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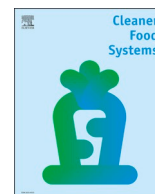
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Too good to waste! Short-term and long-term effects of a leftover meals intervention program on household dinner food waste reduction

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ABSTRACT

Household food waste is a global concern impacting the environment, society, and economy. Effective intervention strategies are needed towards households with children due to their high reported dinner food waste. This study investigates the short-term and long-term impact of a behavioural intervention on dinner food waste in households with children, discussing the behaviour-change mechanisms in light of the Comprehensive Action Determination Model framework. A randomised controlled trial was conducted with 230 Norwegian families that involved incorporating leftovers into dinners and using online learning resources for 4 weeks (intervention group). Additionally, the participants monitored their dinner food waste for 7 weeks (intervention and control groups). Short-term, both groups reduced their total waste, but the reduction was more significant in the intervention group ($n = 113$) than the control group ($n = 117$), with -39% against -22% in the control group. Both groups discarded less fresh fruit, bread and dairy products. The intervention group additionally discarded lower amounts of fresh vegetables, potato products and pasta. Long-term, at 52 weeks follow-up ($n = 144$), the difference in reduction between the groups was no longer significant. However, both groups had reduced their total food waste, indicating the sustained impact of increased awareness regarding household waste, also from mere self-reporting. Globally, the participating households reduced their dinner food waste by -29% at week 52, equivalent to -146 g/week. These results suggest that food waste organisations and policymakers should consider combining practical and informational strategies for effective short-term waste reduction results, and highlight self-reporting as a valuable tool for triggering long-term behavioural change.

1. Introduction

Food waste has emerged as a critical global issue, encompassing multifaceted implications across environmental, social, and economic domains. Approximately one-third of the world's food production is lost or wasted (FAO, 2011, 2019). There is a shared understanding of the importance of confronting the issue of food waste, a key factor in transforming our global food system. Reducing food waste is highly prioritised on national and European political agendas, and the United Nations has called for a reduction in food waste in sub-goal 12.3 of the Sustainable Development Goals (United Nations General Assembly, 2015). Evidence suggests that consumers contribute 53 % to Europe's food waste (Eurostat, 2023; Stenmarck et al., 2016). Therefore, reducing household food waste is necessary to tackle the food waste crisis (United

Nations Environment Programme, 2017).

In Norway, the government aims to halve edible food waste by 2030 compared to 2015 levels (Partnerne i bransjeavtalen, 2020), and the Food Waste Committee has proposed 35 measures to achieve this goal, as no single measure may be sufficient (Matsvinnutvalget, 2023). In 2023, Norway generated 451.600 tons of food waste (Stensgård, 2024b). Households contributed 42 % of the national food waste, with meal leftovers being the largest household food waste category (37 %) at 12.8 kg per inhabitant per year (Stensgård, 2024a). In households with children, meal leftovers are especially high and account for 48 % of the total food waste (Stensgård and Hohle, 2023), emphasising the potential and need for targeted strategies. According to Tonini et al. (2023), families with young children waste perishable items due to poor food management, while those with older children often over-purchase.

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Household food waste typically arises from everyday kitchen activities such as cooking, cleaning, and encountering spoiled ingredients, with lesser contributions from planning, storing, and eating (Aschemann-Witzel et al., 2019). A lack of cooking skills and knowledge about how to use leftovers or partly used ingredients contributes to waste (Nonomura, 2020). Consumers often forget what they have in storage or are unsure how to use partially used items (Cooper et al., 2023). Additionally, fear of illness and overreliance on expiry dates lead to premature disposal of food (Visschers et al., 2016). These behaviours are part of a complex web of food management practices spanning from shopping to consumption and/or disposal (Principato et al., 2021; van Geffen et al., 2020b) and understanding them is essential for designing effective interventions.

Recent literature has explored various household food waste interventions, often combining practical tools with educational components to achieve effective results. For example, van der Werf et al. (2021) provided households with a toolbox to improve food planning, purchasing, storage, and preparation, resulting in a 31 % reduction in total food waste. Cooper et al. (2023) introduced “Use-up Days” and flexible recipes to 909 households with children, achieving reductions of 33 % in Canada and 46 % in the US. However, these effects started to diminish 2–3 weeks after the intervention concluded, highlighting the importance of control groups and long-term evaluations.

While behavioural interventions to reduce household food waste have gained momentum in recent years, the majority of studies focus on short-term effects, typically assessing outcomes immediately after the intervention period. Systematic reviews by Reynolds et al. (2019), Tian et al. (2022) and Jobson et al. (2024) underscore a persistent gap in long-term, household-level research, noting that few interventions include follow-up measurements beyond several weeks or months. One notable exception is Everitt et al. (2023), who reported a sustained 30 % reduction in avoidable food waste among 99 Canadian households, maintained for at least 31 months post-intervention. Furthermore, according to Reynolds et al. (2019), information campaigns can be relatively effective in influencing consumer behaviour related to food waste, in particular when combined with other strategies such as behavioural nudges or structural changes. By raising awareness, correcting misconceptions, and providing practical guidance, information dissemination can empower individuals to make more sustainable choices.

To address the demand for further intervention research (Jobson et al., 2024; Reynolds et al., 2019; Tian et al., 2022), we conducted a randomised controlled trial testing the effectiveness of an experimental food waste intervention program, entitled “Too Good to Waste 7-week challenge”. The program aimed at reducing food waste from dinner meals by using two tasks: 1) Leftover meals: Preparing dinners incorporating meal leftovers and/or partly used ingredients, and 2) Online learning: Visiting a website with different food waste prevention topics. One year after the intervention, the participants from the intervention and control groups were invited to conduct a follow-up food-waste report to evaluate long-term effects. Specifically, our main aim was to investigate whether a 4-week intervention program promoting the use of leftovers and leftover ingredients, combined with online learning, is effective in the short term (follow-up at week 7) and in the long term (follow-up at week 52) for reducing food waste from dinners in households with children. The intervention effectiveness was tested using a validated self-report measurement of household food waste (van Herpen et al., 2019).

The major contributions of this study are: (a) evaluating a 4-week intervention program with a long-term follow-up at one year, which is rare in food waste research; (b) testing an intervention program that is fully digital and therefore highly scalable to broader populations, and (c) being the first food waste study grounded in the Comprehensive Action Determination Model (CADM) framework (Section 2). Additionally, the intervention uniquely included a ‘food waste family chat’ component, which explicitly engaged the household as a social unit. This contrasts with the more individual-focused approaches of prior

interventions. Finally, the paper presents evidence of a long-term impact of mere self-reporting on household food waste reduction. Together, these contributions provide valuable guidance for policymakers and organisations aiming to implement effective and scalable strategies to reduce household food waste.

2. Theoretical background

Although much of the existing literature on food waste behaviour has been grounded in the Theory of Planned Behaviour (TPB) (Ajzen, 1991), and more recently, the Motivation-Opportunity-Ability (MOA) framework (Ölander and Thøgersen, 1995), these models have notable limitations in addressing the full complexity of food-related practices. Gimenez et al. (2023) have demonstrated the effectiveness of an intervention grounded in TPB in influencing attitudes and behavioural intentions, however these authors highlight the importance of also considering habitual and contextual factors in food waste behaviour, which are not considered in TPB. Similarly, while the MOA framework incorporates motivational and contextual factors, van Herpen et al. (2023) suggest that addressing household food-related behaviours requires deeper consideration of habitual routines and competing goals to be effective.

