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Understanding Out-of-Home Plate Waste: A Systematic Review and future research agenda

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Abstract

Consumer food waste represents a critical global challenge with substantial social, economic, and environmental costs. One underexplored but significant domain is plate waste, which poses specific challenges for the hospitality and food service sector and undermines global sustainability goals. Given the theoretical fragmentation and methodological dispersion in this area, a comprehensive synthesis is urgently needed. This study presents a systematic literature review of 101 peer-reviewed publications to consolidate current knowledge of how plate waste has been understood and addressed and identify future research and practical directions.

We find that, despite increasing interest, existing research tends to conceptualise plate waste as a static outcome of consumer choice, often relying on individualised, cognitive-behavioural models while underexploring social, contextual, and systemic influences and dynamic dining procedures. This SLR synthesises evidence to theorise plate waste as a processual and dynamic phenomenon, unfolding through a sequence of "decisive moments" in the dining-out experience—planning, ordering, food evaluation, and leftover handling. These moments are shaped by interacting micro level intrapersonal, meso level-social, physical, and macro-level factors, and entangled with broader household and cultural food practices.

We develop an integrative framework that shifts the analytical focus from static, individualised, outcome-based to process-based, multi-leveled understandings of consumption and waste in hospitality. We conclude with a research agenda and implications for hospitality stakeholders. This review establishes a critical foundation for advancing context-sensitive, sustainable food consumption strategies in hospitality research.

Keywords: Plate Waste; Consumer Food Waste; Out-of-Home Food Consumption; Sustainable Consumption; Hospitality Industry; Systematic Literature Review.

1 Introduction

Plate waste, which refers to served food left uneaten by consumers in hospitality and foodservice (HaFS) settings (von Massow and McAdams, 2015), is a global sustainability challenge. Of the 900 million tonnes of food wasted annually, which is around one-third of global food production, an estimated 35% occurs at the consumption stage across households and out-of-home settings (Gustavsson et al., 2011). Plate waste has significant environmental and economic implications globally, accounting for 20% of total consumption-related food waste in the US (NRDC, 2019), 34% of total HaFS food waste in the UK–causing approximately £1.1 million financial loss globally (WRAP, 2013b), and approximately 18 million tonnes in China averaging 93g waste per guest (Cheng, Jin and Liu, 2018). Global efforts towards United Nations Sustainable Development Goals (i.e. SDG, 12.3) of halving per capita food waste by 2030 remain off track (United Nations, 2023). Plate waste represents the most easily avoidable type of food waste in hospitality (Papargyropoulou et al., 2016; Beretta and Hellweg, 2019), nevertheless it is still a major part of the problem. Research shows that reductions in plate waste can substantially contribute to global food waste reduction efforts, enhancing environmental outcomes and promoting economic profitability within the HaFS sector (Nand et al., 2025; Pizzo et al., 2025).

So far, food waste research has focused on household food waste settings, while plate waste has received less attention (Lee et al., 2024; Filimonau et al., 2020). Plate waste studies have focused on antecedents of plate waste using attitudinal factors (Yuan, Bai and Cheng, 2025), restaurant setting (Goodman-Smith, Mirosa and Mirosa, 2020) and policy level factors (Wang et al., 2024) as well as interventions such as educational campaigns and reduction of portion size (Cozzio, Tokarchuk and Maurer, 2021; Giaccherini et al., 2021). However, these strands often examine isolated variables, and do not provide a cohesive understanding of the interrelations or dynamics amongst behavioural, structural, or cultural factors of waste.

Crucially, plate waste is distinct as it emerges from hospitality contexts, shaped by unique social dynamics (e.g. group dining, social impression management), situational cues (e.g. portion sizes), and operational settings (e.g. menu design, service models). It differs markedly from household or retail contexts and requires targeted investigation (Filimonau et al., 2022). However, plate waste has been simply subsumed under broader hospitality food waste reviews (Roodhuyzen et al., 2017; Filimonau and Delysia, 2019; Zhang, Hsu and Gao, 2025), limiting our ability to draw targeted insights. Only one published review of 27 papers looked at approaches to reduce plate waste (Leung et al., 2025).

Our study aims to advance this area by offering a more comprehensive and integrative systematic literature review on the behaviours, antecedents and interventions of plate waste, specifically. The research question guiding our study is "how have researchers conceptualised the antecedents, processes and consequences of plate waste". In doing so we are also interested in research about tested interventions to reduce plate waste in the extant literature, as well as the research and practice implications included in these studies.

Our analysis reveals a field that is theoretically fragmented and methodologically dispersed across disciplines, with plate waste predominantly framed as a static, one-off outcome of consumer decision-making rather than a processual phenomenon embedded within the contextual consumption experience. By consolidating and bridging these disparate strands together, we make three contributions. First, we provide a conceptual consolidation of how plate waste has been understood and addressed to date. Second, we advance the theorisation of plate waste using a conceptual model that reframes plate waste as a multi-level, context-mediated practice involving multiple stakeholders, moving beyond individualistic accounts. Third, we translate this theorisation into directions for future research and practice that can address the limitations of current approaches.

The remainder of this paper is organised as follows. Section 2 details the methodology. Sections 3 and 4 present the synthesis of extant literature and introduces our integrative conceptual model. Section 5 discusses the research and practical implications.

2 Methodology

2.1 Review strategy

We follow a systematic literature review approach (Denyer and Tranfield, 2009) defined as "a scientific process governed by a set of explicit and demanding rules oriented towards demonstrating comprehensiveness, immunity from bias, and transparency and accountability of technique and execution (Dixon-Woods, 2011, p.232)." This approach addresses challenges arising from a fragmented foundational body of scholarship, such as insufficient theoretical advancement and conceptual contributions (Dhaliwal, Singh and Paul, 2025). The SLR approach has been widely employed in related domains, such as consumption (Wells, Waehning and Arnold, 2025), food waste (Vizzoto, Testa and Iraldo, 2021) and sustainable hospitality (Mahran et al., 2025).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was followed (Page et al., 2021) to maintain transparency and reduce bias in source article selection and analysis. Three interdisciplinary bibliographic databases were utilised: Scopus, Web of Science, and EBSCOhost due to their comprehensive coverage on sustainability, management and hospitality across the social sciences (Kim et al., 2018; Knani, Echchakoui and Ladhari, 2022). Search terms were developed through iterative discussion among the authors, informed by relevant management systematic reviews (e.g. Vizzoto, Testa and Iraldo, 2021), and refined through exploratory searches. Initial exploratory searches based on key concepts 1) *food waste* at the 2) *consumer* level , and in 3) *out of home food consumption* informed the identification of relevant synonyms and concepts (see Appendix A), which were incorporated into truncated search strings to maximise coverage while

maintaining precision (Page et al., 2021). We used Boolean operators (OR/AND) and appropriate truncations (*) to account for alternative spellings and differences in language use (Page et al., 2021). During this iterative process, inclusion and exclusion criteria were defined and refined to ensure consistency (see Appendix A).

