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Combining behaviour change theory and service design to develop household food waste intervention concepts with residents and public sector actors in Sweden

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Abstract

Households generate about 60% of consumer-level food waste globally. Interventions to reduce food waste often rely on awareness-raising, but everyday routines, not lack of awareness, mainly drive it. This study explores how combining the COM-B model of behaviour with service design methods can support the development of intervention concepts to reduce household food waste in Sweden. Thirty semi-structured interviews with household members across Sweden were conducted to map the household food journey and identify where participants described food being wasted and opportunities to reduce it. Concepts developed from this analysis were refined through two rounds of prototyping workshops with households and two focus groups with public-sector actors. Interviewees linked food waste mainly to routine-level challenges of planning, limited overview of stored food, household coordination and time, and half described their household as wasting little or no food. Two leverage points stood out: the organisation and visibility of stored food, and the link between what is at home and what is bought. Participants favoured simple, low-effort tools that fit existing routines, such as “eat soon” prompts and a shared photo of the fridge, and both household and public-sector participants saw potential in feedback that makes food waste visible. Two exploratory motivational orientations, economic and environmental–ethical, were identified, while convenience appeared to shape how these motivations are acted upon. The concepts have not yet been tested in practice. The study illustrates how a behavioural diagnosis can be translated into food waste intervention concepts through co-design.

1. Introduction

Globally, an estimated 1.05 billion tonnes of food is wasted each year at the retail, food service and household levels, equivalent to nearly one fifth of all food available to consumers [1]. When combined with losses earlier in the supply chain, roughly one third of all food produced for human consumption never reaches a plate [2]. Food loss and waste are responsible for an estimated 8–10% of global greenhouse

gas emissions while also placing considerable pressure on land, water and biodiversity [3], [4], [5], [6]. Households account for approximately 60% of consumer-level food waste globally [1], making them a critical target for interventions aimed at reducing the environmental impacts of food systems.

This concern is reflected in sustainable development policy commitments at multiple levels. Target 12.3 of the UN Sustainable Development Goals and Target 16 of the Kunming-Montreal Global Biodiversity Framework [7] call for halving per-capita food waste at the retail and consumer levels by 2030 [8]. Within the European Union, the 2018 revision of the Waste Framework Directive obliged member states to monitor food waste across the value chain and implement reduction measures [9]. In 2025, a further amendment introduced binding national reduction targets to be reached by 31 December 2030: a 10% reduction in food waste from processing and manufacturing, and a 30% per capita reduction across retail, food services and households, measured against the annual average for 2021-2023 [10]. In Sweden, however, progress towards national food waste reduction targets has been slow, prompting calls for more effective, behaviourally informed interventions targeting households [11], [12], [13].

Designing such interventions remains challenging because household food waste arises from a complex set of interconnected practices including planning, purchasing, storage, preparation and consumption [14], [15], [16], [17]. These practices involve multiple household members, compete with other everyday demands and evolve in response to changing circumstances. Furthermore, different households face different behavioural barriers, opportunities and motivations, suggesting that generic "one-size-fits-all" interventions are unlikely to achieve substantial or sustained reductions in food waste [18], [19], [20]. However, there is lack of knowledge about how to systematically translate diverse behavioural insights into food waste reducing interventions in real world settings [21]. This represents a critical gap, particularly for municipalities and other public sector actors seeking practical approaches to reducing household food waste.

This study addresses this gap by demonstrating a process for co-designing behaviourally informed household food waste intervention concepts with households with inputs from public sector representatives. It forms part of a broader research project undertaken in collaboration with households and public sector actors in the Gothenburg Region of Sweden. Previous work within the project applied the Behaviour Change Wheel, including the COM-B model and Theoretical Domains Framework, to identify the principal behavioural drivers of household food waste using qualitative interviews with households across Sweden [22]. That analysis found that although households were generally highly motivated to reduce food waste, they faced barriers mainly related to opportunity, such as time and competing demands, and to knowing how to reduce food waste, including skills and behavioural regulation [22]. The present study builds on this behavioural diagnosis by analysing the interview data to identify motivational orientations, and to identify intervention

opportunities emerging from participants' accounts of how food waste could be reduced. These findings are subsequently explored and refined through a co-design process. In this study, household food waste refers primarily to food that is unnecessarily discarded despite being potentially consumable, rather than unavoidable inedible food residues.

The aims of this study were twofold: first, to understand the household food waste journey in order to identify critical points where it may be possible for an intervention to address the previously identified behavioural barriers and drivers; and second, to co-design and refine prototype intervention concepts targeting these opportunities. In doing so, the study contributes empirical evidence on how behavioural diagnosis can be translated into practical intervention concepts.

The study addresses the following research questions:

1. Where along the household food journey are the most promising opportunities to intervene to reduce household food waste?
2. What types of intervention concepts appear most promising for addressing the behavioural barriers identified along the household food journey?
3. How can iterative prototyping with households and public sector stakeholders support the development of tailored household food waste intervention concepts?

2. Literature review

Household food waste arises from multiple interconnected food-handling routines that span planning, purchasing, storage, preparation, and consumption [14], [15], [16], [17], [23]. Despite this complexity, many interventions continue to rely primarily on general information and awareness-raising strategies [24]. Growing evidence suggests that such blanket approaches are often insufficient, as they fail to address the everyday routines and actions that underpin food management practices. In particular, household routines have been shown to be stronger predictors of food waste behaviour than behavioural intentions alone indicating that effective interventions must move beyond awareness and engage directly with routine practices [17], [23].

In response to these limitations, scholars have increasingly called for greater attention to the everyday practices and behaviours through which food is managed in the home, rather than focusing on individual attitudes alone [25]. From this perspective, even when individuals perceive themselves as motivated to reduce food waste, entrenched routines and practices may still cause disruptions that prevent behaviour change. This highlights the importance of understanding how practices and behaviours interact across stages of the household food journey and where targeted interventions may disrupt or reshape these patterns.

Alongside this need to focus on household practices and behaviours, recent work has emphasised the importance of designing context-specific interventions. Understanding which households are most likely to waste food, why they do so, and which types of incentives are most effective for different groups is fundamental to designing successful interventions[20]. Tailored interventions that make environmental or economic consequences more visible, and that account for differences across socio-demographic groups, have therefore been identified as promising directions for future research [18], [19].

At the same time, there is a trend in the food waste literature towards strongly emphasising individual-level psychological explanations and context-specific sociological analyses, but comparatively fewer systemic and multi-level studies integrate these perspectives [26], [27]. This gap suggests a need for approaches that capture the interactions between individual behaviours, household routines, and broader structural influences. The present study does not attempt a comprehensive multi-level or food-system analysis. Rather, it takes the household as its primary focus and explores how household practices interact with selected wider influences, such as retail practices and public-sector support, as identified by households and public-sector participants.

2.1 The use of co-design in the food waste context

There has been a tendency within the food waste literature to prioritise identifying the drivers of food waste, while comparatively fewer studies have focused on designing and empirically testing interventions in real-world settings [21]. This has led to increasing calls for more solution-oriented research that applies design-based methods to develop, refine, and evaluate interventions in real-world contexts.