The Comprehensive Action Determination Model (CADM) provides a theoretically robust and integrative framework for explaining environmental behaviour (Klöckner, 2013); it is therefore of interest for examining household food waste behaviour (Illustration in Supplementary S1). CADM combines elements from the Theory of Planned Behaviour (TPB), the Norm Activation Model (NAM), and Habit Theory (Hagger et al., 2020), thereby capturing the multifaceted nature of everyday behaviours that are influenced by both reflective and automatic processes (Klöckner and Blöbaum, 2010a,b; Ofstad et al., 2017).

Household food waste often occurs in routine contexts, where actions are not always the result of deliberate planning but are instead driven by habitual patterns and contextual factors such as time pressure, family dynamics, or storage limitations (van Geffen et al., 2020a). CADM is particularly well-suited to food waste because it explicitly incorporates habitual, normative, intentional, and situational determinants of behaviour (Klöckner and Blöbaum, 2010a,b; Klöckner, 2013). For example, habitual behaviours—such as over-purchasing or neglecting leftovers—can override pro-environmental intentions, making it essential to include habit as a predictor in behavioural models.

Ofstad et al. (2017) applied CADM in a waste separation intervention, showing that perceived behavioural control and habit formation were key to sustained behaviour change. Similarly, Fang et al. (2021) applied CADM to recycling behaviour in Taipei, Taiwan and found that awareness, social norms, personal norms, perceived behavioural control, and habits all significantly influenced recycling intentions and behaviour, demonstrating the model’s capacity to capture the complexity of environmentally relevant actions in urban household contexts (Fang et al., 2021). Normative processes in CADM encompass both social norms (what others expect or do) and personal norms (internalised moral obligations), which influence behaviour indirectly through their impact on intentions and habits (Klöckner, 2013). This layered understanding allows for interventions that not only inform but also engage participants in reflecting on shared values and responsibilities.

Despite its relevance, CADM has yet to be applied in household food waste interventions, representing a promising and underexplored avenue for future research and practical application. By utilising CADM as a post-hoc explanatory lens, this study aims to provide a further understanding of the psychological and contextual mechanisms of household food waste.

3. Materials and methods

3.1. General procedure

A randomised controlled trial with short-term follow-up was executed over a total period of 7 weeks in February–March 2023, and a long-term follow-up measure was executed in February 2024, to investigate the impact of an intervention strategy on reducing household food waste derived from dinner meals. The flow of participants through the trial, from eligibility ($n = 346$) to short-term follow-up analyses ($n = 230$ qualified responses) and long-term follow-up analyses ($n = 144$ qualified responses), is presented in a CONSORT flow diagram (Fig. 1). Participants were stratified prior to randomisation using four socio-demographic variables: gender, age, place of residence, and children’s age group. These variables were selected to ensure that the intervention and control groups were balanced with respect to background characteristics that could influence food-related behaviours. The stratification process involved grouping participants into subcategories based on combinations of the selected variables. Within each subcategory, participants were then randomly assigned to either the intervention or control group. The groups remained equally sized, and the distribution

of stratification variables was balanced across both groups throughout the study (see Table 2 in Section 4).

Table 1
Condition of disposed food categories.

Condition of disposed food	Description	Examples as provided to the participants
1. Completely unused foods	Food that has not been used or prepared at all.	Unopened packages, including unopened parts of multipacks, an entire leek, a bag of potatoes, whole eggs, a complete loaf of bread, or a full tube of mayonnaise.
2. Partly used foods	Food that has been partly used.	Half an apple, half a loaf of bread, half a package of fish, half a package of sausages, or half a package of yoghurt.
3. Meal leftovers	Plate, pot, or pan leftovers.	Boiled potatoes or pasta left on the plate or in the pan, half-eaten slice of bread.
4. Leftovers after storing in the fridge or freezer	Leftovers stored in the fridge or freezer.	Boiled potatoes or omelette left in the fridge, a frozen pasta portion.

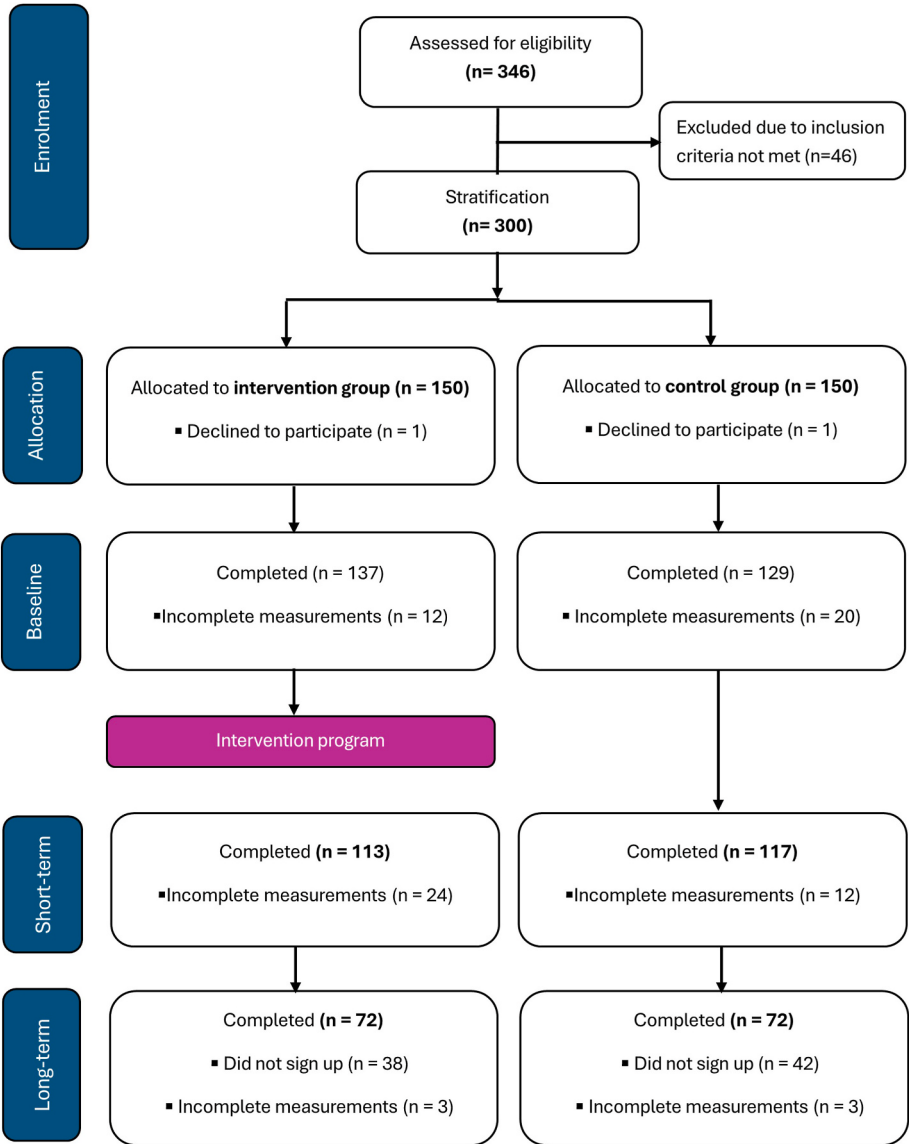


Fig. 1. CONSORT Flow Diagram of the Too Good to Waste study (Baseline: week 0, Short-term: week 7, Long-term: week 52).

