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Research Article

Addressing the Consumer Food Waste Crisis: A Decade of Psychological Interventions

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Abstract

Food waste has become an increasing global crisis, especially in the last few years. Researchers and policymakers have attempted to work towards meeting the Sustainable Development Goals (SDGs) proposed by the United Nations. While much research has been conducted, we are still far from achieving the SDG by 2030. Many interventions have been studied, but each outcome varies. Thus, this review summarizes 30 psychological-based interventions between 2010 to 2022, retrieved via the Scopus database. It is found that each method of intervention works differently based on each type of food waste. Institutional food waste appears to be the most common setting in conducting food waste reduction interventions. Combining knowledge and practical-based interventions are concluded to work best in tackling household food waste; disseminating information, including teaching methods in classrooms and practical interventions for food waste in the educational institution settings; informational messages and prompts for food and beverage settings; ensuring convenience and accessibility, clarity of information and social cohesion as essential intervention factors for tackling municipality and public consumer food waste behaviour. Psychological interventions such as building trust and motivation effectively address cognitive and behavioral modification in food waste reduction. Future research can consider these intervention methods and more consistent follow-up via a longitudinal approach.

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Introduction

Over the past ten years, policymakers, practitioners, and academics from various fields have begun to view food waste as a global problem [1]. The term "food waste" refers to discarding edible foods at retail and consumer levels, particularly in industrialized countries. The environmental consequences of this waste are substantial, as evidenced by the resources and ecological burden necessary to create the food and emissions related to any food waste [2].

In 2020, the United Nations (UN) estimated that 2.37 billion people worldwide - a rise of over 320 million people in just one year—did not have sufficient access to food. However, approximately one-third of all food produced annually, equivalent to 1.3 billion tons and valued at around $1 trillion, ends up decaying in the waste bins of consumers and retailers. This widening gap between food production and consumption, coupled with the detrimental effects of food waste, exacerbates the problem [3]. The second among the United Nations' 17 Sustainable Development Goals (SDG) is to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture". Additionally, goal 12.3 of the SDG states that "by 2030, global food waste at the retail and consumer levels per capita should be halved, along with reductions in food losses across production and supply chains, including post-harvest losses". To effectively address this issue, it is essential to recognize the need for a significant transformation in the management of global food and agricultural systems.

When examining the twelfth SDG of the UN, which focuses on "responsible consumption and production," it

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becomes evident that both businesses and consumers have a role in mitigation efforts. Practical elements are outlined to encourage the public's participation in achieving the SDG. These elements include making informed pur-chasing decisions, minimizing waste, and avoiding food disposal. A crucial initial step is identifying "hot spots" along the value chain where interventions can substantially impact the system's environmental and social aspects.

Research has delved into various factors, determinants, motivators, and barriers related to food waste behavior. Aydin and Yildirim [4] discovered that moral attitudes and shopping habits play a significant role in influencing food waste behavior. On the other hand, Graham-Rowe et al. [5] identified several barriers to minimizing food waste, including a desire to maintain a 'good' provider identity, a preference for convenience over waste reduction, a lack of prioritization of waste reduction, and a sense of exemption from responsibility. Motivators for reducing food waste, as identified by the same study, included concerns about waste and a desire to do the 'right' thing.

Understanding the motivators and barriers related to food waste behavior is important, but it is equally crucial to recognize the significance of practical components in driving behavioral changes among consumers and achieving the SDGs. Consumer behavior plays a significant role in food waste, with a substantial proportion originating from consumers themselves. For example, Stenmarck et al. [6] reported that consumers accounted for 53% of food waste in the European Union in 2012.

However, a knowledge gap exists regarding the long-term effectiveness of past interventions in reducing consumer food waste. Although interventions have been implemented to address this issue, evaluating whether they result in sustained behavioral changes and long-term reductions in food waste is necessary. Ongoing research and evaluation are needed to identify effective strategies that can lead to lasting changes in consumer food waste behavior.

A review by Reynolds et al. [1] revealed significant findings regarding food waste reduction interventions. Plate size interventions were associated with a reduction of approximately 57% in food waste. Implementation of school nutritional guidelines resulted in a decrease in vegetable waste by 28%. Information campaigns were successful in reducing food waste by up to 28%. However, it is important to note that while these interventions effectively reduced food waste, their impact ranged from 5-20%. This highlights the necessity of conducting a comprehensive examination of factors influencing the efficacy of food waste reduction interventions or the need for a combination of strategies to achieve a more substantial impact on reducing food waste behaviour.