2.2 Data collection and screening

The initial search retrieved 2639 records in August 2025, covering publications from 2013 onwards (Figure 1). The year 2013 was selected as a baseline, coinciding with the release of influential reports by the Waste and Resources Action Programme (WRAP, 2013b, 2013a) that first brought global attention to the significance of food and particularly plate waste.

Informed by the PRISMA guideline (Page et al., 2021), study screening and selection were conducted collaboratively by the research team following the selection protocol. The first author led the screening and filtering of all retrieved records, while the second and third authors reviewed and approved inclusion decisions. Final decisions were reached through phased discussion and agreement among all authors.

Removal of non-English records and duplicates yielded 997 peer-reviewed articles for title-level screening against predefined criteria (see Figure 1): peer-reviewed articles published since 2013 that explicitly focused on plate waste and provided evidence relevant to the research question; work was outside the HaFS scope or not centred on consumer plate waste. A total of 137 were excluded at the title level. The remaining 860 articles were screened at the title-and-abstract stage, resulting in the exclusion of 678 additional records. Common reasons were a focus on general food waste rather than plate waste and on waste processing rather than behavioural aspects. A full-text review was then conducted on 182 articles. The final corpus comprised 101 academic papers.

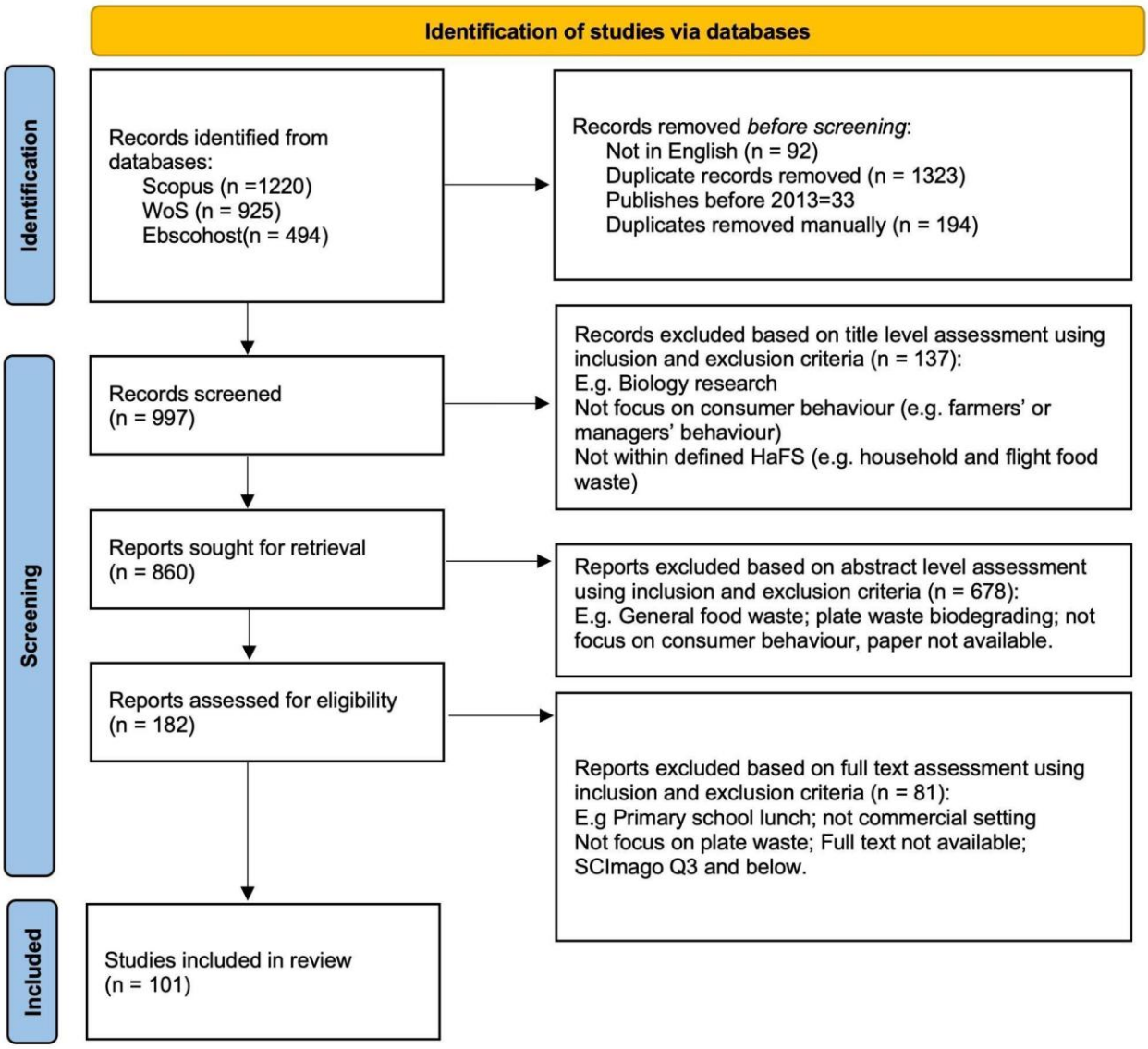


Figure 1. PRISMA diagram for systematic literature review (Page et al., 2021)

We aimed to identify a literature base that was both comprehensive and quality robust: following the exclusion criteria, we included only peer-reviewed journal articles from the three widely used and trustable databases (de Lurdes Calisto and Sarkar, 2024); and following Busulwa, Pickering and Mao (2022), we excluded papers published in and below Q3 of Scimago Journal Rank as high-caliber journals are more likely to represent the advancement of scholarship (Jones, Manoharan and Madera, 2024.). Out of the 101 articles, the highest number of articles (n=90) were extracted from Scimago Q1 journals, with 11 from Q2 journals.

Additionally, to contextualise plate waste, we supplemented grey literature, nationwide reports from WRAP (WRAP, 2023, 2013a, 2013b), the Natural Resources Defense Council (NRDC, 2019) and Zero Waste Scotland (2014).

2.3 Narrative synthesis

We employed a narrative synthesis approach (Cassell, Denyer and Tranfield, 2006) to qualitatively integrate and interpret the selected studies (Vasist and Krishnan, 2022; Wells, Waehning and Arnold, 2025). This method systematically organises descriptive data into a structured "map" of the conceptual terrain, enabling consolidation of diverse disciplinary research into a coherent perspective to answer research questions. First, the selected paper was summarised in terms of bibliographic, methodological, and substantive findings (Appendix B). Second, we synthesised key characteristics to profile the field's temporal, geographical, and methodological landscape (Section 3). Finally, we conducted a narrative synthesis to identify thematic relationships and reveal broader patterns (Section 4).

3.0 Descriptive Results

Publication has shown a marked upward trajectory over the past decade (Figure 2). Early contributions were sporadic until interest in consumer plate waste in hospitality contexts accelerated from 2016 onwards. Publishing peaked in 2021, reflecting heightened industry and scholarly attention to sustainability agendas. Recent counts for 2024 and 2025 indicate its transition into an established research domain.