In response to these challenges, participatory and co-design methods have gained attention. Co-design approaches involve households and practitioners directly in the development of interventions, enabling solutions to be grounded in lived experience and practical constraints. These approaches involve end-users as active collaborators in identifying behavioural challenges and developing potential solutions, thereby increasing the relevance and feasibility of interventions [28]. Co-design approaches have been widely applied across a range of sustainability domains beyond food waste, particularly in areas characterised by complex socio-technical systems and behaviour-dependent outcomes. These include household energy use and clean energy transitions [29], [30], urban water management [31], sustainable mobility and transport planning [32] and municipal waste management initiatives [33].

A growing number of studies have applied co-design approaches to the design of food-waste reduction interventions. For example, Kim et al. [34] used co-design workshops with consumers to develop household food-waste reduction campaign strategies, demonstrating that consumer insights can inform the design of more relevant and acceptable interventions. Choi and Lee used participatory design with a

school community to develop and implement a care-centred intervention for food waste recycling, finding that it increased students' awareness and engagement [35]. Similarly, Jenkins et al. [36] used co-design methods to develop leftover-reuse strategies with participants, highlighting how collaborative processes can generate practical solutions tailored to everyday food practices. Other studies have explored participatory approaches to designing household interventions that are adaptable to diverse lifestyles and household routines [37]. Participatory approaches have also been used to reduce food waste in hospital settings [38].

Beyond individual studies, participatory and living-lab approaches have increasingly been proposed as promising frameworks for developing sustainability interventions in real-world contexts. Living labs, for example, enable researchers and stakeholders to collaboratively experiment with behavioural interventions in everyday environments, allowing solutions to be iteratively refined based on user feedback and real-world testing [39], [40].

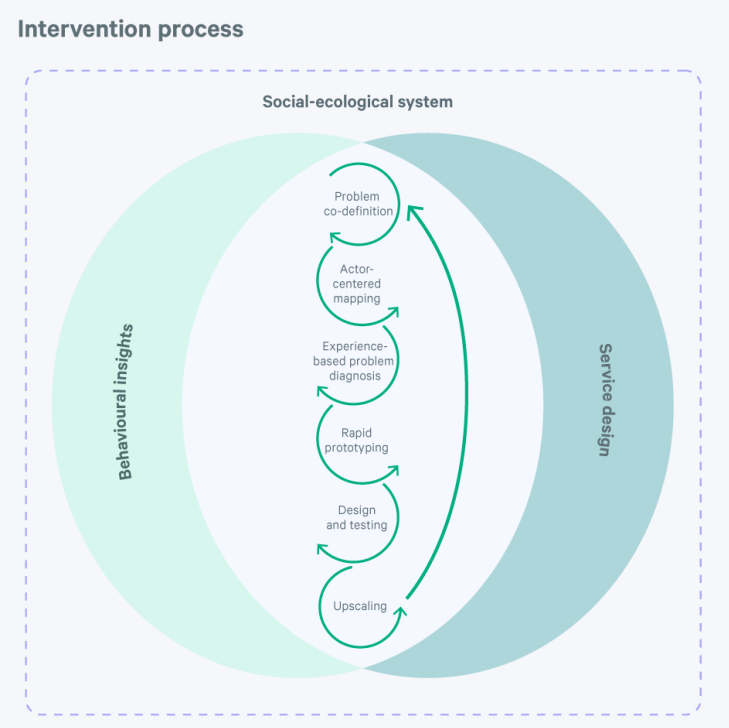
3. Theoretical framing

The conceptual basis for this study is an integrative framework developed by Lambe et al. (2020) [41] that combines service design and the COM-B model of behaviour change. Service design is a human-centred and collaborative approach to designing services that focuses on understanding user needs, experiences, and interactions in order to develop effective and desirable solutions [42], [43]. It typically involves engaging stakeholders including service users throughout the design process and using iterative methods such as mapping, prototyping, and testing to improve service experiences. The COM-B framework (**C**apability, **O**pportunity, **M**otivation–**B**ehaviour) proposes that behaviour arises through the interaction of an individual's capability, opportunity, and motivation to perform a given behaviour [44]. Capability refers to the knowledge and skills required to act, opportunity refers to external factors that enable or constrain behaviour, and motivation encompasses the cognitive and emotional processes that drive action. Originally developed by health psychologists to bridge the gap between fragmented, overlapping theories of human behaviour and practical, real-world intervention design, the framework is increasingly being applied to sustainability challenges. Examples include developing interventions to increase household recycling [45], identifying barriers and enablers to food waste recycling [46], and understanding the drivers of sustainable food purchasing behaviour in Sweden [47]. In these applications, COM-B is valued for linking a structured behavioural diagnosis to the selection of intervention types. However, it has less often been used to inform the design of interventions together with the people expected to use them, which is the gap the integrative framework of Lambe et al. [41] seeks to address.

The Lambe et al. (2020) framework provides a structured approach for designing behaviour change interventions that account for the complexity of real-world contexts. It combines behavioural diagnosis with service design methods to identify

context-specific barriers and opportunities for change, and to iteratively develop and refine interventions in collaboration with stakeholders. The framework emphasises the importance of understanding behaviours as embedded within social, institutional, and material systems, enabling the design of interventions that are both behaviourally informed and contextually grounded. The framework uses the main stages of a co-design process including problem co-definition, problem diagnosis, rapid prototyping, design and testing (see figure 1).

Fig. 1. The main stages of the co-design process [41]



4. Methods

Following similar applications of the Lambe et al. (2020) framework [41] a service design approach was used, including semi structured interviews and prototyping conducted during a series of participatory co-design workshops with households and focus group discussions with public sector actors. The three components were conducted sequentially, with each building on the previous one: the interview analysis produced the food journey models, hotspots and initial intervention concepts; these were used as trigger material in the workshops; and the concepts refined in the workshops were reviewed in the focus groups (Fig. 2).

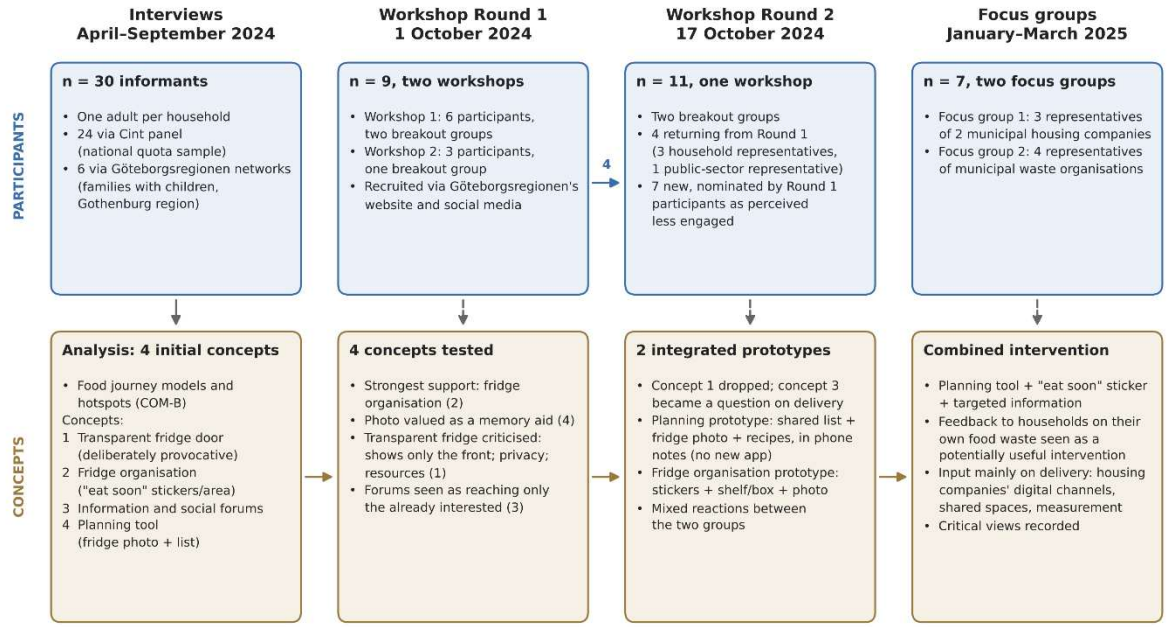


Fig. 2. Overview of the study design: participants at each stage and the development of the intervention concepts from the interviews to the focus groups.