Table 2

Characterisation of the participant sample (Short-term n = 230, Long-term n = 144).

Measure/variable	Characteristic	Intervention group		Control group		Total sample		National reference
		Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	
		n = 113, %	n = 72, %	n = 117, %	n = 72, %	n = 230, %	n = 144, %	%
Sex	Women	79	76	80	79	80	78	50 ³
	Men	21	24	20	21	20	22	50 ³
Age range (years)	18–29	3	1	3	1	3	78	15 ³
	30–39	31	35	30	33	30	22	25 ³
	40–49	52	50	55	54	54	1	30 ³
	50–69	14	14	13	11	14	34	10 ³
Residence	City	69	68	68	63	68	52	60 ³
	Village	23	10	26	6	25	13	
	Countryside	8	22	6	32	7	65	40 ³
Education level*	Secondary School	0	0	2	3	<1	1	23 ³
	High School	8	4	5	6	7	5	36 ³
	University and college: 0–4 years	36	35	24	21	30	38	41 ³
	University and college: >4 years	54	60	68	68	61	64	
Household Income**	Other	2	1	<1	0	1	1	n/a
	0–400 000 NOK	<1	0	<1	1	<1	31	10 ³
	400 001–800 000 NOK	12	14	9	8	10	1	30 ³
	800 001–1 200 000 NOK	26	24	20	22	23	1	35 ³
	1 200 001–1 600 000 NOK	27	31	29	29	28	11	15 ³
	>1 600 000 NOK	31	31	29	25	30	23	10 ³
	No answer	4	1	12	14	8	30	n/a
Employment	Working full-time	87	89	87	92	87	28	70 ³
	Working part-time	8	6	3	0	6	8	20 ³
	Unemployed	<1	0	<1	1	1	90	3 ³
	Student	<1	1	0	0	<1	3	5 ³
	Other	3	4	7	4	5	1	n/a
	Prefer not to answer	<1	0	2	3	1	1	n/a
Responsible for food shopping	Main responsibility	58	58	60	65	59	4	70 ⁴
	Shared responsibility	40	39	38	35	39	1	25 ⁴
	No responsibility	2	3	2	0	2	62	5 ⁴
Responsible for cooking dinner	Main responsibility	57	58	51	53	54	37	n/a
	Shared responsibility	43	42	50	47	46	1	n/a
Goal to reduce food waste in their household ¹	Mean (Sdev)	4.6 (0.81)	4.5 (0.87)	4.4 (0.96)	4.6 (0.97)	4.5 (0.89)	4.6 (0.92)	n/a
Household size	2 people	3	4	5	6	4	5	10 ³
	3 people	24	22	17	14	20	18	25 ³
	4 people	50	53	57	56	54	54	30 ³
	5 people	22	19	17	19	20	19	15 ³
	6 people or more	1	1	3	6	2	3	n/a
Number of children per household ²	0–1 years	1	1	4	2	3	3	30 ³
	1–5 years	13	6	18	9	15	15	
	6–11 years	43	22	34	18	38	40	70 ³
	12–15 years	44	20	44	22	44	42	
Number of adults per household	Over 18 years mean	1.9	1.9	2.0	1.9	2.0	1.9	2 ³

Notes: ¹ 5-point scale from Disagree completely to Agree completely, ² Parentheses indicate the percentage of total children, ³ Retrieved from Statistics Norway (Statistisk sentralbyrå, 2023b), ⁴ Retrieved from the Norwegian Institute of Public health (Folkehelseinstituttet, 2023).

Food-waste data were gathered at eight time points, including baseline (week 0), week 1, weeks 2–5 (during intervention), week 7 (short-term follow-up), and a long-term follow-up at week 52 (Fig. 2), using a modified version of the Household Food Waste Questionnaire (HFWQ) (van Herpen et al., 2019) adapted to Norwegian dinner meals. Following the baseline assessment (week 0), in week 1, all participants received a practical one-pager including information and an overview checklist of the forms (both groups) and tasks (intervention group) for the next six weeks of the study (Supplementary S3 and S4). Participants allocated to the intervention group had two tasks throughout the four-week intervention period (weeks 2–5): 1) Leftover meals: Preparing a minimum of two dinners every week that incorporated leftovers and/or partly used ingredients, and 2) Online learning: Visiting a website covering four different food waste prevention topics (one topic per week). In addition, they received information on the procedure for weekly self-reporting of their food waste until week 7. Participants allocated to the control group only received information on the procedure for weekly self-reporting their food waste until week 7 (Fig. 2).

The intervention terminated in week 5. No tasks nor measurements were conducted in week 6. The short-term post-intervention measurement was conducted at the end of week 7, i.e. two weeks after the end of the intervention, allowing participants time to (possibly) return to their usual routines before reporting final outcomes. All participants received weekly reminders (except in week 6) of the forms to fill in throughout the trial.

At the baseline stage, all participants also completed a questionnaire measuring their personality traits (Engvik and Clausen, 2011) and responded to a series of statements focused on attitudes toward food waste and environmental awareness (Myhrer et al., 2024). As a voluntary offer, participants in the intervention group could also join a private Facebook group (Meta Platforms, Inc., USA) for study participants. This aspect of the study is reported elsewhere (Senstad, 2023). At the culmination of week seven and again at week 52, all participants responded again to the questionnaires on environmental awareness and attitudes toward food waste, and (for the intervention group only) provided feedback associated with their experiences during the



Fig. 2. Flow chart of the Too Good to Waste 7-week Challenge (N = 230) with 1-year follow-up (N = 144). Both the intervention and control groups recorded weekly dinner food waste at weeks 0–5, at week 7, and at week 52. The intervention period (pink) consisted in preparing at least two dinners using leftovers or partially used ingredients, and accessing online resources on leftovers, saving tips, shelf-life, and family chat.

intervention period. The present paper reports the intervention program's short-term and long-term effects on food waste measures for the intervention and control groups, while effects of personality traits and attitudinal measures will be reported elsewhere (Svartebekk et al., 2025).

3.2. Participants

Participants across Norway were recruited to participate in the 'Too Good to Waste 7-week challenge' study. Adhering to predefined criteria, all participants were members of households with at least one child under the age of 16 and were either fully or partly responsible for preparing dinner. Participants who participated in the study were either fully or partly responsible for food shopping in their households.

Nofima AS was responsible for recruitment and data collection, and the questionnaires were delivered online through EyeQuestion software (v5.1.4, Logic8, Holland). The Norwegian Agency for Shared Services in Education and Research (Sikt) and Nofima's independent Ethical Committee approved the study protocol before the data collection (Ref. nr. 254094). All participants enrolled via an online informed consent form before participating in the study. An incentive of 1000 NOK (≈90 €), either donated to the local sports club or free-time association of the participant's choice, or as a personal digital gift card, was used to encourage enrolment. The incentive was awarded upon completion of at least 6 out of the 8 expected food waste reports.

