs and benefits. The output of the transformative process is the quantity of waste generated.

The amount and composition of the waste provide feedback, which can help revise decisions at the input level.

6. Conclusion, implications, limitations and future research areas

6.1 Conclusion

This study presents the status of food wastage in food service establishments in educational institutions, as reflected in the extant literature. To the best of the authors' knowledge, there are no contemporary SLRs that have analyzed food wastage in the food service establishments in educational institutions as a separate vertical. The current study addresses this gap to offer insightful implications for theory and practice. First, it sets the conceptual boundary by including all food service establishments in schools and universities. We selected this subdomain because the focus of the studies has largely been school lunch, where researchers have mainly assessed food waste to compute nutritional loss. In comparison, studies focused on food waste as a central concern, and studies examining food waste in higher education are limited. This indicates a need to catalyze research in the area. Thereafter, the study rigorously follows the SLR method to identify, synthesize and critically evaluate the 88 studies on the topic to reveal their research profile and thematic foci. The seven themes we identified through content analysis are the drivers of food waste; quantitative assessment of food waste; assessment of behavioural aspects of food waste; operational strategies for reducing food waste; interventions for inducing behavioural changes to mitigate food waste; food diversion and food waste disposal processes; and barriers to the implementation of food waste reduction strategies. The review goes beyond presenting the state-of-the-art in the area to uncover the gaps in the extant investigations and to suggest potential research questions that could motivate future academic research from the hospitality perspective. In addition, we developed a framework based on the open-systems approach to depict the complexity of the area and the multiple factors that influence its decision-making.

For the novel contributions of this study, it is the first SLR to review food waste in food service establishments in educational institutions. To the best of the authors' knowledge, no prior review study has systematically reviewed and evaluated the extant research on food waste in the education sector. The only other review study on food waste in the area was the review of the NSLP in the USA (Byker Shanks *et al.*, 2017). This review focused on the methods of quantifying food waste and the respective results of each method in the NSLP context from 1978 to 2015. The current SLR goes beyond both quantification and NSLP. Another novel contribution of this study is that the gaps that we identified in the extant research are theme-oriented, paving the way for encouraging future academic research through tangible suggestions in the form of theme-based potential research questions. This study also presents a systems view of the dynamics of food waste in food service establishments in educational institutions by identifying the input decisions; the transformative processes; the influence of low-threshold interventions and barriers; and the output in terms of the quantity of food waste. Finally, the practical inferences offered by the study are actionable, useful, contextual and easily transferable across various food service establishments serving educational institutions.

6.2 Theoretical implications

SLR has four key theoretical implications. First, although several researchers have investigated food waste in food service establishments in educational institutions, most have skewed towards the nutritional implication of unconsumed food in the school lunch context, with the quantification of food waste merely serving as a basis to capture

nutritional loss. The hospitality literature has yet to focus on the issue of food waste in institutional settings in spite of its strong implications for sustainability and direct association with food services, an inherent part of the hospitality sector. By presenting the key themes, we have provided a ready platform for hospitality researchers to expand the scope of their investigations to include food wastage in educational institutions.

Second, we identified theme-based gaps (Table 7) in the extant research that need to be addressed through empirical investigations from a hospitality perspective. Besides identifying theme-based gaps, we also suggested potential research questions (Table 7) in consonance with prior reviews (Swani *et al.*, 2019), which can help set the future research agenda in the area. Furthermore, our study revealed that future studies need to focus on food waste as contributing to increased carbon footprints and food insecurity. Such studies will take the focus beyond the nutritional emphasis on ecological implications for the greater good.

Third, in addition to identifying the theme-based gaps and potential research questions, we conducted research profiling of the retrieved and screened literature to identify the scope of the future research concerning the need for theory-based examinations, geographies that need attention and the type of educational institutions that have remained neglected in food waste research. The need for theory-driven investigations, which are now quite deficient, is supported because "theory" alone can yield consistent conclusions from causal patterns in data (Han,2015). The need to explore diverse geographies is justified, considering that food consumption and leaving food unconsumed may be rooted in culture (Yoder *et al.*, 2015; Pinto *et al.*, 2018; Izumi *et al.*, 2020). The need to focus on hitherto under-explored subsectors in higher education is justified because more granular findings are required to help food service establishments, regulators and university authorities plan and execute sustainable food waste control strategies targeting a group that makes independent decisions. Finally, the FWE framework that we developed presents a systems approach to food waste management that provides researchers with a bird's eye view of the key areas to investigate in a study examining food waste generation and mitigation in food service establishments in educational institutions.

6.3 Practical implications

SLR has six key practical implications. First, a systematic tracking system can help create awareness and motivate anti-food-waste behaviours at the pre-consumer level, as prior studies have discussed (Burton *et al.*, 2016). Therefore, catering companies offering food services in educational institutions should implement software with a simple interface to capture food-waste-related data, forecast the number of meals, identify popular menu items and classify waste into edible and non-edible.