Methods to promote and proactively cooperate with consumer behaviours that reduce waste remain unclear [3]. Seeing the importance of behaviour modification of consumers in addressing this global crisis, identifying which methods of intervention would be most effective in food waste reduction for different sources of consumer food waste calls for urgent attention [3]. To date, there are no publications show a comprehensive overview of effective food waste reduction methods. Therefore, this systematic literature review aims to gather and analyze the types of interventions previously conducted to reduce food waste and gear the public towards long-lasting food waste reduction habits with three objectives:

1) To examine psychological interventions conducted in various countries from different sources of consumer food waste.

2) To analyze current psychological interventions and their efficacies to address gaps in the literature.

3) To summarise the effective intervention approaches for different sources of food waste.

Method

This systematic review utilized the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) standard [7-8]. The PRSMA guideline is adopted to provide a clear, and reproducible and reliable information with minimum biasness. A PRISMA flow diagram (Figure 1) summarized the detailed process of identifying, screening, and selection of articles with inclusion and exclusion criteria at each stage [9]. In addition, a computerized literature search and resourcing of articles were conducted through the Scopus database until the 4th of August, 2022.

Studies that met the following criteria were included in the systematic review:

i) Studies that indicated factors, motivators, and barriers for food waste reduction behaviour mainly in households, educational settings, restaurants and municipalities.

ii) Studies that included interventions aimed to improve and promote food waste reduction behaviour.

iii) Studies that focused more on psychology and/or behavioural approaches.

iv) Studies that were published in English.

v) Studies in the final publication stage.

Table 1 Search String (SCOPUS database)

"food waste*" OR "domestic food waste*" OR "household food waste*" OR "restaurant food waste*" OR "university food waste*" OR "kitchen food waste*" OR "school food waste*" OR "campus food waste*") AND ("motivator*" OR "driver*" OR "factor*" OR "determinant*" OR "barrier*" OR "predictor*" OR "behavio?r" OR "attitude*" OR "intention" OR "habit."

From this search string (Table 1), 310 articles were retrieved and downloaded as full-text. Articles were then screened for eligibility based on the inclusion criteria. Titles were screened based on relevance to the keywords. Articles centred on non-behavioural fields such as biology, chemistry and business were excluded and categorized as "out of scope." All systematic reviews, meta-analyses and conference papers were excluded. Out of the 310 articles, no duplicates were found, and 135 articles were out of scope. The remaining 175 articles were categorized as "to be reviewed" and further analyzed and assessed for inclusion in the qualitative synthesis. Upon further analysis and review of the 175 articles, 125 articles were gathered relevant to food waste reduction behaviour, particularly the usage of psychology constructs, theoretical and/or intervention application. The remaining 50 articles were categorized as "lack of data" and excluded due to a lack of supportive findings and a lack of relevance to the goals of the current review.

The 125 articles were then further reviewed and segregated into four different categories of food waste, i.e. household food waste (n=42), institutional food waste (n=23), food and beverage food waste (n=15), and municipality-public consumer food waste (n=45). Of the 125 articles, 30 articles centred on food waste reduction behaviour interventions were included in Supplementary Material (SM) 1. Of these 30 intervention articles, five were on household food waste, 12 were on institutional food waste, five were on food and beverage, and eight were on municipal and public consumer food waste. The selected data was arranged according to countries where the study was conducted, type of food waste sources, use of a theoretical framework, demographics, methodology and measurement time interval/ duration of the study. The selection process is illustrated in the PRISMA flow chart in Figure 1. The 30 studies centred on household food waste reduction behaviour interventions are tabulated in SM 1. The data coding framework was designed based on key variables and categories as follows (Table 3). The coded data was analysed to compare and contrast the patterns, trends, and insights.