We received 300 eligible responses, of which 230 participants (77 %) balanced between the intervention group (n = 113) and the control group (n = 117) answered all questions from start to week 7 and were retained for the analysis at short-term follow-up (Fig. 1). A post hoc power analysis was conducted, using XLSTAT version 2025.1.3 (Lumivero, USA) to assess the statistical sensitivity of the study in detecting differences in food waste reduction between the intervention group and the control group. The intervention group (n = 113) showed a 39 % reduction in food waste, while the control group (n = 117) showed a 22 % reduction. Given the sample sizes and a significance level of (α) of 0.05, the resulting statistical power ($1 - \beta$) of the test was 0.804, corresponding to a beta risk of 0.196. These values indicate that the sample size was adequate to detect a meaningful difference between the groups with a power matching the commonly accepted threshold of 0.80. This suggests a low probability of committing a Type II error and supports the reliability of the observed differences.

Several months after the intervention trial, all participants of the

completed study who had given us authorisation to contact them again in the future were invited to participate in a follow-up food-waste report after one year, conducted in February 2024, i.e. one year after the original trial. In total, 144 households completed the questionnaires, representing 63 % of the households from the short-term study. The intervention and control groups were equally represented, with 72 households in each group. Participants in the long-term follow-up received a 300 NOK (≈27 €) reward.

3.3. Leftover meals and online information intervention

The intervention extended over a four-week period (weeks 2–5). Specifically, the intervention group was instructed to prepare at least two dinners per week incorporating one or more leftover items, such as previously cooked pasta or ingredients that might otherwise be discarded (e.g., limp vegetables or leftover sour cream). In addition, participants were e-mailed a link to a website every week, each time presenting information and tips on a new food waste reduction topic. These web pages were specifically developed for the study and located on one of Norway's largest recipe banks. The topics were not published to the general public to avoid potential access by participants in the control group.

- 1) The first topic (week 2) was "Leftover Kitchen", which focused on incorporating leftover ingredients into new dinner meals. The introduction was: *What do you keep in the fridge? Be sure to use up your food while it's still fresh. Here, you have many tips for simple and delicious dishes from leftovers.* The website provided recipes for specific, searchable leftover ingredients.
- 2) The second topic (week 3) was "Money-saving tips", with the introduction: *If you throw away food, you throw away money, and you will learn more about that in this week's topic. You get useful saving tips and test digital solutions that can help you plan your shopping trip and use up partly used ingredients stored in the fridge.* The website included an informative and entertaining short video, and a digital tool for money-saving calculations.
- 3) The third topic (week 4) addressed "Storage & Shelf Life" with the introduction: *Are you sometimes unsure if food is safe to eat? How should it be stored – or how long can it stand? This week's topic is to use your senses and learn more about storage and shelf life so that you can feel completely safe the next time you wonder if the food can be saved.* The website provided advice for optimal food storage.
- 4) The fourth topic (week 5), "The food waste family chat", focused on how to include the whole family in the fight against food waste. Participants were prompted to gather their family and use question cards (provided on the website) as a catalyst for a good discussion about food waste and leftover food in their household. As an outcome of their discussion, the families were instructed to set three precise objectives to reduce food waste in the future.

3.4. Measures

3.4.1. Quantification and condition of food waste from dinner

Self-reported food waste from dinner meals was quantified weekly using the HFWQ (van Herpen et al., 2019), a validated survey tool for household food waste. The original English questionnaire was translated into Norwegian by native speakers and reviewed by three researchers in consumer science. Furthermore, the questionnaire was adjusted to specifically accommodate dinner meals in Norway in terms of common product categories and quantities.

The HFWQ was presented online in four sections: I) a general introduction, where food waste was defined; II) a Check-All-That-Apply (CATA) question for reporting waste occurrences from 17 food categories in the last 7 days; III) explanations of the following food waste quantification and condition measures, and IV) for each of the food categories selected in (II), questions for reporting the quantification and

condition of the disposed foods. The fully adjusted HFWQ for dinner meals is presented in Supplementary Material S1 for the English version and S2 for the Norwegian version.

In the introduction (I), participants were instructed to report all the edible food the household had thrown in connection with dinner meals in the last week (past seven days). This included a) food items purchased online, in a supermarket or takeaway, b) food grown at home, c) food items that were degraded (spoiled, damaged, or poor quality), d) products that had passed their expiration date and e) leftovers that remained after dinner, on plates, in serving bowls, in pots or in pans. Furthermore, the instructions specified to include all edible food either thrown in ordinary rubbish bins, food waste bins or compost heaps, washed down the sink, given to animals (pets, birds, etc.), or otherwise not used for human consumption. Participants were instructed to disregard non-edibles (bones, shells, seeds, trimmings) and food products that were thrown away when eating outside the home (e.g., at a restaurant or canteen).

In the CATA section (II), the participants were instructed to think about their last week (past seven days) and mark all food categories they had disposed of from the dinner meal in their household. This also included leftover dinner that had been stored from previous days/weeks. Participants were instructed to report the main ingredients separately in the case of mixed dishes. We registered waste for the following 17 food categories: fresh vegetables and salads, non-fresh vegetables (canned and frozen), fresh fruit, non-fresh fruit (canned, frozen, and dried), potatoes and potato products, pasta, rice and grains, beans, lentils, chickpeas, meat, meat substitutes, fish, bread toppings (cold cuts and spreads), bread and baked goods, dairy products, cheese, eggs, and sauces. An alternative answer, "None (I have not thrown away any food from dinners)", was also offered.

For the quantification of amounts of food disposed (IV), appropriate consumer-friendly units were used for each food category (e.g., serving spoons or tablespoons, pieces of fruit, meat portions, bread slices, number of potatoes or eggs, containers). Five options from 1 to 5 were given for each category, where 1 corresponded to the smallest amount and 5 to the largest amount. Additionally, participants indicated the condition of the food items when disposed, such as completely unused items, partly used items, prepared leftovers or stored leftovers (Table 1). Participants were asked to tick off the condition representing the major portion of the discarded item, or to tick off multiple conditions if they discarded two condition categories equally for the same food type.

3.4.2. Engagement in the intervention tasks

An assessment of consumers' engagement in the intervention tasks was conducted using a four-item questionnaire.

1. *How many dinners did you prepare that included leftovers or leftover ingredients this week?* (7-point scale from zero to seven dinners).
2. *What leftovers or leftover ingredients did you use in the dinners?* (CATA question with 16 alternatives: Boiled pasta, Boiled potatoes, Bread (e.g., dry bread, crust), Sauce (e.g., leftovers from pasta sauce, gravy), Over-ripe fruit or berries, Sausages/burgers (e.g., boiled, sautéed, remains in a package), Cheese (e.g., dry, crust or remains), Open canned food, Boiled rice, Limp or remains of cut vegetables, Meat/chicken (e.g. boiled, sautéed, remains in a package), Taco tortillas or similar, Fish (e.g. boiled, sautéed, remains in a package), Dairy products (e.g. sour cream, milk, cream, yoghurt), Sautéed minced meat, Leftovers from a previous dinner, or Other (specify)).
3. *This week's topic was "Leftover Kitchen" [or "Money-saving tips"/"Storage & Shelf Life"/"The food waste family chat", according to the topic of the week]. Have you visited the website with the information on this week's topic?* (Yes/No).
4. *What do you think of the content of the topic page this week?* (CATA with adjectives: useful, not useful, interesting, not interesting, exciting, boring, inspiring, not inspiring, educational, not educational, overwhelming, deficient).