Second, the overemphasis on nutritional content and rigid food-serving guidelines can increase food waste, as school authorities may determine portion sizes accordingly. This could be counterproductive from both the nutritional and waste perspectives if the food served is not consumed. For instance, the larger portion sizes that the school determines may cause overnutrition and obesity (Balzaretti *et al.*, 2020). Therefore, the dietary guidelines that the concerned authorities issue should be indicative so portion sizes are adjusted according to hunger level and personal preferences. Competitive foods that usually have higher fat and sugar contents (Templeton *et al.*, 2005) can be removed or vended at other times to ensure that the served meals are consumed to satiate hunger.

Third, formal guidelines for quantifying food waste should be prepared and made available to the food service managers in the cafeterias. There also should be a board or display where the aggregate daily food waste at the pre- and post-consumer levels is

displayed for everyone to see. This likely will increase food waste awareness and encourage kitchen staff and students to reduce food waste.

Fourth, as food waste is a critical issue, school and college authorities hiring catering services (including cooks and kitchen staff) can also adopt a more structured approach to discouraging food waste. For instance, an inefficiency index (Falasconi *et al.*, 2015) can be calculated weekly as the percentage of food wasted at the pre-consumer and serving stages compared to the amount of food prepared. Such an index will highlight the deficiencies in the kitchen processes, the slackness of the staff and the inaccurate forecasting of the number of consumers.

Fifth, the proper sorting of food waste can reduce it in two ways: by increasing the chances of recovering edible leftovers for donation and by making concerned stakeholders aware of the waste they are generating. Therefore, regulators or administrative authorities at the educational institution level can make it compulsory for every dining hall to have separate bins with labels for the disposal of different types of waste, including liquid waste, according to Schupp *et al.* (2018). Furthermore, consumers should be asked to throw their individual plate waste in the designated bins.

Finally, from a regulatory standpoint, the policy guidelines for food waste reduction should consider the cost of waste reduction processes and offer financial incentives such as tax rebates for initiatives to reduce waste through food diversion. The issue of the legal liability associated with donating food to non-profit organizations for charity is a great disincentive, preventing the giving away of food for charity. To overcome this impediment, donors can be freed of any such legal liability. This practice exists in countries such as Italy and the USA (Derqui *et al.*, 2018). Furthermore, policymakers should promote an approach to menu design based on the inclusion of more low-carbon-emission food items and fewer high-carbon-emission food items. This is likely to provide food cost savings at the food service level and environmental cost savings at the societal level.

6.4 Limitations and future research areas

We conducted a deep analysis of the extant research on food waste in food service establishments in educational institutions to uncover key themes and gaps. This has made a significant contribution to theory and practice by presenting potential research questions and implementable practical suggestions. However, readers should evaluate the contributions of this study in the context of the following limitations. First, we used Scopus and Web of Science only to search congruent studies and did not juxtapose any other digital library or database. This could have resulted in the exclusion of studies not listed in these two databases. Second, we included articles published only in English and could have missed important regional findings in the local language. Third, like any other SLR study, we faced the challenge of executing extensive search and screening, complexities in synthesis and presentation of findings in a manner that would be palatable to a wide variety of readers. Accordingly, we could have missed information because of inadvertent human error. Fourth, although we followed a systematic approach to identify keywords for searching the congruent literature, the area of food waste is quite vast. We may have excluded keywords. However, we used a robust search and screening protocol to present rigorous analysis to serve as a reliable basis for guiding future research and practice. Future researchers can extend our work by including keywords such as “campus dining”, “food rescue”, “food scarcity on campus”, “food recycling”, “food waste tracking”, “meal plans”, “food supply chains” and “food clubs on campus”. Future work can advance this study by reviewing reports from governments and policies implemented to highlight the gaps between academic research and government initiatives or between evidenced-based and

non-evidenced-based methods. In addition, researchers should examine food waste in schools/universities in developed and developing economies, because the extant literature primarily skews towards US-based educational institutions. In this regard, researchers can also focus on cross-cultural/national comparison to provide deeper and more generalizable insights. Food waste studies in educational institutions can also include employees who consume food in the school/university dining facility, as examined in the case of frontline employees working in various hospitality establishments (Luu, 2020). Furthermore, as the drivers and, ultimately, the remedial actions/strategies for handling the issue of food waste may differ between public and private educational institutions, future researchers can build on our findings by separately reviewing the sample of studies on public and private educational institutions. Finally, future studies can explore whether increasing organic food consumption (Tandon *et al.*, 2020a, 2020b; Tandon *et al.*, 2020c) has impacted food waste behaviours in educational institutions.

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