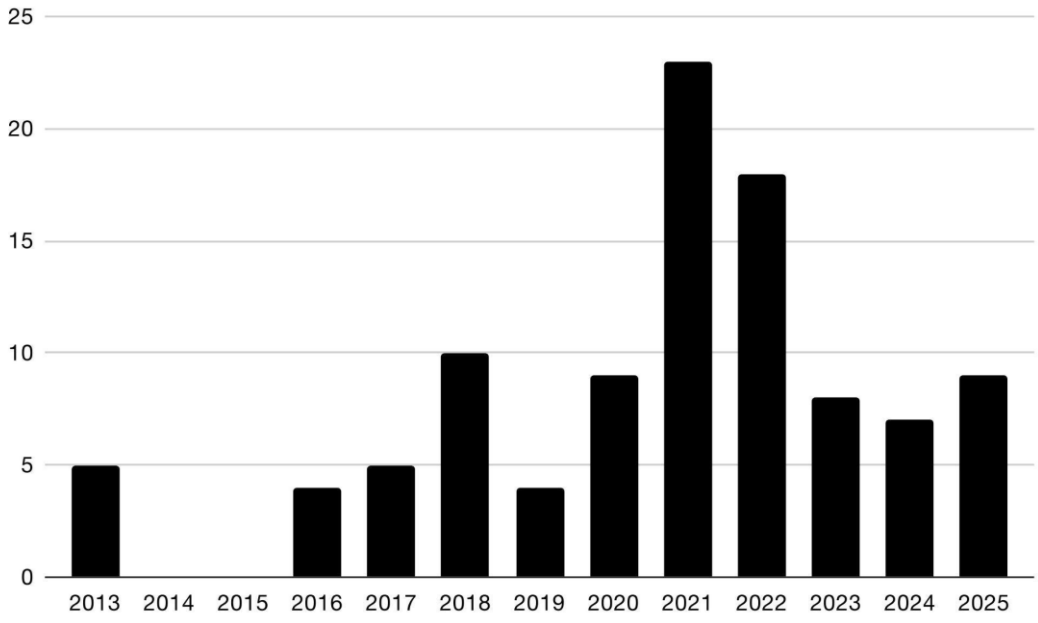


Figure 2. Year of publication of the selected studies

Geographically, research spans 29 countries but remains concentrated in a small number of national contexts (Table C1, Appendix C). China accounts for the largest share (n = 35), followed by the USA (n = 15). Only four studies employed cross-national designs (e.g. Brazil–USA; France–Czech Republic), suggesting an underutilisation of comparative perspectives.

Publication outlets (Table C2, Appendix C) are diverse, spanning sustainability science, hospitality and tourism, food studies, consumer behaviour and environmental management, reflecting the field's interdisciplinary character. However, the landscape remains fragmented, with few studies published in leading hospitality journals such as the International Journal of Hospitality Management.

The majority of studies adopt quantitative approaches (n = 90), with qualitative (n = 6) and mixed-methods (n = 5) designs used sparingly (Figure 3). Among quantitative studies, 35 employed experimental designs to evaluate interventions, while the remainder examined underlying determinants predominated by survey methods without testing interventions. Approximately three-quarters of quantitative studies on determinants relied on self-reported measures of waste behaviour

or quantity, whereas intervention studies more frequently used direct weighing for accuracy. The remaining studies used qualitative data acquired through interviews, which emphasised gathering an in-depth understanding of plate waste phenomena.

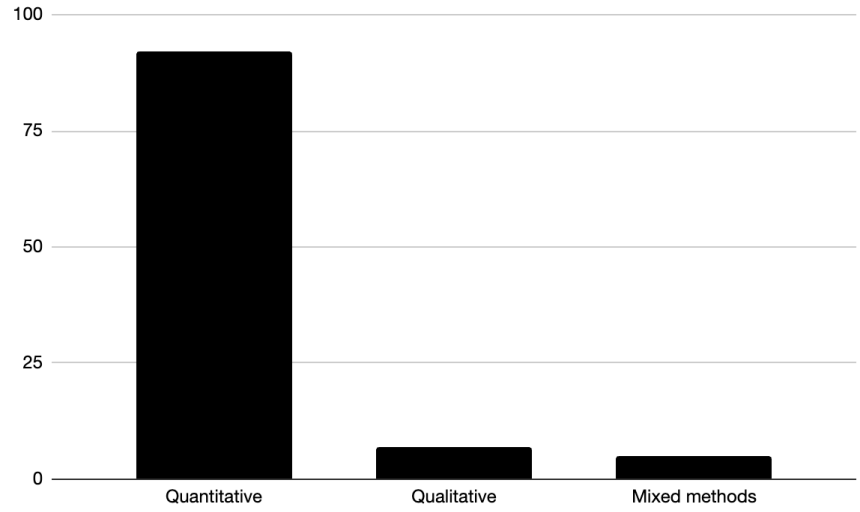


Figure 3. Research design of the selected studies

Theoretically, behavioural models dominate. The Theory of Planned Behaviour (TPB) and its variants are the most frequently applied frameworks (Coşkun and Filimonau, 2021; Teng, Wang and Chuang, 2022). The Norm Activation Model is also common (Huang, Ma and Yen, 2025; Wang et al., 2024; Yu et al., 2021). In intervention studies, TPB remains popular (Lorenz-Walther et al., 2019), while Nudging Theory has been primarily adopted to conceptualise and test choice architecture strategies designed to reduce waste (Giaccherini et al., 2021; Kallbekken and Sælen, 2013; Visschers, Gundlach and Beretta, 2020). Finally, intervention experiments are disproportionately concentrated in controlled institutional settings (i.e. university and workplace canteens, n = 17) and laboratories (n = 3), with fewer in commercial restaurants (n = 7) or buffets (n = 8), limiting generalisability to the full range of hospitality environments.

4.0 Analytical Themes

This review organises the literature on plate waste into three analytically linked themes: (1) its multi-level determinants, (2) its processual nature across the dining-out experience, and (3) interventions evaluated in the extant literature. They underpin our integrative model, combining temporal sequencing (when) with multi-level structuring (where and how).

First, we synthesised factors influencing plate waste and mapped them across multiple levels of influence (Section 4.1), mirroring multi-level analytical approaches in household (Boulet et al., 2022) and general food waste reviews (Roodhuyzen et al., 2017). Second, drawing on the "decisive moments" model from household food waste research (Hebrok and Heidenstrøm, 2019), we identify processual consumption behaviours spanning pre-consumption to post-consumption stages (Section 4.2). This temporal framing positions plate waste not as a discrete event but as the cumulative outcome of sequential, interlinked actions. Third, we mapped existing interventions against these two structuring themes, aligning them with both multi-level determinants and specific stages of the consumption process (Section 4.3). Finally, integrating the processual lens with the multi-level model, we theorise plate waste as a dynamic outcome shaped by the interplay of drivers operating across both the consumption process and multiple levels of socio-ecological organisation (Section 4.4).