Table 3 Data coding framework in this study

Intervention type	Country	Demographics (Characteristics of the participants)	Methodology (Study design & data collect method)	Intervention details	Results (Outcomes of the intervention)
Household		Age	Cross-sectional	Description of the intervention	Percentage reduction in food waste
Educational institutions		Gender	Longitudinal	Duration	Behavioural changes
Food and beverage		Income level	Data collection methods (e.g., surveys, interviews)		
Municipality and public Consumer					

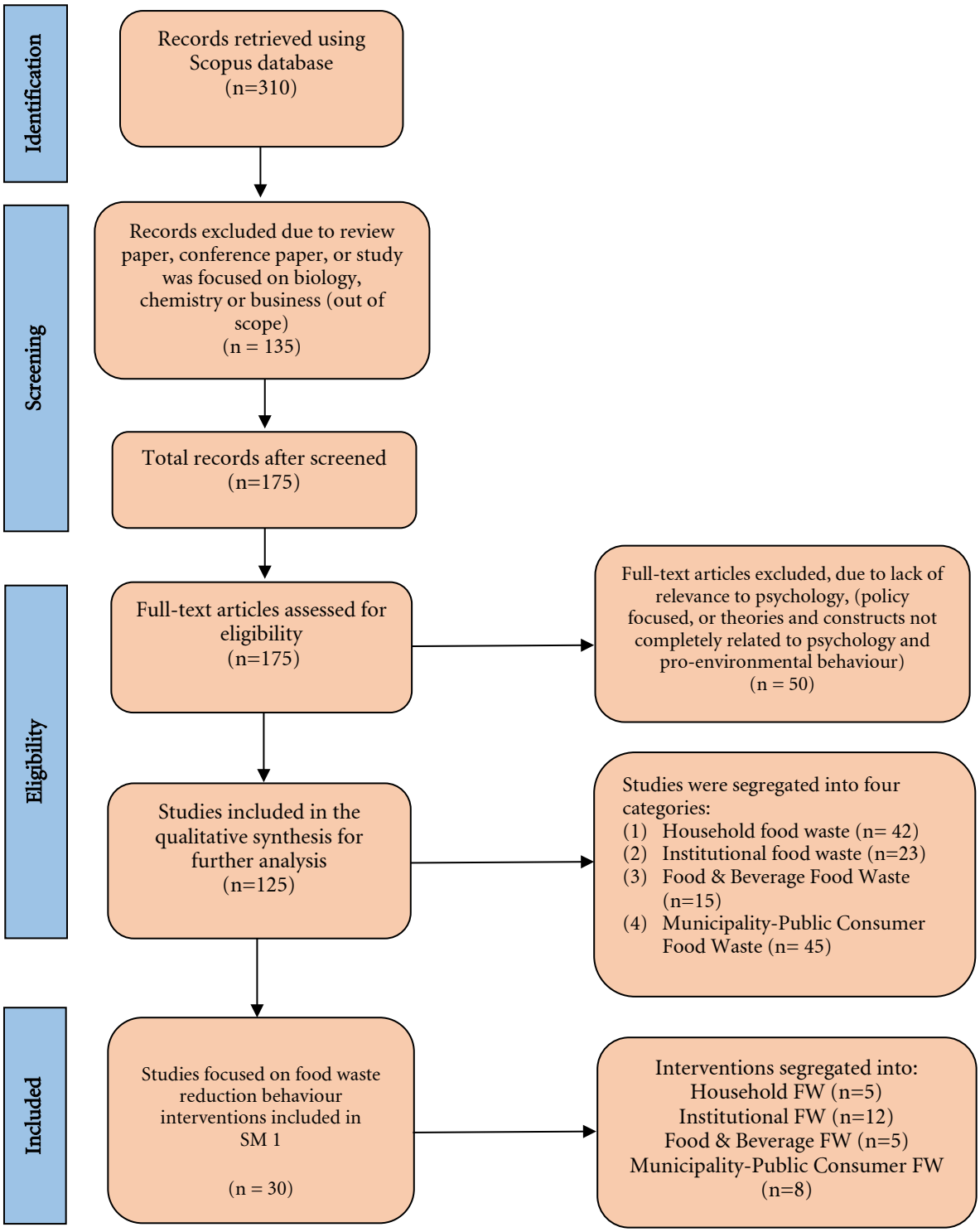

Figure 1 PRISMA flow chart.

Results and article analysis

1) Psychological constructs

This section highlights the eight psychological constructs found in the search analysis, as shown in Figure 2. Out of the 125 articles included in the in-depth review, only 30 were intervention-based studies that incorporated psychological constructs. This shows that limited study on practical application and a need for more research focuses on designing and implementing the interventions to address food waste issues. In contrast, the remaining 95 studies focused on these psychological constructs but were not intervention-based (e.g. survey, focus group, food waste audit). Majority of the 125 studies studied factors and determinants of food waste behaviour (n=66), but only 9 out of 66 studies were interventions. Predictors appear to be the least studied construct in food waste behaviour. Concerning intervention studies, behaviours, attitudes and factors affecting food waste behaviour appear to be the most reported psychological constructs.