3.4.3. Long-term follow-up measurements

To assess the long-term effects of the intervention, participants completed a follow-up questionnaire at week 52 (one year after the intervention). This questionnaire included.

1. The Food Waste Questionnaire (HFWQ) – repeated from baseline, weeks 1–5 and week 7.
2. Attitudes towards food waste – repeated from baseline and week 7 (reported elsewhere).
3. Food waste engagement – assessed only at week 52. These items measured participants' self-reported behaviours and reflections post-intervention (i.e., *I actively search for information on food waste/I serve leftover dinner every week/I find that I have fallen back into old habits after the study was over/I find that the Too Good to Waste study has reduced our food waste*). Responses were rated on a 4-point scale (1 = strongly disagree to 4 = strongly agree).
4. Perceived benefits from participation – assessed only at week 52. (*To what extent has participation in the Too Good to Waste study ... contributed to your increased knowledge?/ ... contributed to you being more aware of your food waste?/... been helpful to you?/... given you the motivation to reduce your food waste?/... led to other household members being involved in food waste reduction?*). Responses were rated on a 5-point scale (1 = very small degree to 5 = very large degree).
5. Open-ended feedback – repeated from week 7, which provided an opportunity for participants to share qualitative reflections on their experience with the study.

The food waste engagement and perceived benefits items were included only at week 52 to capture participants' retrospective evaluation of the intervention and its sustained impact over time. These questions were not relevant at earlier time points, as they specifically address long-term behavioural change and perceived outcomes following the conclusion of the study.

3.5. Data analysis

Each participant's anonymity was maintained, and each individual was assigned a unique identification number, which was used consistently throughout all data collection and analysis phases. Statistical analyses were conducted using XLSTAT software (versions 2023.1.3 to 2025.1.3; Lumivero, USA)

3.5.1. Analysis of food waste quantities

Food waste quantities reported by the participants (e.g., number of serving spoons, number of items) were converted into grams following the procedure from van Herpen et al. (2019). Then, for each of the experimental groups, waste weights were summed and averaged to obtain the waste in grams per household per food category per week. In addition, the average total waste in grams (over the 17 food categories) per household per week was calculated for each experimental group to represent a global dinner waste amount indicator. Respondents who reported zero waste were included in the analysis, as we also observed them reporting high levels on statements regarding food waste engagement. Approximately 10 % of participants reported zero waste in any given week, while only 3 % consistently reported zero waste at both the baseline (week 0) and short-term follow-up (week 7) assessments.

The standard method for analysing longitudinal randomised controlled trials is the analysis of covariance (ANCOVA). However, given that the two groups in our study were similar in all demographic variables but differed in baseline food waste amounts, we opted for constrained longitudinal data analysis (cLDA). This method accounts for the correlation between repeated measurements on the same subjects. A cLDA model was conducted for the short-term follow-up with factors Week (6 points besides Baseline) and Group $\times$ Week interaction, and dependent variable Total waste in grams per household per week. In the cLDA model, baseline means were constrained to be equal between the

intervention ($n = 113$) and control groups ($n = 117$) while allowing for different means for each group at each weekly measurement (Madsen et al., 2021). Tukey's post hoc test was conducted for pairwise comparisons among the group means. In the cLDA analysis the data were log-transformed due to high skewness in the distribution (skewness range before/after transformation: 2,1 to 2,2/2,1 to -1,9). An offset of 0.1 was added to zero values before doing the log transformation.

3.5.2. Analysis of condition of disposed food categories

Participants were asked to categorise their food waste into four condition categories: "Meal leftovers" (plate, pot, or pan leftovers), "Stored leftovers", "Partly used food", and "Completely unused food". The number of households selecting each condition category was recorded at every week. These counts were used to calculate the total number and percentage of waste condition occurrences for all food categories, separately and combined. A bar plot was created to show the changes from week 0 to week 7 in the number of occurrences. Results on each condition category are presented for the nine most discarded food items, and the intervention group is compared to the control group.

3.5.3. Long-term follow-up measurements

A constrained longitudinal data analysis (cLDA model) was conducted for the long-term follow-up with factors Group, Week (7 data points besides Baseline) and Group $\times$ Week interaction, and dependent variable Total waste in grams per household per week. Differences between the intervention group ($n = 72$) and the control group ($n = 72$) for their food waste engagement (4-point scale, see section 3.4.3) were assessed by using one-way Analysis of Variance (ANOVA) with Tukey's post hoc test.

All analyses used a significance level of $\alpha = 0.05$ to determine statistical significance, and no data were missing for any of the participants retained in the analyses (Fig. 1).

4. Results

The background characteristics of the participants are shown in Table 2. The participants were between 18 and 69 years old, with the majority (54 %) being in their forties, and the sample consisted of more women (80 %) than men. Most of the children in the households (82 %) were over 6 years old. A substantial majority of participants (91 %) had University or College as their highest education level, while a minor proportion (8 %) reported lower education levels. Thanks to the stratified group allocation, background characteristics were highly similar between the intervention and control groups.

4.1. Short-term reduction in total food waste

Participants completed the HFWQ every week (except week 6) during the 7-week period and at one-year follow-up, resulting in eight measurements. Fig. 2 shows the average amount of self-reported food waste per household for the intervention ($N = 113$) and control groups ($N = 117$) over the first 7 weeks. At baseline, the intervention group's average corresponded to 462 g/household, with a median of 230 g, and the control group had an average of 602 g/household, with a median of 475 g. The total weekly amount of discarded food waste across the 17 food categories ranged between 0 and 3120 g/household, with a median of 370 g (intervention and control groups combined). The cLDA showed a significant main effect of week ($p < 0.034$) for the intervention and control groups combined, and Tukey's post hoc test indicated a lower food waste with increasing time (Supplementary S6). The total sample's average short-term food waste reduction was 151 g/week per household.

The interaction effect between week and group was not significant at week 1 ($p = 0.071$) or week 2 ($p = 0.191$). However, this interaction was significant at week 3 ($p = 0.034$), week 4 ($p = 0.001$), week 5 ($p = 0.021$), and week 7 ($p = 0.001$), indicating a greater reduction in food

waste in the intervention group than in the control group during this short-term period (Fig. 3). The average amount of food waste in the intervention group was reduced from 462 g at baseline down to 281 g at week 7, corresponding to a 39 % reduction. The average amount of food waste in the control group was reduced from 602 g at baseline to 470 g at week 7, corresponding to a noteworthy but non-significant 22 % decrease (Fig. 3).