4.1 Household interviews

Thirty semi structured interviews were conducted with one adult member of each of 30 households from across Sweden. Each interviewee acted as an informant for their household, describing the food-related practices of the household. Quota sampling was used for the first 24 interviewees to ensure that they were as representative as possible to the demographic distribution of Sweden. Twenty-four interviewees were recruited by a research company (Enkätfabriken) via an aggregator of web panels, Cint, where households sign up to take part in surveys or interviews[1]. To take part, individuals had to be at least 18 years old.

Recruitment continued until data saturation, operationalised as three consecutive interviews that added no new codes [48]. Because the analysis had raised questions specific to households with children that the existing data could not fully answer, a further six households with children were recruited via contacts of the project partner Göteborgsregionen, all of whom lived in the Gothenburg region. Apart from specifying that families with children were sought, these participants received the same invitation as the panel recruits.

Of the 30 interviewees, 21 were women and 9 were men. The panel participants were aged 31–78 years. Age was not systematically collected for the six participants recruited through Göteborgsregionen. Interviewees lived in six of Sweden's eight

[1] The panel provider's invitation list was based on quotas from Swedish population statistics, aiming for national variation in age, gender and place of residence. Although recruitment followed this list, the final sample depended on who accepted and attended, and it included more women than men and covered six of Sweden's eight NUTS 2 regions, not the whole country (Supplementary Material S5).

NUTS 2 regions[2], and a third lived in West Sweden. Fourteen lived in cities, eight in towns, three in suburban areas and five in rural areas. Twelve households had children under 18 living at home, and seven interviewees lived alone. Fourteen interviewees were mainly responsible for food purchasing and preparation in their household, and eleven shared this responsibility with a partner. Full characteristics are given in Supplementary Material S5.

In each household, one member was interviewed and reported on the household's food practices. References to "households" therefore refer to the accounts of the 30 interviewees, and counts (n) refer to the number of interviewees describing a given practice or experience; each interviewee was counted at most once per category. Unless stated otherwise, categories are not mutually exclusive, as interviewees could describe more than one practice, reason or motivation. Counts indicate how prominent a theme was among the interviewees and should not be read as estimates of prevalence in the wider population.

Each interview lasted approximately 40 minutes. Sixteen interviews were conducted by video call (Teams or Zoom), audio-recorded with participants' consent and transcribed. The remaining 14 were conducted by telephone: ten participants asked to be interviewed by phone, for example because they were unfamiliar with Teams or Zoom or had an unstable internet connection, and four switched to phone when they had technical difficulties connecting at the scheduled time. Telephone interviews were set up as three-way calls so that both researchers could take part. Since arranging these calls was already technically demanding, they were not recorded, to avoid adding further technical complexity and the risk of disrupting the interview. In all interviews, one researcher led the conversation while the other took detailed notes. Immediately after each unrecorded interview, the two researchers held a debriefing session to compare and consolidate their notes into a single, detailed record of the interview. Interviewees received a gift certificate of 150 SEK (14 EUR) valid in 150 stores in the Nordic region. The interview guide is provided in Supplementary Material S6.

4.2 Prototyping workshops

Two rounds of prototyping workshops were held with household representatives in Gothenburg in October 2024. Prototyping makes ideas tangible so that they can be discussed, tested and refined [49]; here it was early-stage, using visual representations of intervention concepts as trigger material (Supplementary Materials S3 and S4). Round 1 comprised two workshops (six and three participants), recruited through Göteborgsregionen's (GR) website and social media channels. Round 2, held two weeks later, comprised one workshop (11 participants). To broaden participation, Round 1 participants were invited to nominate people in

[2] NUTS (Nomenclature of Territorial Units for Statistics) is the EU classification of regions for statistical purposes. Sweden has eight NUTS 2 regions (riksområden).

their networks whom they perceived as less engaged with environmental or food waste issues; nominees' level of engagement was not assessed independently.

Each 90-minute workshop first presented the food waste journey from the interviews for feedback, and then discussed intervention concepts in breakout groups, each facilitated by a researcher and supported by two designated notetakers. The research team developed four initial concepts from the interview findings, including a deliberately provocative transparent fridge door intended to prompt discussion about food visibility. In both rounds, participants critiqued the concepts and proposed changes, new features and combinations; the research team decided which concepts and features to take forward and translated participants' suggestions into prototypes. Supplementary Material S2 summarises how each concept developed and what participants contributed.

4.3 Focus group discussions

Two online focus groups with public-sector actors were held between January and March 2025, recruited through GR's networks: one with three participants from two municipal housing companies, and one with four members of a Preventive Working Group, a regional network of municipal waste-prevention practitioners. These organisations were selected for their experience of engaging households in waste management and recycling. The focus groups discussed the concepts emerging from the workshops and the role their organisations could play in implementation.

Neither the workshops nor the focus groups were audio-recorded. Göteborgsregionen advised that recording could make participants uncomfortable and discourage participation. Instead, detailed notes were taken throughout: in the workshops, two designated notetakers in each breakout group recorded participants' contributions independently, and in the focus groups, notes were taken by a designated notetaker. In both cases, notes were compared and consolidated by the researchers immediately after each session. Quotations from the interviews are taken only from the recorded and transcribed interviews; quotations from the workshops and focus groups are close paraphrases based on the consolidated notes.

4.4 Data analysis

The analysis of interview data followed a codebook approach to thematic analysis [50] in two parts: a mapping of household food practices across the food journey using COM-B, and an analysis of participants' motivational orientations. The interview guide was structured around the household food journey (Supplementary Material S6). It did not ask participants directly about their capability, opportunity or motivation. Instead, it asked them to describe their everyday food practices and routines: what they did at each stage of the journey, what helped or hindered them, and when food was wasted. COM-B was then applied in the analysis, consistent with its proposition that motivation is shaped by capability and opportunity [44], [51],

which made it possible to identify capability, opportunity and motivation factors from participants' own accounts of their practices.

For the food journey mapping, two researchers coded transcripts and consolidated notes manually in Mural, each in a separate space. Each excerpt was coded by journey stage and by the COM-B component(s) it reflected and could receive more than one code [50]. Both researchers coded the same two interviews independently, then compared their coding and agreed definitions for each journey stage and COM-B component. They divided the remaining 28 interviews between them, then reviewed all coding together and resolved disagreements by consensus.