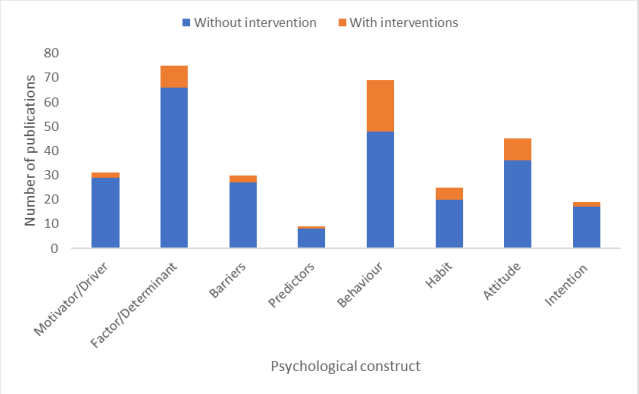

Figure 2 Chart of (a) Number of publications without intervention, and (b) with interventions for respective psychological constructs.

Out of the 30 interventions reported, four types of food waste were observed from the search results: household food waste, institutional food waste, food and beverage waste and municipality and public consumer food waste. As seen in Figure 3, educational institutions food waste (studies conducted in educational settings) appears to be the most common setting for interventions to be undertaken (n=14, 47%), followed by the municipality and public consumer food waste (n=7, 23%), household food waste (n=5, 17%), food and beverage settings (n=7, 13%). The success outcomes for each intervention based on each type of food waste vary and are outlined below.

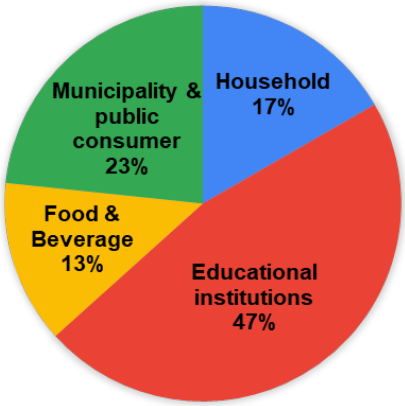

Figure 3 The percentage of publications with interventions of different sources of food waste.

2.1) Interventions targeting household food waste

Several interventions targeting household food waste were reviewed. Four studies found a significant reduction in food waste and one in unsuccessful intervention. Of the four successful food waste interventions, one study focused on educational intervention of participants' perceived skills related to food preparation planning behaviour [10] and another study on reducing the amount of money wasted on food through food literacy messaging [11]. Two other studies reduced food waste through informational leaflets and the installation of source-segregation waste equipment to reduce the amount of domestic food waste [12] and food waste composters [13]. In contrast, Shaw et al. [14] found no significant change in their pre-post intervention using informative leaflets suggesting that interventions that actively target behaviour change were more successful than those that use passive information-giving methods.

2.2) Interventions targeting institutional food waste

Several studies have examined various interventions to reduce food waste at universities and schools with varying degrees of success. Of the 12 studies reviewed, three reported no change in food waste reduction [15-17], and nine stated changes ranging from 10% to 50%. Four studies used posters or direct prompts in their intervention methods and reported 10-15% of success [18-21]. Signs that encourage action approach information tend to reduce food waste. For example, Pinto et al. [19] found that an education campaign with specific posters that encouraged students to take action and control the amount of food served in the cafeteria was more effective than information to increase students' awareness of food waste. In addition, Visschers et al. [22] found that disseminating information and offering smaller servings reduced plate waste by 20% compared to information intervention only.

While some educational interventions were unsuccessful, three reviewed studies have shown positive impacts on reducing food waste [15, 23-24]. Antyn-Peset et al. (2021) reported a decrease of 30% in food waste on plates from 140 ± 23 g per pupil per day to 111 ± 27 g per pupil after six weeks of direct training in the classroom by teachers [23], while Alcorn et al. [14] reported a decrease of 36.6% in food waste after a 12 weeks training program [15]. Boulet et al. [23] observed that lessons for students, parent engagement, hands-on workshops, and promoting students' involvement in preparing their lunch had a significant effect on student's food choices and food preparation behaviours, leading to a 35% reduction in avoidable food waste items across the entire school sample [24]. Lastly, Thiagarajah and Getty [25] implemented a trayless system to reduce food waste led to an 18% decrease in solid waste per patron.