4.1 The multi-level determinants of plate waste

Plate waste determinants are identified across four nested categories following the ecological framework (Story et al., 2008): micro level: individual factors (consumers characteristics); meso level: social environment (social groups individuals interact); physical environment (venue's material characteristics influencing plate waste); and macro-environment dimensions (structural influences beyond one's immediate physical setting). We present a consolidated synthesis of the evidence below

(Table 1), with detailed narrative descriptions of each paper (see Appendix B) and a synthesised mapping with references (see Table D1, Appendix D).

Table 1. The multi-level determinants of plate waste.

Micro level	**Meso level**	**Macro level**
Demographics:Findings on age, income, education, and gender are inconsistent; other variables, such as marital status, show negligible influence. **Attitudes**: Positive attitudes towards reducing food waste and conscious engagement with food are associated with lower waste and stronger waste-reduction intentions. **Emotions**: Negative emotions (e.g. guilt, shame, embarrassment) can catalyse waste-mitigating actions, such as finishing meals or taking leftovers, though embarrassment about requesting doggy bags may inhibit such behaviours. Anticipated positive emotions (e.g. pride) also strengthen waste-reduction intentions. **Awareness**: Awareness of the environmental and societal harms of food waste motivates responsible dining behaviours and strengthens waste-prevention intentions. **Knowledge**: Greater knowledge about plate waste and its impacts correlates with stronger behavioural intentions to reduce it. **Normative motives**: Personal and subjective moral norms regarding food waste reduction encourage consumers to minimise plate waste. **Monetary motives**: Financial considerations, such as recovering value from food (e.g. taking leftovers), can motivate waste reduction, with stronger	**Dining occasion**: Social cues tied to the meaning of the dining occasion influence waste behaviour. Consumers are less likely to take leftovers in formal settings or when dining with unfamiliar companions, leading to higher waste. **Staff** Communication with service staff can shape ordering decisions and willingness to request doggy bags, influencing both portion sizes and leftover management. **Environmental cues**: Restaurant ambience, décor, and atmosphere shape preferences and consumption. **Service style**: Service format (e.g. buffet, à la carte, shared plates) affects portioning, ordering patterns, and consumption, creating distinct waste dynamics. **Food quality**: Higher satisfaction with food quality is associated with more positive waste-reduction attitudes and lower waste volumes. **Portion size**: Larger portions consistently lead to greater waste; in buffets, plate size also contributes significantly. **Price sensitivity**: Higher meal prices have been linked to greater waste in some contexts, potentially	**Cultural norms**: National eating-out cultures shape prevailing social norms, meanings, and expectations around dining, influencing both consumption and waste practices. **Media and consumerism**: social media and consumerist framings of dining can encourage over-ordering by promoting abundance, novelty, or aesthetic presentation over need-based consumption. **Policy:** Evidence from China's Food Waste Law and related campaigns shows moderate effects, with partial influence on consumer behaviours related to plate waste.

effects observed among specific demographic groups (e.g. younger, female, unemployed; Mirosa et al., 2018). **Habits**: Regular patterns of leaving food uneaten predict higher levels of plate waste. **Hedonic motives**: Pleasure-seeking and novelty-driven dining can increase waste, particularly when the meal is not enjoyed. **Perceived behavioural control / self-efficacy**: Higher self-efficacy strengthens personal norms against plate waste and promotes waste-reducing behaviours, while low perceived control is associated with greater waste.	due to larger portions, presentation-focused service, and reluctance to request leftovers in premium or formal settings. **Cross-context spillovers**: Food waste behaviours in hospitality and at home can influence each other, suggesting spillover effects across contexts.	

4.1.1 Micro level: consumer characteristics

At the individual level, attitudes toward wasting food in HaFS settings and toward its reduction (Coşkun and Özbük, 2020; Huang and Tseng, 2020), alongside awareness (Teng, Wang and Chuang, 2022; Yu et al., 2021), normative understandings (Huang, Ma and Yen, 2025), and knowledge of the consequences of restaurant food waste (e.g. Filimonau et al., 2020; Mumtaz et al., 2022), are frequently framed as decisive determinants. Within this framing, higher awareness of the socio-environmental implications of plate waste, combined with positive attitudes and strong personal norms, is assumed to strengthen intentions to avoid waste, which are then expected to predict behaviours such as sensible ordering and the taking of leftovers for later consumption (Liao et al., 2018; Yu et al., 2021). This logic reflects the dominant rational–cognitive model underpinning much of the literature, wherein behaviour is positioned as the outcome of deliberate, informed decision-making. But we find inconsistency between attitudes, intentions, and behaviours (Lorenz-Walther et al., 2019; Sebbane and Costa, 2018), suggesting plate waste is not limited to individual cognitive preferences.

Emotions like guilt, experienced or anticipated, consistently motivates waste-reduction actions such as finishing meals or taking leftovers (Goodman-Smith, Mirosa and Mirosa, 2020; Kim and Hall, 2019), with similar effects observed for certain positive emotions like awe (Xue, Zhang and Li, 2025). By contrast, shame or embarrassment, particularly around requesting a doggy bag, can inhibit such behaviours (van Herpen et al., 2021; Sirieix, Lála and Kocmanová, 2017).

Additionally, varied motivations work either as facilitators or barriers to waste reduction. A strong financial motivation is associated with behaviours such as taking leftovers home (Goodman-Smith et al., 2020; Mirosa et al., 2018). In contrast, a pursuit of hedonic enjoyment (e.g. novelty-seeking or indulgence) tends to increase the potential for waste (Liu et al., 2022).

Additionally, habit, perceived behavioural control, and self-efficacy have been recurrent focal points in the plate waste literature (Kim, Che and Jeong, 2022; Liao et al., 2018; Lorenz et al., 2017). Habitual patterns of leaving food such as consumers reporting that they "frequently" or "always" leave leftovers are strongly predictive of actual plate waste volumes, underscoring the role of non-reflective behaviours in sustaining waste generation. Together, these findings point to the importance of both automaticity and agency perceptions in shaping plate waste .

Individual demographic variables have been extensively examined in plate waste research, yet no consistent patterns have been established. For example, some studies report that female consumers generate more plate waste than males, while others find no gender-based differences (Chalak et al., 2021; Lorenz et al., 2017; Wang, Filimonau and Li, 2021). We argue that such inconsistencies partly arise from the limitations of the predominantly individualistic theoretical framing of plate waste, which often focuses on behavioural traits and often omits or under-theorises contextual characteristics (See Section 5).