Hotspots were identified using two criteria: how often participants described food being wasted at a stage, and how often they identified opportunities to reduce waste there. Frequency indicated prominence in the interviews, not prevalence among households. Because food waste was not measured, the hotspots reflect participants' own accounts. They were synthesised into the food journey models (Figs. 3 and 4) and Tables 1 and 2. Intervention ideas were then developed to address the COM-B barriers at each hotspot.

The motivational analysis focused on three candidate drivers that emerged inductively from the food journey mapping: saving money; care for the environment and social responsibility; and convenience. To examine these systematically, two researchers independently coded all 30 interviews in MAXQDA against a codebook defining each driver. Agreement was calculated on the presence of each driver per interview and was 94.4% ($\kappa = 0.83$). The remaining disagreements, mainly in interviews where more than one driver was present and none was strongly represented, were resolved by consensus, noting where an interview had a strong secondary driver. The codebook is provided in Supplementary Material S7, and the agreement results in Supplementary Material S1.

The researchers then jointly assigned each interview to one of three categories: a dominant driver; a dominant and a strong secondary driver; or no single dominant driver. These assignments drew on the number of coded segments per driver, but were based on a holistic reading of each interview, not a numerical threshold. This process led to convenience being reconsidered as a driver (Section 5.1.7). An audit trail was kept through the Mural boards on which the interviews were coded, the MAXQDA files, the codebooks and the notes from coding meetings.

The researchers who conducted the interviews also coded the data and contributed to prototype development. To reduce the risk of early interpretations shaping later stages, coding was done independently before joint review. Interpretations were also discussed with the wider research team, and the concepts were tested by workshop and focus group participants.

The workshops and focus groups had different purposes in the co-design process and were analysed differently. The workshop data were the consolidated notes from the two designated notetakers in each breakout group, and the two researchers analysed them inductively. After each session, they reviewed the notes for participants' responses to the food journey and to each intervention concept: what participants found useful, what they questioned and what changes they suggested. Themes were generated together and used to refine the concepts between rounds and to identify key design considerations (Table 2). How each concept changed, and which participant inputs led to each change, is shown in Supplementary Material S2.

The public-sector focus groups were a practical check on the concepts, to assess their feasibility and identify changes needed before implementation. The two researchers analysed the focus group notes deductively against four questions applied to each concept: its perceived feasibility, necessary changes, barriers to implementation, and the possible role of public-sector organisations. Contributions were examined at the organisational level, because participants took part as representatives of their organisations.

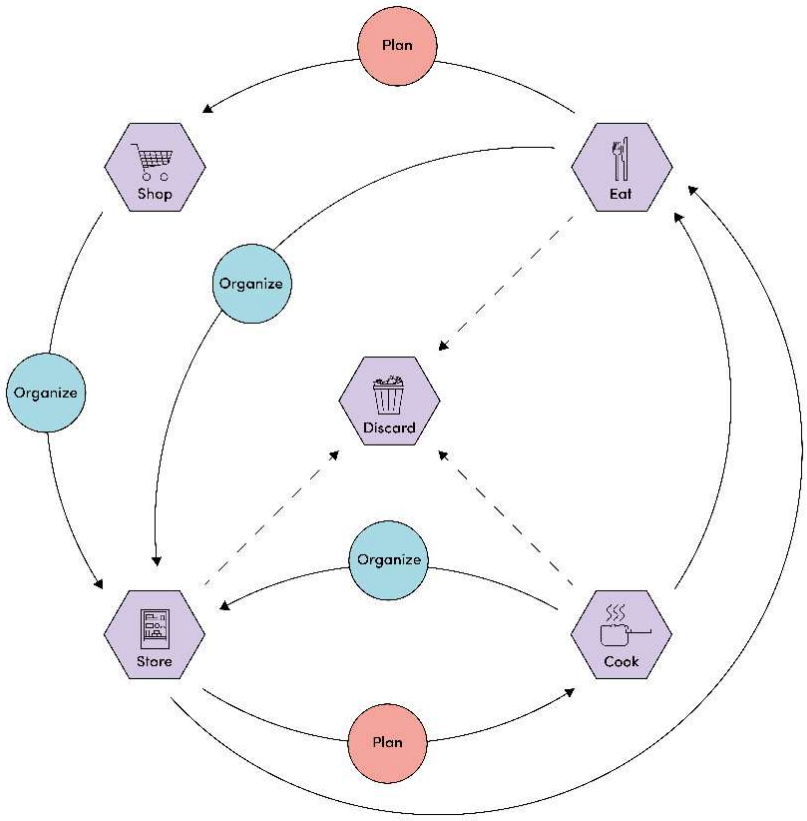
4.5 Ethical considerations

The study was approved by the Swedish Ethical Review Authority (ref. 2023-08108-01, 26 March 2024). Prior informed consent was obtained from all participants. Interviewees received study information and consent forms by email and returned written consent before their interview. Workshop participants completed written consent forms at the start of each workshop, and focus group participants completed consent forms digitally and returned them to the project lead before the session. All participants consented to the use of anonymised quotations in research outputs. To protect confidentiality, participants' names were removed from the notes and replaced with numbers before analysis, and no names or identifying details appear in any outputs. Interviewees received a gift voucher (see Section 4.1), and workshop participants received cinema tickets as a token of appreciation, with refreshments provided during the workshops. Focus group participants were not compensated, as their participation formed part of their professional roles.

5. Results

5.1 Findings from the interviews: the journey of food through the household

Fig. 3. Generic household food waste journey



401

402

403 Figure 3 presents a generic model of how food moves through the home, based on
404 the interview data: planning and purchasing, storage, preparation and consumption,
405 with leftovers stored for later meals or discarded. Food may be discarded at several
406 points, including during storage (forgotten or spoiled items), preparation (unused
407 ingredients) and after meals (uneaten portions). The cycle repeats as leftovers are
408 reused and planning recurs.

409 5.1.1 Planning

410 When asked how they plan their food shopping, 24 interviewees mention making a
411 shopping list, either using pen and paper, a shared digital document on their smart
412 phone, or a store App. Six interviewees mentioned that they do not use any type of
413 list, but rather, they know what they need to buy, or they prefer to shop
414 spontaneously, making on the spot choices in-store.

415 *We write lists, but mostly we shop spontaneously, buying what we feel like*
416 *(*Interview 24)

417 *We don't really plan … it's almost day by day that we decide what to eat.*
418 (Interview 14)

419 Of those who make lists, only six mentioned doing an inventory in the fridge and
420 pantry first to check what they have at home.

5.1.2 Food shopping

Seventeen interviewees describe doing one larger food shop per week and then between one and three complementary shops. Three interviewees reported doing a monthly food shop and three reported consistently adhering to a pre-planned shopping list when in the supermarket. More commonly, participants described modifying their plans in-store, responding to promotions, perceived needs, or spontaneous preferences. Almost half of all respondents (n=14) mention that they make spontaneous purchases in store in response to special offers. Four interviewees explicitly associated supermarket promotions or multi-buy offers with increased food waste, noting that discounted items or bulk purchases sometimes resulted in buying more fresh food than could be consumed before spoiling.

> *Yes, sometimes — especially when it comes to vegetables, you buy things that you don't end up using. For example, two cucumbers, and one goes bad. (Interview 18)*

Eight participants explicitly reflected on the relationship between purchasing behaviour and food waste, noting that buying more food than needed, often due to impulse purchases, promotions, or optimistic planning, frequently resulted in food being forgotten or spoiled before it could be consumed.