Based on the above studies, factors that indicate the more significant success of food waste reduction include interventions that involve more intensive and direct training, simple and direct messages, and individual controllability of food quantity choice.

2.3) Interventions targeting food and beverage food waste

The review encompassed five studies focusing on reducing food and beverage waste, all demonstrating decreased food wastage. Cozzio et al. [26] conducted an intervention using persuasive messaging at a croissant stall in a hotel setting. Their findings indicated reduced food waste from 0.3 units per person during the baseline week to 0.02 units per person during experimental week 3 [26]. Another intervention involving context manipulation resulted in a 14.4% reduction in edible plate waste, with the 'guest table' identified as the most significant contact point [27]. In Stцckli et al.'s study [28], information cards were provided at a pizzeria. The percentage of diners who requested to take away their leftovers was 55% in the informational prompt condition and 64% in the informative and normative prompt condition.

The implementation of a self-serve bar, combined with moral persuasion and a discount, resulted in the lowest volume of food waste, as demonstrated by $F(5, 354) = 16.705$, $p = .000$. Furthermore, no other demographic factors were found to have significant effects on the outcome [29]. Lastly, information campaigns and nudging consumers led to an increased request for meals with smaller portions post-intervention. Additionally, it was discovered that feelings of guilt ($p=0.001$) and shame ($p=0.001$) were associated with consumers' intentions to prevent food waste [30].

2.4) Interventions targeting municipality and public consumer food waste

An intervention using product hampers provided by the retailer containing sustainable products, tailored advice including 'tips and hacks', live expert webinars from nutritionists and chefs including cook-along, and a private Facebook group for study participants to interact, were shown to be successful, particularly 'ask the expert' videos and product samples [31]. Studies using conventional communication channels such as in-store magazines, e-newsletters, social media, product stickers and in-store demonstrations have also been found to effectively increase customers' pro-environmental behaviour [32-33]. In a cooking class method of intervention, participants demonstrated increased confidence in cooking ($p = 0.004$), experimenting with new ingredients ($p = 0.006$) and knowing how to make use of food before it goes bad ($p = 0.017$), as well as valued social interactions [34]. In a longitudinal programme, Geislar (2017) found an increase in organic waste separation when supportive infrastructure (i.e., curbside carts and collection services) and descriptive social norms were used in their intervention [35]. Other studies found effective food waste reduction using gamification intervention [36] reducing portion sizes and poster information [37] and visual prompts and volunteers model [38].

3) Interventions on food waste behaviour by country

A total of 16 countries were identified in the literature search, with a wide geographic distribution spanning Asia, the Middle East, Europe, the UK, and North America (Figure 4). The highest number of food waste behaviour intervention studies were shown to be conducted in the UK and the USA (n=6 each). As highlighted in Section 3.1, institutional food waste was the most targeted setting for food waste behaviour interventions. This is mainly observed in the USA, where 4 out of 6 intervention studies were conducted in academic institutions. In the UK, it is shown that 3 out of 6 interventions were conducted in the municipality and public consumer settings, as opposed to the USA, where 4 out of 6 interventions were conducted in institutions. In contrast, the remaining two only were conducted in municipality settings. UK and Italy are the regions which targeted three different types of food waste, followed by the U.S.A., Canada and Switzerland, which targeted two types of food waste, and the remaining were found to target interventions for 1 type of food waste thus far. Twelve out 30 studies were conducted in the UK and the USA, indicating a need for more diverse and globally representative research to better understand and address food waste behaviour modification.

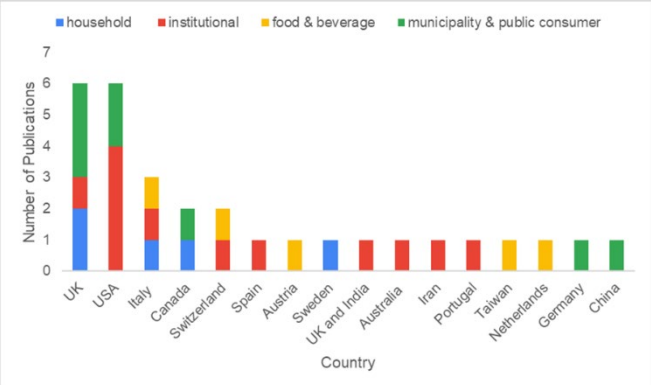

Figure 4 The number of publications with interventions of food waste behaviour in various country.