4.1.2 Meso level: social and physical environment

We found that hospitality settings function as experiencescapes (Pizam and Tasci, 2019), spaces that not only provide food but also serve as social arenas where interactions and shared meanings unfold. First, it is a social occasion where companions shape waste-related behaviour, with social cues and dynamics influencing ordering decisions, portion sharing, and the acceptability of taking leftovers (Hamerman, Rudell and Martins, 2018; Qian et al., 2021). Second, the physical setting, e.g. the service standards (e.g. staff proactively offering to pack leftovers, Yu et al., 2021; van Herpen et al., 2021) and the quantity and type of food available (Wang et al., 2017), plays a significant role in determining waste. Elements such as food quality (Teng, Wang and Chuang, 2022; WRAP, 2023) and portion size (Liu et al., 2022; Tomaszewska, Bilska and Kołożyn-Krajewska, 2022; WRAP, 2023) can directly affect consumption levels and the likelihood of plate waste.

4.1.2 Macro level: structural influences beyond one's immediate physical setting

Cultural understandings and policy frameworks shape plate waste by influencing how eating out and food is socially constructed, such as the meaning of eating out, what one "ought" to do in response to social cues, and the acceptability of waste (Filimonau et al., 2022; Liao et al., 2018; Yu et al., 2021). In some contexts, such as China and some Middle Eastern countries, hosting guests at a restaurant is imbued with the symbolic obligation to order in excess, signalling generosity and respect (Filimonau et al., 2022; Liao et al., 2018). Conversely, certain etiquettes discourage finishing all food served, as leaving a small portion signals that the host has provided abundantly (Mirosa, Liu and Mirosa, 2018).

Other determinants at the macro level include food waste and plate waste authoritative policies (Liu and Liu, 2025) and media-driven cultural narratives (Huang, Ma and Yen, 2025; Zhang, Hsu and

Gao, 2025), which collectively shape shared understandings of eating out and wasting food particularly plate waste.

Individuals' pro-environmental habits, such as reducing food waste, can spillover from home to other settings like restaurants, workplaces, and special events (Liu et al., 2022; Wang et al., 2022; Filimonau et al., 2020). However, social norms and situational cues in new environments can either reinforce or weaken these habits. For example, people may relax their waste-avoidance behaviors when on holiday, prioritizing social expectations over their usual practices (Liu et al., 2022; Zhang et al., 2022). This suggests that established habits are not static and interact with specific contexts.

4.2 Decisive moments

We identify that plate waste is generated through processual practices spanning the entire dining cycle (Table 2; full table with references Table D2, Appendix D)

Table 2. Decisive moments of plate waste

Decisive Moment	Key Behaviours / Practices	Key Drivers / Influencing Factors
Pre-consumption: Planning and Ordering	Menu review, portion anticipation, coordination with companions; over-ordering due to hunger, portion uncertainty, variety seeking; culturally valorised abundance.	Hunger, portion size uncertainty, desire for variety, social signalling (hospitality, generosity), cultural norms; gap between home and dining-out planning habits.
During Consumption: Food Assessment	Sensory evaluation (taste, texture, presentation); justification for leaving food uneaten; normative fluidity where waste becomes socially acceptable.	Perceived quality, value, and satisfaction; social acceptability of waste; interaction between sensory cues and moral commitments.
Post-consumption: Leftover Handling	Decision to take leftovers home; requesting or accepting doggy bags; storage and reuse at home; discarding leftovers despite taking them away.	Embarrassment/stigma, staff proactivity, restaurant policies, packaging quality, cultural scripts; misalignment between provider and consumer sustainability goals.

4.2.1 Pre consumption: planning and ordering

The role of planning has only recently been examined in out-of-home contexts (Talwar et al., 2021b, 2021a). Planning entails reviewing menus online and checking what and how much to order. Such anticipatory strategies reduce over-ordering and increase the likelihood of leftover reuse.

Over-ordering has been recognised as a dominant determinant of plate waste. While often framed as a decision lapse stemming from hunger, uncertainty about portion sizes (Wang et al., 2017; Xu et al., 2020), the allure of variety (Talwar et al., 2021b), or an expression of hospitality or generosity (Yu et al., 2021).

4.2.2 During consumption: Food assessment

During consumption, plate waste is often attributed to dissatisfaction with sensory qualities, particularly taste, which in turn influence perceived value and willingness to finish food (Thongplew, Duangput and Khodkham, 2021; Tomaszewska, Bilska and Kołożyn-Krajewska, 2022). However, food quality evaluations legitimises waste: once food is deemed unpalatable or aesthetically deficient, leaving it uneaten becomes socially acceptable, overriding moral commitments to avoid waste (Jin et al., 2023). This highlights the normative fluidity of waste acceptability.

4.2.3 Post consumption: leftover handling

Leftover handling sits at the intersection of micro-level moral dispositions, meso-level social situation, and macro-level cultural scripts. While providing takeaway containers ("doggy bags") can avoid plate waste (van Herpen et al., 2021), multiple barriers limit their use. At the individual level, embarrassment and stigma are widely reported (Giaccherini et al., 2021; Sirieix, Lála and Kocmanová, 2017), while at the organisational level, some restaurants resist proactive offering due to concerns it signals poor quality (Filimonau et al., 2020). Evidence suggests that proactive offers

by staff can mitigate embarrassment and increase uptake (van Herpen et al., 2021). Yet even when leftovers are taken home, they may still be discarded (Mirosa, Liu and Mirosa, 2018), raising questions about whether doggy bag interventions displace rather than prevent waste, a point largely absent from the current literature.

4. 3 Plate waste interventions

The dominant framing of plate waste in the literature positions it primarily as the product of individual cognitive choice. Within this perspective, providing consumers with the "right" awareness and moral orientation is assumed to be sufficient for behavioural change. Consistent with this logic, most intervention studies have focused on campaigns designed to heighten awareness of the environmental impacts of plate waste. A growing stream targets behavioural adjustment through environmental design, such as portion sizes, plate configurations, or menu layouts (Table 3).

Table 3. Intervention types (detailed references see Table D3, Appendix D)

Intervention Type	Description	Notes
Awareness Campaigns	Raising awareness of environmental, economic, and social impacts; triggering emotional responses (e.g. awe, guilt) and pro-sustainability attitudes via posters, table reminders, service robots, volunteer engagement, and educational sessions.	Increases awareness but often fails to translate into behaviour change due to attitude–behaviour gap. More effective when including actionable prompts.
Action-Oriented Information	Embedding specific prompts for behaviour (e.g. smaller orders, portion choice, takeaway leftovers).	Can reduce waste without attitude change; direct actions yield better outcomes, but results vary depending on effort required.
Normative Framing	Using social norms, altruistic appeals (highlight social/environmental benefits).	Context-dependent; works better when norms are already strong; may be ignored or resisted if norms are weak.
Incentives	Rewards (monetary or non-monetary) for waste reduction, e.g. gamification; penalties for leaving waste.	Rewards are generally well-received; penalties can work but risk negative emotions and loyalty loss.

Portion Size Reduction	Offering smaller default portions or optional smaller portions; adjusting plate sizes in buffets.	Consistently reduces waste; satisfaction unaffected when choice is preserved; risk of dissatisfaction if perceived as reduced value.
Service Setting Changes	Providing smaller plates; removing trays; reducing serving utensils.	Proven effective; highly context-dependent on service style.
Combined Interventions	Integrating environmental changes with information campaigns.	Mixed results; some combinations fail to produce significant change.