> *I often think that I want to eat broccoli, so we buy it, and then we forget to cook it..I want to live in my world where I believe I'm actually going to eat the broccoli.(Interview* 30)

5.1.3 Fridge organisation and food storage

Six interviewees described having a system for organising food storage. In contrast eleven interviewees reported having a limited overview of what was stored in their refrigerators, often leading to food being forgotten in drawers or at the back of the fridge.

> *The jars standing at the back [of the fridge] – those are the ones that end up getting thrown away. (Interview 18)*

Ten interviewees reported routinely checking the fridge before cooking in order to decide what to prepare.

5.1.4 Food preparation and eating

Several respondents described behaviours during the cooking stage that were intended to prevent food waste. Repurposing leftovers into new dishes was mentioned by eight interviewees. Seven respondents reported intentionally cooking extra food so that it could be used for lunchboxes or eaten the following day. Freezing ingredients or cooked meals to prevent spoilage was mentioned by nine

participants. In addition, six respondents described deliberately using ingredients that were close to spoiling, such as baking with overripe fruit or incorporating vegetables that needed to be used soon.

At the same time, eight respondents reported that children's eating behaviours contributed to food waste in their household. Participants described difficulties predicting how much children would eat (n=5), preparing alternative meals when children rejected the main dish (n=3), and discarding food due to uncertainty about the safety of reusing baby food or children's leftovers (n=2).

> *Some days kids won't eat.. we need to switch (type of food) a lot so that they eat (Interview 29)*

5.1.5 Perceptions of what is wasted

Half of the interviewees described their household as wasting little or very little food (n = 12) or no edible food at all (n = 3). Several of these interviewees nevertheless described practices associated with food waste elsewhere in the interview, such as forgetting food at the back of the fridge or buying more than they could use. When asked about the causes of food waste nine interviewees reported food being forgotten due to limited overview of what was stored in the refrigerator.

Seven reported that lack of time or energy to prepare food led to food waste, and six mentioned over-purchasing or buying without a clear plan as a reason. Other commonly reported reasons included changes in daily plans leading to food not being consumed as intended (n=5), and children's eating behaviours introducing uncertainty in portioning and meal acceptance (n=5). Less frequently, participants attributed food waste to cooking too much (n=4) or uncertainty regarding food safety for example, related to the reuse of baby food or eating children's leftovers (n=3).

Fig. 4. Complex household food waste journey

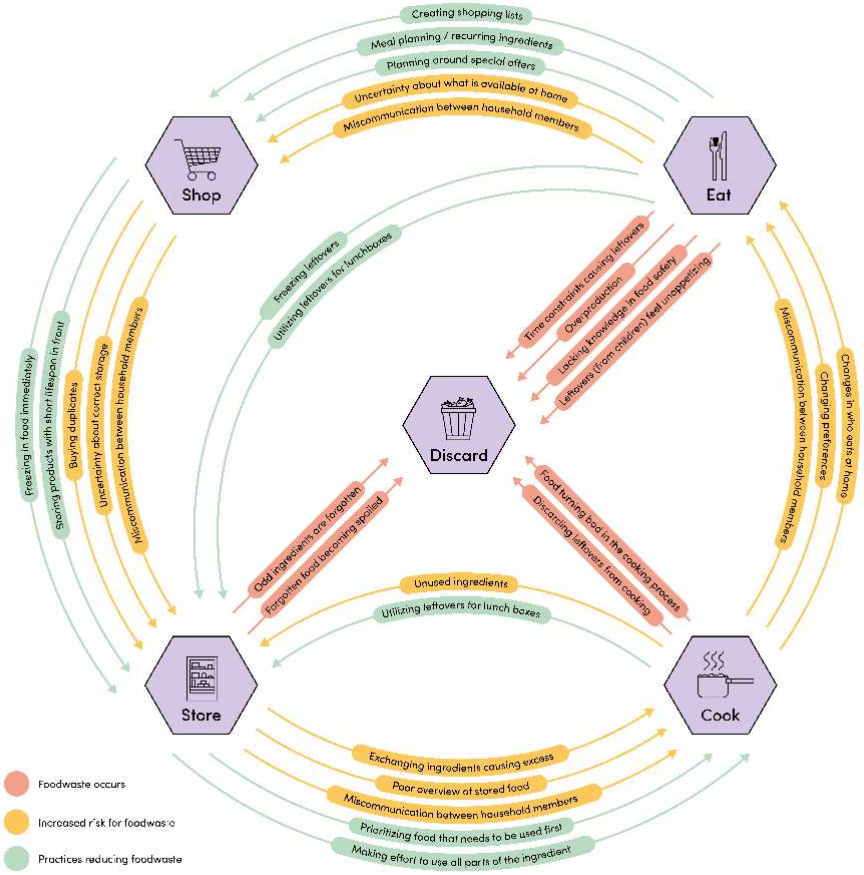


Figure 4 presents a more detailed version of the journey. Red lines show points where food is wasted. Orange lines show factors that increase the risk of waste, such as poor overview of stored food, uncertainty about what is at home, miscommunication between household members, changing meal preferences and time constraints. Green lines show waste-reducing practices, such as meal planning, shopping lists, prioritising food that needs using, freezing leftovers and coordinating within the household. The model shows how food waste emerges from the interaction of everyday routines, coordination and decisions across the journey.

5.1.6 Suggestions on how to reduce food waste

When asked what would help reduce food waste, four participants identified improved planning of meals and shopping as a potential strategy. Nine participants explicitly suggested that improving the organisation and visibility of food in the refrigerator would help reduce food waste, for example by making it easier to see what items are available and preventing food from being forgotten.

> *[One could] Have a jar in the fridge that tells you – use me up!* (Interview 13)

Four interviewees identified reducing unnecessary purchases, resisting promotions, or buying smaller quantities as a strategy for preventing food waste.

Shop less – this is the most important factor (Interview 2)

Five participants highlighted the need for more information or guidance, for example regarding how to store food, how long it can be kept, or how to use specific ingredients and six participants suggested that having access to recipes or inspiration for how to use available ingredients would help reduce food waste.

5.1.7 Motivational orientations

Interviewees framed food waste in economic, environmental and moral terms, often linked to norms learned in childhood (see [22] for a detailed analysis). Initial inductive coding of the interviews suggested three candidate drivers of efforts to reduce food waste: saving money, care for the environment and social responsibility, and convenience in daily life. Systematic coding of all interviews against these drivers (see Section 4.4) supported the first two but not the third. Twenty of the 30 interviews had a single dominant driver: saving money (n = 10) or care for the environment and social responsibility (n = 10). A further three showed a dominant driver with a strong secondary driver, and seven showed no single dominant driver. Convenience did not emerge as the dominant driver in any interview.

An *economic orientation* was evident in interviewees who viewed food waste primarily as wasted money, often in relation to rising food prices and the cost of living: *"stupid to throw money"* (Interview 29). These interviewees were often attentive to discounts and special offers and sought to make their food budget go further.

An orientation towards care for the environment and social responsibility was evident in interviewees who framed food waste as an environmental and moral issue, referring to climate change, resource use and the wellbeing of future generations: "so much resources, transport, water – if we don't use it, it's wasted" (Interview 6). For several, this was linked to norms learned in childhood: "It's baked in since childhood – you just don't do it" (Interview 21).