4.2. Food waste categories and condition of discarded foods

At baseline, the five most wasted foods in both groups were fresh vegetables and salads, bread, meat, potatoes and potato products, pasta, rice and other grains (Table 3). The cLDA with Tukey's post hoc test showed a significant main effect of factor Week for five of the 17 food categories, indicating lower food waste with time across the total study population for vegetables, fruit, pasta, bread and dairy products (Supplementary S8). However, no significant interaction between group and time was observed for any food category, indicating that the change in food waste was not significantly more substantial in the intervention group when analysing each food category separately. Paired t-tests comparing Week 0 vs. Week 7 for each experimental group showed that the intervention group decreased their waste for six categories: fresh vegetables and salads ($p = 0.007$), fresh fruit ($p = 0.016$), potatoes and potato products ($p = 0.041$), pasta ($p = 0.037$), bread ($p = 0.025$) and dairy products ($p = 0.004$) (Table 3). In contrast, the control group reported a significant waste reduction for three categories only: fresh fruit ($p = 0.039$), bread ($p = 0.036$) and dairy products ($p = 0.007$). Supplementary materials S9 and S10 provide full details regarding the average amount of reported food waste for each of the 17 categories for each group at week 0 and week 7.

The major reported condition category of the discarded foods, in Week 0 and Week 7 (both in Intervention and Control groups) was 'Meal leftovers' (i.e., plate, pot, or pan leftovers) with 50 % and 55 %, respectively, followed by 'Stored leftovers' (27 %, 30 %), 'Partly used food' (17 %, 11 %), and 'Completely unused food' (7 %, 6 %).

The intervention group observed a major reduction in waste occurrences across all food condition categories (Table 4). In Week 0 (Baseline), this group reported discarding Meal leftovers 230 times (mean: 2.0 occurrences/household) and Stored leftovers 129 times (mean: 1.1 occurrences/household). By Week 7, these numbers had decreased by over 33 % to 154 (mean: 1.4 occurrences/household) and 78 occurrences (mean: 0.69 occurrences/household), respectively (Table 4). In contrast, the control group reported high occurrences for these two condition categories as well in Week 0 but showed stable numbers of occurrences

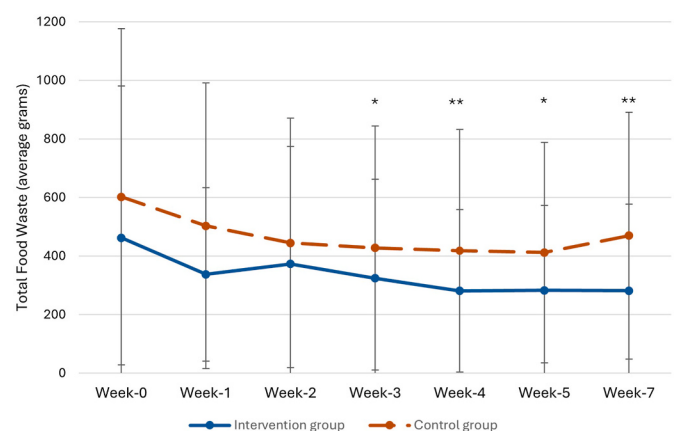


Fig. 3. Average self-reported household food waste (g) for intervention ($N = 113$) and control ($N = 117$) groups before (weeks 0–1), during (weeks 2–5), and after (week 7) the intervention. Stars indicate significant week $\times$ group interaction effects from constrained longitudinal data analysis (cLDA), with greater reductions in the intervention group from week 3–7. * $p < 0.05$; ** $p < 0.01$.

Table 3

Average food waste (in grams) at baseline (Week 0) and post-intervention (Week 7) for the intervention group and the control group.

Category	Grand mean (g) ¹	Intervention group			Control group		
		Week 0	Week 7	p-value	Week 0	Week 7	p-value
Fresh vegetables and salads	66.6	77.0 ^a	44.9 ^b	0.007**	77.8 ^a	66.5 ^a	0.331
Bread	63.8	77.4 ^a	29.8 ^b	0.025*	104.3 ^a	43.8 ^b	0.036*
Meat	59.3	38.9 ^a	50.4 ^a	0.478	61.5 ^a	86.3 ^a	0.223
Potatoes and potato products	53.8	54.6 ^a	33.0 ^b	0.041*	67.9 ^a	59.8 ^a	0.535
Pasta	50.1	53.1 ^a	32.5 ^b	0.037*	60.5 ^a	54.3 ^a	0.593
Rice and other grains	49.1	42.9 ^a	38.5 ^a	0.650	62.2 ^a	52.6 ^a	0.417
Fish	26.1	17.9 ^a	19.2 ^a	0.889	31.4 ^a	35.9 ^a	0.703
Fresh fruit	23.3	24.1 ^a	5.5 ^b	0.016*	44.4 ^a	19.0 ^b	0.039*
Dairy products	13.1	22.3 ^a	3.5 ^b	0.004**	20.9 ^a	5.6 ^b	0.007**

Note: Only the nine most wasted food categories out of the original 17 are shown. * Significant at the 5 % level; ** significant at the 1 % level. Different letters indicate significantly different average scores across experimental groups using ANOVA and Tukey's post hoc test at $p < 0.05$. ¹"Grand mean (g)" represents the mean value calculated across both groups (intervention and control) and both time points (week 0 and week 7).

Table 4

Condition of foods at the disposal stage for all 17 food categories in Week 0 and Week 7.

	Intervention (n = 113)			Control (n = 117)		
	Week 0	Week 7	Change	Week 0	Week 7	Change
	n (%)	n (%)		n (%)	n (%)	
Completely unused foods	32 (7)	13 (5)	−59.4 %	36 (7)	28 (6)	−22.2 %
Partly used foods	90 (19)	37 (13)	−58.9 %	82 (15)	44 (9)	−46.3 %
Meal leftovers	230 (48)	154 (55)	−33.0 %	278 (52)	254 (54)	−8.6 %
Stored leftovers	129 (27)	78 (28)	−39.5 %	140 (26)	143 (31)	2.1 %
Total occurrences	481 (100)	282 (100)	−41.4 %	536 (100)	469 (100)	−12.5 %

in Week 7.

Fig. 4 shows the food consumption categories for each of the nine most discarded food types in the intervention and control groups at baseline (Week 0) and post-intervention (Week 7), expressed as the number of households that reported occurrences. The intervention group showed the most prominent reduction in number of households discarding meal leftovers and leftovers after storing, especially for fresh vegetables and starchy foods. The disposal of Partly used and Leftover bread was remarkably reduced in both the intervention and the control groups, as well as Partly used dairy products.

4.3. Compliance of the intervention group with the leftover meals cooking task and the online food waste information reading task

On average, the participants in the intervention group prepared two leftover dinners per week (median = 2.0, range = 0–6) throughout the intervention period. The five most used leftover-categories (out of 16) were leftover dishes from previous dinners (14 % of the total number of times the 16 leftover-categories have been selected), limp or leftover cut vegetables (11 %), meat/chicken products (10 %), dairy products (8 %), and boiled potatoes (8 %). Respondents reported every week if the online 'topic of the week' had been visited. On average, across the four topics, 64 % (n = 73) reported visiting the online resource. Topic 1 (Leftover kitchen) was the least visited (n = 64, 57 %), and topics 3 (Shelf life and Storage) and 4 (Food waste family chat) were the most visited (n = 77, 68 %). The four most frequently selected descriptors across all topics in the CATA assessment were useful, interesting, inspiring and educational (Supplementary 11). Even though topic 4 was highly visited, only 39 % (n = 44) of the whole intervention group (corresponding to 57 % of those who visited the webpage) reported conducting a food waste chat with their family as encouraged to do in Topic 4. Topic 3 - Shelf Life and Storage was considered the most useful of the four topics and qualified as interesting and informative.