4.3.1 Interventions targeting individual factors

Information-based campaigns aimed at increasing awareness of the environmental, economic, and social impacts of plate waste, enhancing knowledge, triggering emotional responses (e.g. awe, guilt; (Xu et al., 2025; Xue, Zhang and Li, 2025), and stimulating pro-sustainability behaviours, are among the most widely implemented interventions (Alattar and Morse, 2021; Ellison et al., 2019; Pinto et al., 2018). These campaigns typically rely on one-way communication tools such as posters or table reminders (Giaccherini et al., 2021; Pinto et al., 2018), though multiple delivery mechanisms including service robots (Su, Kuang and Wang, 2025), volunteer engagement and educational sessions (Alattar and Morse, 2021). While these initiatives can raise awareness and influence perceived social norms, evidence suggests that awareness and attitude change have difficulty translating into behavioural change (Visschers, Gundlach and Beretta, 2020; Dolnicar, Juvan and Grün, 2020).

More effective strategies use instructive action-oriented guidance (Antonschmidt and Lund-Durlacher, 2021; Jiang et al., 2024). Examples include encouraging actions like choosing smaller portions, or takeaway of leftovers (Dolnicar, Juvan and Grün, 2020; Jiang et al., 2024). Alattar and Morse (2021) found that participants are already equipped with sustainable attitudes but lacked the operational skills to act on them; embedding actionable prompts, such as leftover management reminders or decision aids at ordering, helped bridge this gap. Similarly, Antonschmidt and Lund-

Durlacher (2021) find that instructive prompts can directly influence outcomes even without attitudinal change. However, unexpected results exist: consumers tend to follow suggested waste-reduction actions selectively, favouring those requiring minimal effort (Lorenz-Walther et al., 2019).

Message-framing techniques have yielded mixed success. *Normative messages*—positioning waste reduction as a socially accepted or expected behaviour—have shown promise; for example, prompts such as "An increasing number of Italian restaurant guests are asking for doggy bags…" doubled requests in Italy (Giaccherini et al., 2021) and achieved similar results in China by emphasising the moral oughtness of avoiding waste (Jiang et al., 2024). Yet, in other experimental settings, such framing produced negligible effects (Ellison et al., 2019). These divergences suggest that the effectiveness of normative or altruistic framing is contingent on contextual alignment such as cultural norms and audience receptivity.

Incentive-based interventions appear to be promising. Rewards, both monetary (e.g. reducing plate waste bring discounts) and non-monetary (e.g. gamification intervention, Dolnicar, Juvan and Grün, 2020), are generally more effective and better received than penalties (Chang, Lin and Hsiao, 2022; Dolnicar, Juvan and Grün, 2020; Jiang et al., 2024). For example, a stamp-collection game reduced plate waste by 34% (Dolnicar, Juvan and Grün, 2020). While penalty-based approaches can be effective—such as a university intervention that cut waste by 54% (Kuo and Shih, 2016)—they often evoke negative emotions, potentially harming customer loyalty (Chang, Lin and Hsiao, 2022).

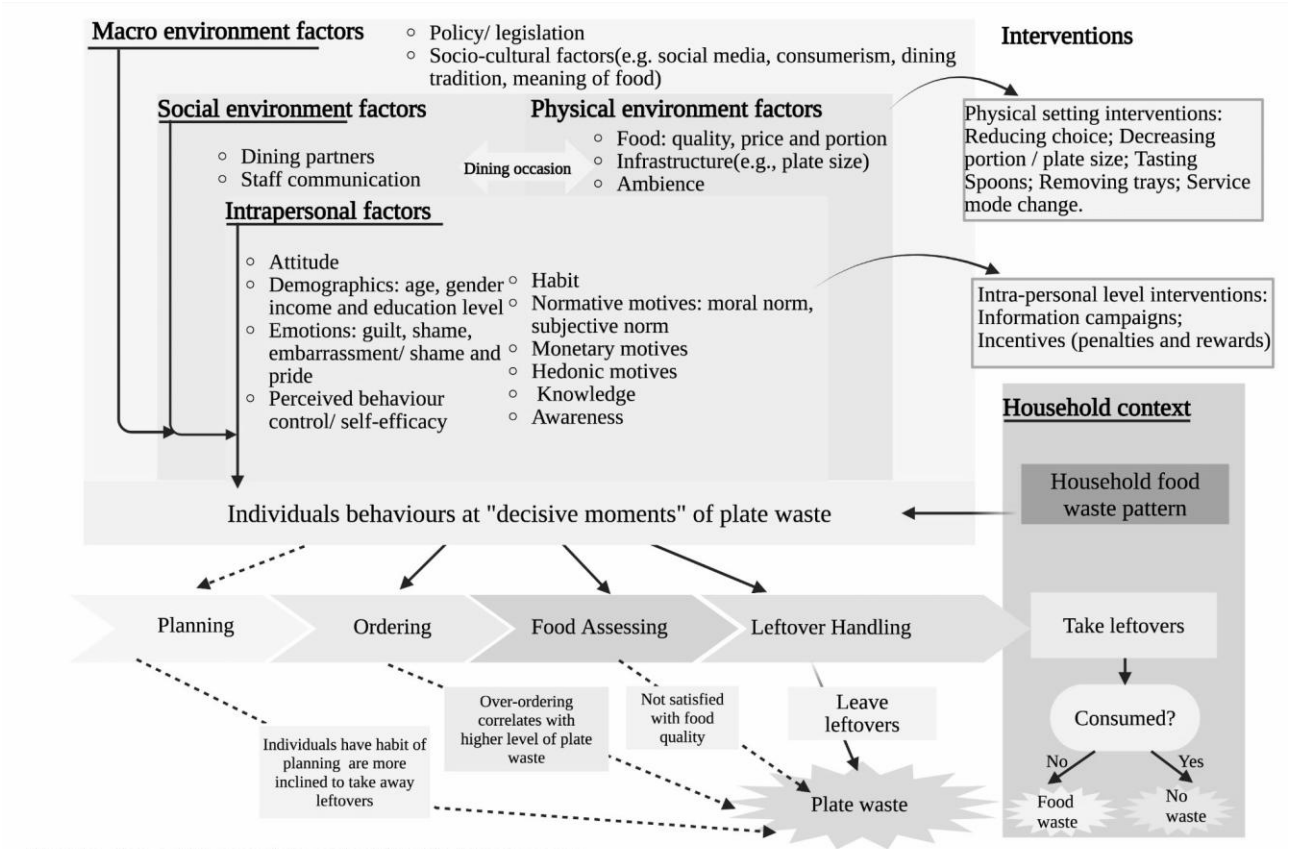
4.3.2 Meso level Interventions

At the service-environment level, portion control is a well-established means of reducing plate waste, applied through smaller default servings, flexible portion sizes, or reduced plate size in buffet settings (Werkman, van Doorn and van Ittersum, 2022). Importantly, reducing portion sizes does not necessarily diminish consumer satisfaction (Kallbekken and Sælen, 2013; Werkman, van Doorn and

van Ittersum, 2022). Finally, researchers have *Combined Interventions* showing significant results suggesting further research is needed to identify their effect (Chang, Lin and Hsiao, 2022) because some combinations fail to produce significant change (Ahmed et al., 2018).