Convenience was prominent in the initial coding, as many interviewees described busy lives, competing priorities and limited time or energy for planning and cooking. However, the systematic coding showed that it was never the dominant driver of efforts to reduce food waste. It appeared as a secondary driver in one interview and alongside other drivers in the seven interviews without a dominant driver. Rather than a motivation to reduce food waste, convenience therefore appeared to act as a condition shaping whether, and how, interviewees could act on their economic or environmental motivations. In COM-B terms, it relates mainly to opportunity (time) and capability (mental effort), not motivation.

These orientations are not mutually exclusive. Most interviewees expressed more than one, and seven showed no dominant orientation. They should therefore be

understood as exploratory motivational orientations derived from a small qualitative sample, not as validated household segments.

5.1.8 Summary of findings from interviews

Table 1 summarises the key insights from the interviews, linking practices to the behavioural drivers and barriers identified in the earlier diagnosis [22] and outlining their implications for intervention design. Interviewees linked food waste mainly to routine-level challenges of planning, visibility, coordination and time, not to a lack of motivation. The intervention opportunities in the table emerged from participants' descriptions of their practices and their own suggestions. Notably, although planning was frequently discussed as influencing food waste, it was seldom proposed as a solution, suggesting that households may recognise problem areas without identifying actionable strategies.

Table 1 Key insights derived from the household interviews

Key insight from interviews	**COM-B component(s)**	**Design implication**
Planning behaviours are common, but rarely systematic	Psychological capability (planning not linked to knowledge of what is already at home)	Strengthen planning routines by linking shopping lists to fridge inventory and visual prompts.
In-store decision-making drives spontaneous purchasing	Physical opportunity (exposure to promotions and in-store cues); Automatic motivation (impulse purchasing)	Support decision-making at the point of purchase through reminders, visual prompts, or linking planning tools to available food.
Limited fridge overview leads to forgotten food	Physical opportunity (limited visibility of stored food); Psychological capability (forgetting what is stored)	Improve visibility of stored food through fridge organisation systems, visual prompts, or prioritisation zones.
Food waste reducing behaviours exist but are inconsistently applied	Automatic motivation (behaviours not yet habitual); Psychological capability (remembering to apply them)	Reinforce existing behaviours through reminders, prompts, and routine-supporting tools rather than introducing entirely new practices.
Time pressure and competing priorities disrupt routines	Physical opportunity (limited time)	Design low-effort interventions that work under time pressure and require minimal mental effort.
Children introduce uncertainty into portioning and meal preparation	Social opportunity (household dynamics and children's preferences)	Develop flexible tools that support portion planning and adaptability in family contexts.
Half of the interviewees described wasting little or no	Psychological capability (limited awareness of own food	Introduce feedback mechanisms that increase awareness of actual

food, while some also described practices associated with food waste	waste); Reflective motivation (perceiving own waste as low)	food waste levels and make consequences salient.
Strong motivation exists, driven by environmental, social and economic concerns	Reflective motivation (environmental and economic concerns)	Activate existing motivation through feedback mechanisms that visualise financial losses, environmental impact and implications for daily routines.
Planning is widely recognised as important but less frequently articulated as a concrete solution	Psychological capability (recognising a problem without translating it into a plan of action)	Highlight planning as a core focus area in the intervention co-design process.
Food waste occurs across multiple stages of the household food journey	Capability, opportunity and motivation (multiple components across stages)	Design integrated interventions that target multiple stages of the food journey rather than isolated actions.

5.2 Findings from the prototyping workshops with households

5.2.1 Round one prototyping workshop

In Round 1, participants generally recognised their own practices in the food waste journey map and used it to discuss influences on food waste within and beyond the household. Supermarket promotions such as “two-for-one” offers, and package sizes exceeding the needs of smaller households, were seen as encouraging over-purchasing. Participants suggested that the model should distinguish more clearly between planning what to buy and planning to use food already at home, and expressed a need for practical guidance on storage, shelf life and judging whether food is still edible.

A set of preliminary intervention concepts derived from the interview findings was then discussed (Supplementary Materials S2 and S3): a transparent fridge door, fridge organisation using “eat soon” stickers or a designated area, information and social forums, and a planning tool combining a shopping list with a photo of the fridge contents.

Fridge organisation received the strongest support in both workshops:

“I believe in this concept” (Round 1, Workshop 1). Participants compared the stickers to the red reduced-price labels in supermarkets

–“the little red label with a short date makes me eat it so much faster” (Round 1, Workshop 2) – and saw them as a way of involving the whole household:

“it feels like a way to involve the whole family” (Round 1, Workshop 1). The photo-based planning tool was valued as a memory aid when shopping:

"Do I have butter at home? Check the photo" (Round 1, Workshop 1).

Not everyone agreed, however: *"My husband took a photo of the fridge once, but I still couldn't see any more. He was very pleased, but it didn't help me"* (Round 1, Workshop 2).

Some participants also argued that tools could not substitute for knowledge: *"If we rely on apps, it becomes harder to build up our knowledge… The hardest thing is knowing whether I can use something or have to throw it away"* (Round 1, Workshop 1).

The transparent fridge door, designed to provoke discussion, was largely rejected. Participants pointed out that it would show only the front of the fridge, while

"what gets forgotten is what's at the back" (Round 1, Workshop 2).

They also raised concerns about resources and appearance, and about privacy:

"It would be an extra stress in everyday life that my fridge is on display… it's almost a bit private" (Round 1, Workshop 2).

The information and social forums concept was seen as reaching mainly those already interested:

"Those who don't care – why would they start caring?" (Round 1, Workshop 1).

Newsletters were seen as easy to ignore:

"Fun, interesting, I'll read it later – and then I don't" (Round 1, Workshop 1).

Participants saw money as an important motivator, suggesting that visualising the financial impact of food waste could be effective, and several were themselves environmentally engaged. They did not evaluate the motivational orientations as such, but distinguished between households by level of engagement and suggested adapting interventions to household type. As participants were generally highly motivated and positive towards most concepts, they suggested involving people they considered less motivated in the next round.

5.2.2 Round two prototyping workshop

The second round consisted of one workshop (17 October 2024) with 11 participants in two breakout groups, including four returning participants (three household representatives and one public-sector representative) and participants nominated by first-round participants as less engaged with environmental or food waste issues (Fig. 2). Based on Round 1 feedback, the transparent fridge concept was not taken forward, and the remaining ideas were refined into two integrated prototypes (Supplementary Materials S2 and S4). The first supported planning by combining a shopping list with a photo of the fridge contents and links to recipes, using the existing notes function on participants' smartphones, so no new app was needed.

The second supported fridge organisation through “eat soon” stickers and a designated shelf or box, linked to the fridge photo.

Reactions to the planning prototype differed between the two groups. In one group, participants welcomed that it *“isn’t yet another app”* and considered it simple enough for households that want to reduce waste but find planning difficult, particularly for top-up and spontaneous shopping. In the other group, participants were sceptical. They noted that a photo shows little of what is actually in the fridge, including dates and items at the back, and several already used lists or retailer apps that met their needs. One participant who already took stock of their fridge before shopping commented: *“I don’t relate to the photo, but I think it would be good for many people”* (Round 2, Group 1). Across both groups, some participants found the combination of list and photo too complicated and suggested simplifications, such as a single photo in a shared album, a weekly photo with a reminder to update it, and pages for the pantry and freezer. Recipe suggestions based on what is already at home or about to expire were welcomed in both groups, while links to fixed recipes divided opinion.