4) Theoretical Framework

The Theory of Planned Behaviour appears to be the most commonly used theoretical framework in interventions for food waste behaviour (n=3) (Figure 5). The other theories used would be the Capability, Opportunity and Motivation-Behaviour (COM-B) Model, Antecedents, Behavior, Consequences (ABC) Theory, Social influence and Norm Communication. In one

study, the researcher proposed a multi-level framework targeting household food waste and consumer behaviour. The remaining intervention studies did not apply a theoretical framework (n=23). Lack of theoretical grounding in the development of interventions will limits the ability to understand and generalize the finding.

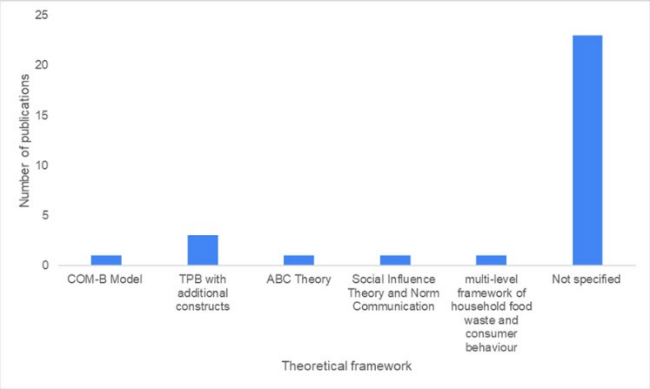

Figure 5 Theoretical framework used in interventions for food waste behaviour versus the number of publications.

Methods of interventions based on each type of food waste source

This section discusses the different methods of interventions based on each type of food waste source, its efficacy, and theoretical lenses. SM 1 showed innovative food waste intervention, such as novel strategies such as gamification approaches [36], comparative effectiveness of several contexts such as the impact of cultural [18], new insights into behavioural and psychological aspects such as trust issues [17], enhances communication techniques using informational and normative prompts [28], and new measurement metrics [26]. These published work offers practical insights in various countries and populations enhance our understanding of effective food waste reduction methods that could be applied in policy and social structure change. To date, there are no publications show a comprehensive overview of effective food waste reduction methods.

1) Interventions for household food waste

1.1) Knowledge-based interventions

When Romani and colleagues [10] conducted an educational intervention using supportive articles and links targeted to improve meal planning skills among participants, it was shown that the intervention succeeded in reducing domestic food waste when participants improved their meal planning skills through educational materials. However, this finding is inconsistent with Shaw et al. [14], who disseminated information on the costs and impacts of food waste in leaflets. A potential point of limitation in this intervention could be due to the targeted sample. Shaw and colleagues utilised a sample of high and low-income subgroups to read the leaflets while Romani and colleagues [10] targeted adults who were already responsible for shopping and cooking at home.

1.2) Knowledge and practical-based interventions

The three interventions involving knowledge and practical-based components were all shown to be efficient in reducing household food waste. Woodard and Rossouw [13] found that conducting workshop activities such as introduction, singalong, presentations, residents sharing their challenges, and demonstration of composter succeeded in increasing recycling habits and social cohesion towards recycling. Similarly, for food literacy messaging, garbage collection services [11], distributing leaflets, and installing waste segregating equipment in each home were also effective methods in reducing food waste [12]. Van der Werf and colleagues [11] additionally highlighted that helping people save money on food waste was a good motivator, which stimulated the success of the intervention. All three studies observed that having a knowledge component combined with a practical or social component assisted in making the interventions successful in reducing household food waste.

2) Interventions for food waste in educational institutions

2.1) Disseminating information

Most of the interventions conducted in reducing institutional food waste were centred on disseminating knowledge and methods for food waste reduction. This could be due to easy accessibility for experimentation and the academic mentality of students in a learning environment. Out of the seven studies that focused on disseminating information related to food waste, only one was unsuccessful, while the remaining six produced positive outcomes. The study conducted by Alcorn et al. [15] which consisted of training employees, preparing smaller batch sizes of food, and informing customers of the sustainability goals at the campus restaurant, was shown to be minimally successful in an overall reduction in consumer food waste from pre-intervention to post-intervention. However, this intervention identified several barriers and motivators of the restaurant employees: the amount of inedible trimmings and food expiration. The motivators were: knowing the number of resources used to generate food waste, understanding the cost associated with food waste, and fostering the growth for employees to motivate themselves to make a difference. These factors could be considered when developing interventions for campus restaurants and cafes.