4.4 A Proposed plate waste framework

Bringing the systematic synthesis together with temporal sequencing ("when") with multi-level structuring ("where" and "how"), we advance a theorisation of plate waste (Figure 4).



E.g.	Planning	Ordering	Food Assessing	Leftover Handling
Buffet	Low	High	Medium	High
À-la-carte	Medium	High	Medium	Medium

*Service-style variation indicates that the relative risk of plate waste concentrates at different decisive moments depending on service format (e.g. buffet, à la carte).

Figure 4. A conceptual framework of out-of-home consumer plate waste

Plate waste is positioned as the cumulative outcome of consumer behaviours unfolding across sequential decisive moments—planning, ordering, food assessment, and leftover handling. These moments are shaped, consciously and unconsciously, by the interaction of intrapersonal attributes with external environmental conditions spanning meso and macro levels. The model also incorporates spillover effects between out-of-home and household food waste, recognising that habits and orientations formed in one context can influence the other.

This theorisation challenges the dominant view of plate waste as a discrete, end-stage outcome, instead positioning it as an emergent property of temporally sequenced, socially embedded, and materially mediated dining practices. Across planning, ordering, eating, and leftover handling, behaviours are shaped by interactions spanning multiple levels.

At the bottom of the figure, a service-style risk matrix highlights variation across hospitality formats by linking plate waste risk to decisive moments within the consumption process. The matrix illustrates how risk concentrates differently by service format. For example, buffet settings tend to elevate plate waste risk at the food taking or ordering and leftover-handling stage (e.g. Chang, Lin and Hsiao, 2022; Dolnicar, Juvan and Grün, 2020) due to structural features such as "order-as-you-can" arrangements and no-takeaway policies, with the latter elevating leftover handling risk while constraining possibilities for mitigation. In contrast, à la carte format settings exhibit a more moderate and distributed risk profile, with interventions targeting multiple decisive moments rather than dominant spots (e.g. planning, ordering,Talwar et al., 2021b and using doggy bags, van Herpen et al., 2021). Consistent with the reviewed literature, intervention approaches also vary by service context. For example, warning mechanisms or penalty cues more commonly examined at the point of food selection in buffet settings (Chang, Lin and Hsiao, 2022). Overall, the matrix foregrounds the importance of accounting for hospitality-format specificity when applying the framework. Our theorisation reflects the reality that out-of-home dining is a service-mediated practice involving multi-

stakeholders' responsibility: consumers engage not only with food but also with menus, pricing systems, environmental cues, service staff, and companions, embedded within broader cultural and policy environments.

5 Discussion, Conclusions and Future Research Agenda

Based on the theorisation above, we identify gaps in extant literature and outline future research pathways to move the field beyond its current stagnation.

5.1 A research field skewed towards individualistic behavioural approach

Our review finds that individual cognitive factors such as attitudinal factors and normative variables are the most frequently examined determinants of plate waste, reflecting the dominance of individual-level theoretical framings. The extant literature falls short accounting for the complex interplay of factors driving waste in real-world settings (Nand et al., 2025). For example, reported gender differences in plate waste may reflect not inherent behavioural tendencies but operational constraints—such as standardised portion sizes—that ignore variation in individual needs (Tomaszewska, Bilska and Kołożyn-Krajewska, 2022). In such cases, waste emerges from a misalignment between service-level practices and varied consumer requirements—an ecological interaction obscured when analysis is confined to the individual.

As emphasised in our conceptual framework factors interact through multi levels so the significance of influencing factors is uneven across contexts: in some settings, social norms (e.g. reluctance to request leftovers in group dining; Hamerman, Rudell and Martins, 2018) outweigh personal anti-waste convictions, while in others, macro-level cultural scripts (e.g. over-ordering to signal hospitality; Filimonau et al., 2022; Wang et al., 2024) dominate both social and individual considerations. Evidence from household food waste research indicates that waste generation follows multiple, context-dependent pathways rather than a single, linear route (Roodhuyzen et al., 2017;

Boulet et al., 2022) which is also reflected in hospitality settings. The specific pathways through which these interactions influence plate waste at each decisive moment remain largely uncharted.

5.2 Beyond the micro-level: Multilevel influences and their interactions

Future research should therefore move beyond studying static, individual attributes in isolation toward analysing the consumer-in-context, conceived as a dynamic actor navigating and adapting across interconnected, shifting environments. From these reflections two priorities emerge for future research.

First, research should examine the dining process as a sequence of stages, identifying *decisive moments* when behaviours pivot toward waste generation or prevention. In particular, we emphasise the need to investigate not only the life but also the "afterlife", the post-dining moment, of out of home food. While some studies suggest that providing doggy bags may displace waste from restaurants to households rather than prevent it (Mirosa, Liu and Mirosa, 2018), there is a lack of empirical evidence examining what happens to these leftovers. Future research should therefore track the second life of restaurant leftovers, adopting longitudinal designs to examine whether/ how takeaway food is subsequently consumed, stored, or ultimately discarded within the household. Analysing how multi-level factors shape these moments can inform more precisely targeted interventions.

Second, greater attention should be paid to the interplay between intrapersonal, meso-environmental, and macro-environmental influences, enabling the development of strategies that are contextually and systemically attuned. For instance, although some studies mention the COVID-19 pandemic as macro-background information (e.g. Chang, Lin and Hsiao, 2022), empirical evidence on how post-COVID eating-out has changed and the effects on plate waste remains limited. Future research could therefore explicitly investigate post-COVID effects, such as hygiene perceptions and contamination

concerns (Byrd et al., 2021) in shaping consumers' decisions to take leftovers home. Similarly, macro-wise, existing research shows the geographical concentration of China and USA, leaving Global South and many European contexts underrepresented. This concentration leaves a narrow understanding of how local foodscape context, hospitality traditions, and regulatory environments shape plate waste. This pattern could be partly shaped by the English-language search strategy adopted in this review. Future research could therefore extend to examine plate waste practices across a wider range of contexts.

Additionally, future research should examine tourism economies, where meso-level contextual changes associated with consumers' "holiday habits," may give rise to plate waste practices distinct from everyday dining-out patterns. Tourist-related food waste behaviours is an underexplored topic. While existing studies suggest that plate waste patterns may differ between tourist and non-tourist contexts, the scope of the existing evidence remains limited (Zhang et al., 2022; Liu et al., 2022). Identified behavioural variations are largely attributed to demographic and cultural factors rather than tourism-specific attributes. Given this limited and fragmented evidence base, tourism-related factors were not explicitly integrated into the analytical framework. Nevertheless, tourism economies remain an important and underexplored context for future research.