The fridge organisation prototype was seen as fun and potentially useful for families, particularly as a way of communicating within the household and involving children: *“If my children brought it home, that would be OK”* (Round 2, Group 2). Participants preferred a shelf to a box, which they feared would become *“a throw-away box”*, and suggested reusable stickers with space to write a date. However, several doubted that stickers would be used for long – *“the stickers would probably be used for a while and then not anymore”* (Round 2, Group 1) – and saw them as an extra step that could add stress: *“Good in theory, but it creates a lot of stress. You have to be organised at work, and then you’re forced to be structured at home too”* (Round 2, Group 2). Some also doubted that stickers would reach households without an existing interest in food waste, and proposed simpler organising principles instead, such as moving older items to one side.

Feedback on food waste emerged as a recurring theme across workshop discussions, particularly in relation to visualising financial losses and providing information about collective waste levels. Participants suggested that such feedback could strengthen motivation to reduce waste by increasing awareness of consequences and reinforcing social norms around waste reduction.

Compared with Round 1, participants placed more emphasis on social norms, public campaigns and institutional support in sustaining long-term behaviour change, citing successful long-term campaigns on smoking and recycling as possible models. Visual prompts and planning tools were seen as potentially effective in the short term, but broader societal reinforcement, through campaigns, education, and collaboration with public actors, was considered necessary to maintain engagement.

5.3 Findings from focus group discussions with public sector representatives

The two focus groups discussed a combined intervention developed from the workshops, comprising the planning tool, the “eat soon” sticker, targeted information, and feedback to households on their food waste (expressed in costs and environmental impact). Discussions focused less on the design of the individual components than on their feasibility and on how the intervention could be delivered and scaled.

Representatives of the housing companies emphasised that their existing digital channels, such as resident apps, online tenant pages and text messages for older tenants, now reach residents more effectively than posters or letters. They saw no obstacle to communicating about food waste in shared spaces, even if not all households were taking part:

“I see no problem; it is positive for everyone, even those who are not involved” (housing company representative).

They stressed, however, that communication must not be *“too general – it has to feel genuine”*, and that information needs regular updating because of tenant turnover. One participant described a previous waste project in which monthly feedback using diagrams displayed in waste rooms, combined with praise and encouragement, was associated with a 14% reduction in residual waste: *“What made the biggest difference was the dialogue with residents – a lot of feedback and nudging”* (housing company representative).

Participants from municipal waste organisations saw measurement and feedback as the most important contribution municipalities could make beyond information. Asked what municipalities could do other than inform, one replied:

“Measure and give feedback!” (waste organisation representative).

They also raised several reservations. Much information on food waste is already available:

“There is already a lot of material out there – how will this make a difference?” (waste organisation representative).

Past social media campaigns had received positive reactions but no visible effect in waste composition analyses. Participants noted a potential conflict between messages encouraging households to sort more food waste and messages encouraging them to waste less food. Some questioned whether the proposed measures addressed the underlying barriers:

“The barrier to behaviour change is the same regardless of the message – we think these measures are too far removed from it” (waste organisation representative), referring to households’ cooking knowledge and skills. Participants also questioned how the intervention could reach households not already interested in the issue if rolled out widely.

5.4 Summary of findings from prototyping workshops and focus group discussions

Table 2 summarises the key insights from the workshops, linking participant feedback to behavioural drivers and the design implications. Participants favoured interventions that are simple, low-effort, and compatible with existing routines, particularly those improving the visibility of stored food and linking planning and storage. Both household and public-sector participants saw potential value in feedback mechanisms drawing on economic and environmental motivations, while public-sector participants questioned the added value of new information and noted the risk of competing messages.

Table 2 Key insights emerging from the prototyping workshops

Key insight from workshops	COM-B component(s)	Design implication
Low-effort, routine-compatible interventions were consistently preferred	Physical opportunity (limited time); Psychological capability (limited capacity for additional tasks)	Design interventions that require minimal effort and integrate into existing routines (e.g., use familiar tools such as lists and reminders).
Improving visibility of food emerged as a central intervention focus	Psychological capability (remembering stored food); Physical opportunity (fridge layout and organisation)	Use visual prompts (e.g., stickers, designated zones, fridge photos) to improve awareness of available food and reduce forgotten items.
Linking planning and storage practices was seen as more effective than single-stage solutions	Psychological capability (connecting what is at home with what is bought); Physical opportunity (planning and storage supported by separate, unconnected tools)	Develop integrated tools that connect planning (shopping lists) with storage (fridge visibility) to reduce duplicate purchasing.
Household communication and shared responsibility are critical	Social opportunity (coordination between household members)	Design tools that can be shared across household members (e.g., shared lists, visible prompts).
Simplicity and usability are essential to long-term adoption	Psychological capability (ease of understanding and use); Automatic motivation (forming new routines)	Avoid complex multi-step solutions and prioritise intuitive, low-friction designs.
Motivation linked to financial and environmental concerns can be activated through feedback	Reflective motivation (financial and environmental concerns)	Integrate feedback mechanisms that visualise economic and environmental impacts of food waste.

Visual reminders and prompts support memory and prioritisation	Automatic motivation (cues that trigger action); Psychological capability (remembering and prioritising food)	Use cues such as stickers or reminders to prompt timely use of food.
Participant diversity revealed differences in engagement levels	Reflective motivation (varying engagement across households)	Design interventions that work for households with differing levels of engagement.
Sustained behaviour change requires ongoing reinforcement	Social opportunity (ongoing communication and social norms); Automatic motivation (maintaining routines over time)	Combine existing tools with repeated communication and feedback over time.
Views differed on combining concepts: some saw value in linking tools, while others found combined tools too complex	Psychological capability (mental effort of multi-step tools); Physical opportunity (limited time)	Link components only where this does not add steps for households, and keep each component usable on its own.

6. Discussion

From the interviews, workshops and focus groups, this study explored and refined with participants an understanding of the journey of food through the household, identifying stages that participants described as problematic and where opportunities for intervention may arise (RQ1). Two leverage points stood out: planning and purchasing, and the organisation and visibility of stored food. This suggests that strengthening the link between planning and storage practices is a key opportunity for intervention.

Regarding the design of intervention concepts (RQ2), participants favoured fridge organisation that involves several household members, and simple ways of linking what is in the fridge to shopping decisions. Previous research has identified fridge organisation, food visibility and planning routines as important facilitators of household food management [15], [17], [52], [53] and several digital inventory and meal-planning applications have been developed on this basis [17], [52], [54]. The present findings add that participants considered such strategies more acceptable when they fit into existing routines, and preferred low-effort solutions to dedicated apps.

The findings point to a trade-off in intervention design. Combining planning support, fridge organisation and feedback could address several barriers at once, but participants preferred simple solutions, and several found combined tools too complex. The planning prototype therefore built on practices already common among interviewees, such as keeping shopping lists on their phones, instead of introducing a new app. Even so, integration may add to the burden on household members

already responsible for managing food, suggesting that each component should work on its own and be adoptable gradually. Implementation would also raise practical questions: who provides and maintains the tools (e.g., via housing companies' resident apps), the cost of repeated feedback, privacy, digital exclusion, and the need for food-safety guidance when encouraging the use of leftovers. These lie beyond the scope of this concept-stage study but should be examined in future testing.