Interventions using discussion, signages in the cafeteria, and quizzes with prizes as incentives showed that food waste quantity decreased, and students' attitudes towards

food waste have also changed [39]. Prompt-type messages using information related to food waste were also shown to help reduce food waste by 15% in the university dining facility [20], another study which used table cards and posters with focus groups and weighing food waste showed a tremendous reduction in food waste and found that students in India had social concerns regarding food waste. In contrast, students in the UK had more economic concerns regarding food waste [18]. Targeting such concerns would additionally ease the planning of future interventions. Another study found that between disseminating information alone and disseminating information together with offering smaller servings, the latter reduced the amount of plate waste by 20% [22]. Lastly, organizing education campaigns [19], giving out pamphlets, posters and leaflets, offering containers, and meeting students' demands for preferred food reduced food waste [21].

2.2) Teaching methods in classrooms

Another intervention approach that can be used in educational settings is teaching sessions. Two of the three studies that conducted teaching sessions were successful, while one was not. In Favuzzi et al.'s study [16], 12 primary schools participated in a flipped classroom intervention to reduce food waste. It was concluded that food waste would increase if the appearance, taste, and smell were unpleasant. Possible factors affecting the outcome of this intervention could be the level of consistency in teachers' guidance and teachers' and students' familiarity with the tasks. The two successful studies included not only teaching sessions but other activities such as awareness activities [23], parents' engagement, hands-on workshops and "make your own lunch" programs [24]. The sample size, involvement of parents, and type of engaging activities could affect the program's efficiency, which can be further delved into when planning interventions for institutional food waste.

2.3) Use of social media

In the study by Lazell [17], social media was used to communicate with participants regarding the availability of leftovers for collection. This intervention was unsuccessful due to trust as a barrier, as participants were uncertain if the food being posted was clean and uncontaminated. Social media may be a helpful platform for communication, but the details of the information being posted matter. From this study, we can gather that hygiene is vital in motivating a person's trust towards food leftover collection if posted on social media.

2.4) Trayless system intervention

From Thiagarajah and colleagues' [25] study, we can see that changing the norm within a university setting did bring about a positive change and reduced solid waste per patron, even with a large sample size. The study concluded that participants, particularly the employees, were willing to cooperate and switch to the new trayless system as long as it helped reduce the food waste crisis. We can gather that altruism towards food waste may be an essential factor or motivator to consider in food waste prevention and reduction interventions.

3) Interventions for food waste in hospitality industry

3.1) Informational messages and prompts as a means of communication with diners

Five studies conducted in restaurants and hotels use messages and prompts to persuade and nudge diners and guests to reduce food waste. For instance, Cozzio et al. [26] found that displaying information on nutritional values, recommended intake, and sustainable food goal messages decreased food waste from baseline 0.3 units to experimental 0.02 units per person. Similarly, a context manipulation study involving the display of graphic and written messages regarding food waste behaviour in a hotel in Austria reduced edible food waste by 14.4%. It is highlighted that leaving these messages at the guest's tables was the most effective contact point for persuasion [27]. Displaying information cards in a pizzeria was also proven effective, as the percentage of diners that took away their leftovers was higher than the control conditions [28]. Displaying knowledge regarding food waste through prompts shows its efficiency in reducing food waste, particularly in restaurants and hotels. This could be easier due to crowd control and manipulating the intervention within a smaller vicinity than in more extensive settings and crowds or samples. When considering financial penalties or incentives, it is found that moral persuasion alone reduces food waste compared to inducing a penalty at a restaurant buffet [29]. The information campaign conducted among customers at a university restaurant was also proven effective as more participants requested smaller portions [30]. Future studies can consider implementing informational messages and prompts in restaurant and cafe settings.

4) Interventions for municipality and public consumer food waste

For interventions targeting the reduction of the municipality and public consumer food waste, it is observed from these eight studies that the level of convenience, clarity of information and social cohesion, affects the success of an intervention. All eight studies were shown to be successful in reducing food waste and improving food waste reduction behaviour.