Moreover, in the open-ended feedback question at week 7, some participants from the intervention group (15 %) and the control group (19 %) reported increased awareness of their food waste. Many were surprised by the amount of food waste they reported in the HFQWQ,

having initially believed it to be lower. One participant described: "(...) seeing that we often throw away the same thing every week has been eye-opening. For example, we always make too much rice and pasta and are not good at using this as leftover food" (woman, age 40–49 years).

4.4. Long-term follow-up one year later

One year after the intervention, a subset of the participants (n = 144) completed the follow-up questionnaire, which was used to analyse the long-term effects of the intervention. Each experimental group had 72 families participating.

The cLDA model for the subset shows a significant effect for the Group × Week interaction at weeks 3, 4, 5, and 7, highlighting a stronger waste reduction in the intervention group than in the control group, in line with the results from the original complete participant sample. In week 52, however, this interaction effect was no longer significant (Fig. 5, Supplementary S12). Congruent with those results, the share of participants reporting 'very low', 'low', 'medium' and 'high' waste levels at week 52 was not significantly different between the groups (p-value = 0.147) (Supplementary S13). However, the share of high wasters compared to baseline had reduced by 5 % only (from 13 to 8 %) in the intervention group against 15 % (from 26 to 11 %) in the control group (not shown).

From week 7 to week 52, the intervention group did not continue to decrease their food waste but increased it from 248 g/household to 318 g/household. In contrast, the control group continued to reduce their food waste, decreasing from 447 g/household to 384 g/household. At week 52, both groups showed a reduction in food waste compared to baseline, with a 23 % reduction achieved in the intervention group and a 34 % reduction in the control group. The global average reduction in dinner food waste from baseline to week 52 for the total subset of long-term participants (n = 144) was 29 % with a marginal significance (p = 0.083), equalling 146 g/week per household.

As regards food waste behaviour one year after the initial study, no significant difference was found between the intervention and control groups for any of the three long-term follow-up questions. On the 4-point scale, both groups reported actively searching for information

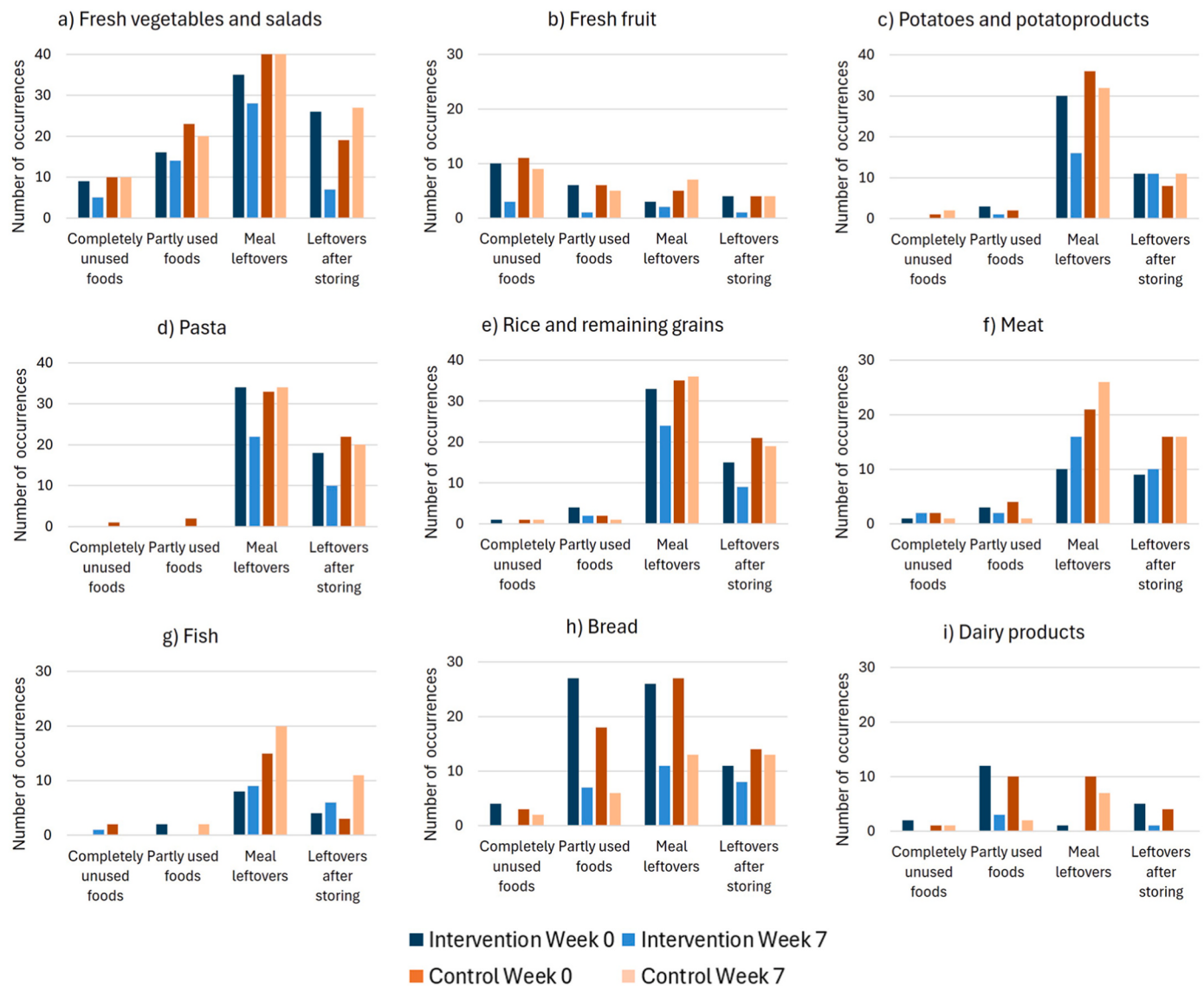


Fig. 4. Condition of discarded food in selected food categories for the intervention group (dark blue = week 0, light blue week 7) and control group (dark orange = week 0, light orange week 7). Values represent the sum of occurrences the condition category is selected by the households who reported discarding each food category. Participants had the possibility to check more than one condition category.

on food waste (Intervention group mean = 2.2; Control group mean = 2.4; $p = 0.366$), serving leftovers for dinner every week (Intervention = 3.3; Control = 3.1; $p = 0.225$), not having fallen back into old habits (Intervention = 1.8; Control = 1.8; $p = 0.926$, reversed scale), and feeling that the study contributed to food waste reduction in their household (Intervention = 2.9; Control = 2.7; $p = 0.163$) (Supplementary S14).

5. Discussion

This study explored the effectiveness of a behavioural intervention strategy for reducing dinner food waste in households with children, focusing on dinner meals. The intervention used a combined practical and informational strategy. To the best of our knowledge, this study is among the first to explore both short-term and long-term effects on behaviour changes related to food waste in households with children.