Across the interviews, two motivational orientations emerged, economic and environmental–ethical, while convenience, initially identified as a third driver, appeared on closer analysis to act as a condition shaping how those motivations are acted upon, not as a motivation in its own right. Workshop participants likewise identified money as an important motivator, but distinguished between households mainly by their level of engagement and by household type. Together, these findings suggest that differences between households may lie both in why they want to reduce food waste and in how engaged and able they are to act on it. Similar distinctions between environmentally and pragmatically motivated groups have been reported in research on consumer perceptions of sustainability-oriented innovations [55]. Whether tailoring interventions to such differences improves engagement remains a hypothesis for future testing.

Previous research has highlighted a lack of real-world testing of household food waste interventions, with many studies focusing on identifying behavioural drivers rather than evaluating practical solutions in everyday settings [20], [21]. The findings of this study indicate how relevant and acceptable participants perceived the intervention concepts to be; they do not establish their feasibility in everyday use, their adoption, their effect on behaviour or their effect on the amount of food wasted. The concepts must therefore be tested in real household contexts over longer periods, using objective measures of food waste [56], [57].

Finally, as also reported in [22], half of the interviewees (15 of 30) described their household as wasting little or no food, although several also described behaviours associated with food waste, suggesting that some households may underestimate their own food waste [58]. The co-design process adds that making waste visible was proposed by participants themselves: in line with previous research on feedback interventions [59], workshop participants suggested feedback that visualises financial losses and collective waste levels, and municipal waste representatives saw measurement and feedback as the main contribution municipalities could make beyond information. However, as food waste was not measured in this study, the findings cannot establish the extent of underestimation or the relative importance of different intervention points.

6.1 6.1 Reflecting on co-design as an approach to developing the intervention concepts

Regarding RQ3, the co-design approach generated practical, experience-based insights that supported the development of behaviourally informed intervention concepts, consistent with previous research on participatory design in sustainability and behaviour change [28], [41], [60], [61]. Visual trigger materials and prototype concepts encouraged participants to critique underlying assumptions, reflect on their own routines and propose alternatives grounded in their lived experience [62], [63], [64], [65].

Visualising the household food waste journey provided a shared reference point that helped surface influences beyond the household, such as supermarket promotions and policy, as perceived by participants. Similar findings have been reported in previous co-design studies on food waste and sustainability behaviours, which show that participatory approaches can help reveal the systemic and practice-based dimensions of everyday consumption [34], [66], [67], [68].

Interviewees often did not connect their own food waste behaviours with potential solutions. As [22] found, households generally knew why food waste should be reduced but found it harder to identify how; consistent with Nisbett and Wilson [69], participants could articulate broad motivations, but the workshops revealed behavioural influences embedded in everyday routines, that were less readily identified through direct questioning during interviews, suggesting that part of the value of co-design lies in making tacit practices visible.

Iteration was also important [70], [71], [72]. Returning participants could see how their feedback had been incorporated into revised designs, which seemed to strengthen engagement, while new participants, nominated by others as less engaged with environmental issues, helped to test the relevance and usability of the intervention concepts across a broader range of households, and reduced reliance on highly motivated perspectives. Finally, the co-design process complemented the earlier behavioural diagnosis by situating behavioural drivers within everyday household practices, supporting arguments that co-design can help translate behavioural complexity into practical, context-sensitive interventions [41], [73], [74].

6.2 Limitations

The central limitation of this study is that the intervention concepts were not implemented in households, and food waste was not measured. The study can therefore speak to how relevant and acceptable participants perceived the concepts to be, but not to whether they would be adopted or reduce the amount of food wasted. Similarly, the motivational orientations are exploratory and have not been externally validated. Finally, the findings reflect a Swedish context, including its

811 waste management system, the role of municipalities and housing companies, and
812 national campaign traditions, and may not transfer directly to other countries.

813 The number of prototyping sessions was limited by available time and resources.
814 Round one participants appeared relatively engaged with environmental issues,
815 which may have influenced the initial direction of intervention development. Round
816 two participants were classified as less engaged on the basis of other participants'
817 perceptions, not an explicit screening measure, so the extent to which they differed
818 from first-round participants is uncertain; four of the 11 had also taken part in Round
819 1, which may have reinforced earlier views. The initial concepts were selected by
820 the research team based on the interview findings, which may have shaped the
821 direction of discussions. The workshops were deliberately held in Gothenburg, where
822 the concepts will next be tested, which may limit the transferability of the workshop
823 findings.

824 Interviewees were recruited mainly through a non-probability online panel, which
825 may over-represent people inclined to take part in research or motivated by the
826 incentive, and the six participants recruited through Göteborgsregionen all lived in
827 the Gothenburg region. Fourteen telephone interviews were not recorded and were
828 documented through both researchers' notes, consolidated immediately after each
829 interview; these records are less complete than verbatim transcripts and may reflect
830 the researchers' interpretation of what participants said. The interview data were
831 obtained from one member of each household, so household-level practices were
832 inferred from individual accounts. Findings on household coordination, shared
833 responsibility and children's eating behaviours therefore reflect one member's
834 perspective and may not capture how other household members experience these
835 practices. Furthermore, the findings rely largely on self-reported behaviours, which
836 may be subject to recall bias or social desirability effects. Although participants
837 identified upstream factors such as supermarket promotions as contributors to food
838 waste, actors from the retail sector were not directly involved in the co-design
839 process. The wider influences identified in this study therefore reflect the
840 perspectives of households and public-sector participants only, and the study does
841 not claim to represent the wider food system. Including retailers, food manufacturers
842 and packaging actors may have enabled the development of intervention concepts
843 addressing broader systemic drivers of food waste.

844 7. Conclusions

845

846 This study illustrates a process through which behaviourally informed, co-designed
847 intervention concepts for reducing household food waste can be developed. By
848 mapping the household food journey, engaging households in iterative prototyping
849 and reviewing the resulting concepts with public-sector actors, the study identified

intervention concepts that participants considered relevant and acceptable, particularly for improving food visibility and strengthening planning routines.

Methodologically, the study shows how a behavioural diagnosis framework can be translated into a design process. It also identified two exploratory motivational orientations, economic and environmental–ethical, which may provide a starting point for future message development.

These findings have implications for practitioners and policymakers seeking to reduce household food waste and suggest that interventions could prioritise routine-level support, feedback mechanisms and sustained engagement, rather than information campaigns alone, and that these merit testing in practice. The next steps are to involve retail and other food-system actors, and to implement the concepts in diverse households, with objective measurement of food waste, assessment of adoption and sustained use, and comparison of tailored and non-tailored delivery. More broadly, combining behaviour change theory with service design may help move from identifying behavioural barriers to co-designing intervention concepts in other areas of household sustainability.

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Ethical Approval and accordance

The study protocol was approved by the Swedish Ethical Review Authority (Approval No. 023-08108-01) in accordance with the Swedish Ethical Review Act (2003:460). The research was carried out in accordance with the relevant guidelines and regulations.

Consent to participate

Written informed consent was obtained from all individual participants involved in the study.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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