4.1) Convenience and accessibility

When yellow bin covers were allocated in the area along with assistance from volunteer advisers, participants showed support, and both intervention methods achieved good results [38]. Another study which provided curb-side carts to leave food waste reported a reduction in perceived barriers; placing carts at the residents' curbside improved the participation from residents as well [35].

4.2) Clarity of information and communication

Customers were found to prefer combined communication channels (such as e-newsletter) when disseminating information related to food waste [33]. The same study also found that social media was a powerful tool in persuading and teaching customers about food waste reduction behaviour [32]. Putting up posters together with reducing portion sizes decreased participants' out-of-home portion sizes post-intervention. However, it is uncertain whether putting up posters alone would produce a similar positive outcome [37]. Drawing from Trewern and colleagues [31], participants found the "Ask the Expert" videos impactful. This shows that having the expertise to rely on when learning new methods like these would be vital and beneficial.

4.3) Social cohesion

Social cohesion was observed when cooking classes were used as an intervention when community engagement and gamification approaches were taken, and when there were live webinars and private Facebook groups for participants to interact as well as ask questions regarding food waste from experts [31, 34, 36].

5) Theoretical framework in intervention studies

From these 30 studies, the TPB was found to be most commonly used as a theoretical framework in food waste behavioural intervention studies. Interestingly, 23 of the 30 intervention studies did not include any theoretical framework. This could be due to the possibility that researchers decided to fill in the research gaps by improving past studies on food waste behaviour. Another possible explanation, as mentioned by Quested et al. [40], is that existing theories in behavioural change may not apply to food waste prevention in consumption settings due to their differences. As seen from the results of this review, TPB was the most applicable, but even so, the researchers had to include external constructs to fit the dimension of their respective studies. Without explicitly using a theory, readers can infer relationships between causes and effects in food waste behaviours or assume relationships among constructs without specific justification [1, 41].

Nevertheless, the 23 studies which did not utilize any framework still produced respective successful outcomes. We can infer from this that the inclusion or exclusion of a theoretical framework does not necessarily affect the efficacy of an intervention design. However, it can highlight more explicit connections among tested variables and provide further explanations.

6) The implication

This review provides the insight into effective intervention methods to reduce food waste across different sources of consumer food waste. The integration of knowledge and skill in food waste management is found to be the most effective intervention in reducing household food waste [42-43]. The dissemination of information and social media interventions are comparatively effective in the educational institution and food services industries [44]. The key elements of a success intervention include convenience, clear communication, and social cohesion. Effective interventions combine multiple strategies and consider behavioural modification through psychological and social factors to reduce food waste with sustainable behaviour change. Future studies should consider longitudinal methods to determine the long-term efficiency of interventions on achieving the SDGs, particularly SDG 12. The finding provides recommendations to policymakers and stake-holders on the impactful interventions in the development of new programme or policies.

Conclusions and our perspectives

This review discussed the 30 psychological interventions that have been conducted in food waste reduction behaviour from 2010-2022. Methods such as gamification, comparing the cultural differences, communication techniques, have been used to address food waste reduction. Some interventions may be novel and practical but their effectiveness remains unconvincing. Intervention incorporate knowledge with practical and social components showed effectiveness in reducing food waste. It is found that behavioural interventions have been most commonly conducted in schools and university settings. Future research can consider combining knowledge and practical interventions to tackle food waste behaviour in household settings. Disseminating information, including teaching methods in classrooms and practical interventions for food waste in institutional settings; informational messages and prompts for food and beverage settings; ensuring convenience and accessibility, clarity of information and social cohesion as essential intervention factors for the tacking municipality and public consumer food waste behaviour. It is worth noting that some interventions

successful reduced food waste succeeded without theoretical frameworks, regardless of country, with or without adoption of theory.

Although this review has successfully grouped the different methods of interventions and discussed their efficacy based on the types of food waste, we can only provide empirical speculations on what intervention approach would aid in gearing the public towards food waste reduction behaviour. Therefore, further research must be conducted to test and prove which intervention approaches would produce successful outcomes. In addition, most of the research on food waste intervention measures short-term intervention outcomes. Although such studies can reveal if the intervention strategies are effective, they do not address whether these methods remain stable over time. Future studies should measure intervention effects at successive points in time via longitudinal studies or consistent follow-ups with participants to observe if the interventions have a long-lasting impact towards meeting the SDGs.

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