Moreover, recent shifts in service formats, in particular the increasing use of self-service digital ordering systems (e.g. QR codes and mobile applications), has altered consumer interactions at the meso level by reducing human staff mediation (Bonfanti et al., 2025). However, despite this growing prevalence, empirical research remains limited regarding how digitally mediated service interfaces influence over-ordering and plate waste, as well as how such interfaces might be designed or utilised to mitigate plate waste. To summarise, the responsibility for, and investigation of, plate waste reduction should extend beyond static models of consumer choice to encompass multiple stakeholders and their differentiated levels of influence.

Given the well-documented attitude–behaviour gap in sustainable consumption (D'Acunto, Filieri and Okumus, 2025) and the discrepancies between self-reported and observed plate waste behaviours (Lorenz-Walther et al., 2019; Sebbane and Costa, 2018), a methodological priority is therefore the context-sensitive investigation of plate waste. Qualitative approaches and observational measures (e.g. Juvan et al., 2021) remain underrepresented but are essential to look into the "experiencescape" (Pizam and Tasci, 2019) of out-of-home food consumption. Such directions may include ethnographic approaches to capture practices of consumption and waste that are difficult for consumers to articulate and may not be accurately reported through quantitative, consumer survey methods(Sandiford and Divers, 2019). Additionally, methods like go-along observations, and multi-stakeholder (e.g. chefs and managers) interviewing (Nand et al., 2025) can uncover the operational side of plate waste being produced and managed.

5.3 Contextual sensitive and audience tailored interventions

The dominant focus on individual determinants reflects an underlying assumption that waste is primarily a product of consumer choice. However, the mixed results of intervention studies indicate that effectiveness is highly contingent on context and audience.

First, methodological variation is substantial: some studies compare self-reported intentions or requests (e.g. for doggy bags) rather than actual waste reduction, which may inflate or distort effects. Second, service context matters: as conceptualised in the framework through the service-style risk matrix, service contexts shape where plate waste risk concentrates across decisive moments. However, the existing literature reflects this variation only in a limited way and lacks systematic comparison across service modes. Emerging evidence already suggests that context matters. For example, Xue, Zhang, and Li (2025) show that motivational framing operates differently in hedonic versus utilitarian settings. Future research should therefore adopt more context-sensitive approaches to examine how plate waste dynamics vary across the consumption process across different service

contexts (e.g. fine dining, à la carte, buffet). Third, consumer profile, shaped by cultural norms, dining habits, and personal values means that uniform messaging is unlikely to be effective. Moreover, most intervention experiments have been conducted in controlled, institutional settings, like university canteens. This concentration limits validity, as findings may not translate to hospitality environments with diverse service formats and consumer profiles. A further limitation is the short duration of most interventions (Dolnicar, Juvan and Grün, 2020; Pinto et al., 2018); long-term studies are needed to assess whether behavioural changes are sustained.

Our theorisation of plate waste points to the need for a processual, contextually embedded model of behavioural change, one that aligns interventions with specific stages of the dining process and the situational motivations at play. Practically, this calls for segmented, context-tailored interventions tested systematically across diverse service formats, coupled with cross-context comparative research using consistent, behaviour-based outcome measures (Xue, Zhang and Li, 2025). We thus provide a research agenda that is detailed in Appendix E.

5.4 Managerial implications

In the hospitality sector, decreasing food waste is not only a socio-environmental responsibility but also a strategic lever to enhance brand image and improve financial performance (Filimonau and Delysia, 2019; Nand et al., 2025; WRAP, 2013b; Goh and Jie, 2019). Based on our theorisation (4.4) we propose a processual and context-sensitive management approach of plate waste that involves multi-stakeholder, and multi-level influence.

First, plate waste should be managed across the whole consumption stage.

Pre-consumption: Interventions can focus on shaping expectations and informed decision-making before food is ordered. Examples include communicating portion sizes clearly on menus, providing visual guides, and using point-of-decision prompts (e.g. posters, table cards, Donnicar et al., 2020))

to promote mindful consumption. Transparent, accessible portion information (e.g. photos, models) offers a dual benefit: increasing customer satisfaction while curbing waste (Berkowitz et al., 2016).

Consumption: Portion control and flexible pricing models, e.g. "pay-by-portion," variable portion sizes, (Berkowitz et al., 2016; Matzembacher et al., 2020) help to match servings to appetite, discouraging over-ordering without compromising experience.

Post-consumption: Providing attractive takeaway containers with clear reheating/reuse guidance increases the likelihood that leftovers are consumed rather than discarded (Sirieix, Lála and Kocmanová, 2017). Monitoring feedback channels (e.g. surveys, online reviews) can gather insights on portion adequacy and menu design, enabling continuous service improvement (Ozdemir et al., 2023; Xie, Zhang and Zhang, 2014).

Additionally, effectiveness depends on contextual tailoring. Distinct business models (e.g. buffets, à la carte restaurants, and institutional canteens) require tailored strategies. Similarly, campaigns have divergent effects across consumer segments: the same message may resonate with one audience but fail with another (Ozcicek-Dolekoglu and Var, 2019). This highlights the necessity for target audience profiling.

Such a context- and audience-sensitive approach requires a multi-level understanding of the plate waste issue, enabling managers to address drivers operating at different scales.

Macro level: Examine how broader cultural, policy, and societal narratives shape the meaning of eating out. We found dining in some cultures is framed as an opportunity to demonstrate hospitality or status through abundance, which can encourage indulgence and over-ordering. Managers and practitioners need to reframe value around quality, variety, and mindful enjoyment (e.g. tasting menus, seasonal sharing platters) rather than volume.

Meso level: Assess how the physical and operational setting may implicitly encourage or discourage over-consumption and waste e.g. whether leftover-taking is normalised and easy, and whether the layout, service flow, or pricing model prompts over-ordering (e.g. “all-you-can-eat” cues). Managers can test and adapt settings e.g. default smaller portions, flexible sizing options, and positive framing of takeaway practices, to guide customers toward waste-reducing behaviours without diminishing satisfaction.

There is a need to consider key stakeholders and train staff as “waste-aware facilitators,” making personalised recommendations, prompting sharing, and offering doggy bags proactively (Pearson et al., 2025; Peng and Chen, 2025). Beyond staff, an effective strategy for plate waste reduction also requires the active involvement of multiple stakeholders (Pearson et al., 2025). Environmental leadership from managers and owners can inspire commitment at all organisational levels, embedding sustainability into the service culture (Jang, Zheng and Bosselman, 2017).

Implementation must balance effectiveness, cost, and satisfaction. Start-up costs (training, packaging, operational changes) can be offset by reduced disposal fees, enhanced brand positioning, and loyalty gains (Reynolds et al., 2019). Ultimately, the trade-off between short-term implementation costs and long-term value creation underscores the need for strategic, evidence-informed decision-making in sustainable hospitality management (Zhang and Jeong, 2023).

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