5.1. Short-term effectiveness of the intervention

The intervention group decreased their food waste by 39 % over the

first 7 weeks, which was significantly more than the control group, indicating the intervention strategy's effectiveness. Our findings align with other household food waste studies, emphasising practical strategies like leftover recipes and tool-kits, as well as informational approaches that educate consumers on meal planning and proper food storage to reduce waste. [Cooper et al. \(2023\)](#) reported that through a 5-week intervention using flexible recipes, households surveyed in Canada and the US significantly reduced their food waste by 33–46 %. Also, [van Herpen et al. \(2023\)](#) reported a 39 % reduction in food waste among Dutch consumers when they used a tool package containing, among other things, leaflets and recipes to avoid wasting food. Regarding information strategies, [Wharton et al. \(2021\)](#) observed a 28 % reduction in American households' food waste through their 5-week intervention using educational materials and strategies for food waste reduction through a dedicated website. Further, [Boulet et al. \(2023\)](#) scored behaviours based on their impact on reducing food waste and their likelihood of adoption, described as the Impact-Likelihood methodology. These authors report that behaviours with a high likelihood of adoption require minimal effort and can be seamlessly incorporated into existing habits, and recommend implementing weekly dinner meals

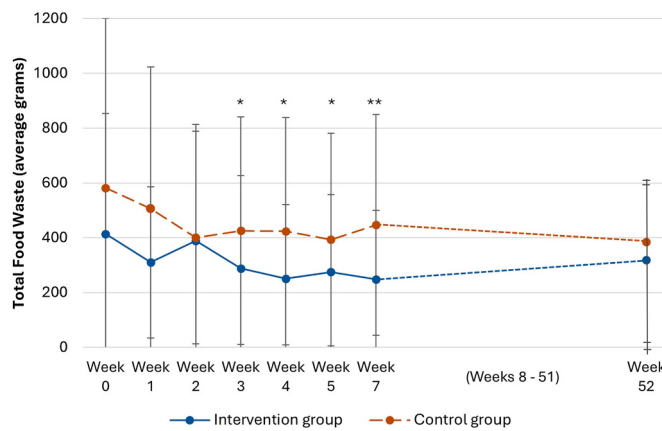


Fig. 5. Average self-reported household food waste (g) for long-term participants in intervention ($N = 72$) and control ($N = 72$) groups before (weeks 0–1), during (weeks 2–5), after the intervention (week 7), and at 1-year follow-up (week 52). Stars indicate significant week $\times$ group interaction effects (cLDA). * $p < 0.05$; ** $p < 0.01$.

from leftovers in household interventions. From the four informational topics during our Too Good to Waste intervention, participants received tips on how to get an overview of the refrigerator, plan and purchase groceries and make portion calculations, and these tasks are all categorised as high impact-high likelihood behaviours (Boulet et al., 2023). Our participants' significant decrease in the amount of discarded food can result from better meal planning and more efficient use of ingredients and leftovers already available in their kitchens. The simplicity and practicality of checking food stocks before shopping, and planning meals with leftovers, make these behaviours accessible to many households, regardless of their initial engagement with food waste reduction efforts. Nonetheless, our results from the cLDA analysis suggest that it took three weeks of ongoing intervention (four weeks since baseline) before the intervention was significantly effective beyond the mere measurement effect affecting the control group. This implies that even in a very supervised setup such as the *Too Good to Waste* study, behaviour change for food waste reduction is a slow, progressive process (Vittuari et al., 2023a).

The food waste measurements in our study indicate that leftover dinners have helped participants reduce several food waste categories. Participants in the intervention group reported a significant reduction in the food categories of fresh vegetables, fresh fruit, potatoes and potato products, pasta, bread, and dairy products from week 0 to week 7. Furthermore, the results also showed that the intervention group had significantly lower food waste from fresh vegetables, fresh fruit, potatoes, and pasta than the control group at week 7. The food categories of fresh vegetables, potatoes and potato products, pasta, and dairy products were some of the categories specially targeted by the online information. The results could be explained by participants finding more dinner options or recipes using these ingredients. In addition, the participants in the intervention group reduced in priority their waste of meal leftovers and leftovers after storage, both in general and for fresh vegetables and starchy foods including bread. This is in line with Norwegian data from Stensgård et al. (2023), who identified vegetables, fruit and berries, bread, and dairy products as the top categories with high household food waste reduction potential. Similarly, Leverenz et al. (2019) found that vegetables accounted for 22%–26% of food waste in their German study. Their intervention, involving coaching on meal planning, shopping lists and food storage, led to a significant reduction in vegetable waste by 38% and 49% in offline and online experimental groups, respectively.

5.2. Mere measurement effect and long-term effectiveness

While the intervention group demonstrated a more substantial short-term reduction in food waste, a decrease was also observed in the control group (–22%). However, this change did not reach statistical significance. Increased awareness of food waste has been frequently discussed as a potential outcome of self-reported waste measurement (Questa et al., 2020; Reynolds et al., 2019). Over a span of 166 days, Ramos et al. (2024) conducted an experiment involving 80 households, during which they measured their food waste every time the trash bin was full (average 1.6 times per week). The findings revealed that while the specific interventions (purchasing and cooking planning) did not significantly reduce food waste beyond the control group, there was a notable "mere measurement effect." Similarly, Gimenez et al. (2023) examined control and intervention groups with 1117 US households for approximately 15.5 days, and found that simply measuring food waste weekly reduced it in both groups. This effect suggests that by the simple act of measuring food waste over time, participants became more aware of their wasteful habits and adjusted their behaviour accordingly. In contrast, van Herpen et al. (2023) found minimal effects from self-reported measurements in a study with 150 participants. The intervention tested a toolbox designed to reduce food waste, with participants randomly assigned to receive it either with or without an additional social norm message. Food waste was measured before the intervention and two weeks after the toolbox was distributed. This conflicting result possibly underlines the need for longer study designs to be able to capture the slow effect of awareness raising on behaviour change.

Very few studies have conducted a follow-up several months later to evaluate the long-term effect of the intervention. Our study extends the literature by demonstrating that mere measurement effects may be achieved up to one year after the self-reporting period. At week 52, the Intervention group had somewhat increased their food waste again (21%) compared to week 7 (39%), such that no significant reduction was observed any longer compared to week 0. This rebound was partly expected because new habits are difficult to establish in just a few weeks, and participants can fall back into old habits even though their intentions are good (Jobson et al., 2024). This suggests that our direct behaviour change instructions and supportive online information to the intervention group may have prompted rapid change, but without reinforcement, their impact diminished. According to the Motivation Crowding Theory (Frey and Jegen, 2000), interventions based on external engagement, completion, or performance can "crowd out" intrinsic motivation because the intervention is perceived as controlling (Frey and Jegen, 2000). For example, Xu et al. (2023) found that while financial rewards increased household recycling behaviour, they simultaneously reduced individuals' intrinsic motivation to protect the environment. In contrast, participants in the control group continued to decrease food waste such that at week 52, their waste amounts matched those of the intervention group and achieved a significant 34% reduction from baseline. They also reported making leftover meals weekly and independently seeking information on reducing food waste at similar levels to the intervention group. This suggests that based on the awareness of their weekly self-reported food waste, participants in the Control group experienced intrinsic motivation and developed their own strategies based on personal reflection to tackle the problem. The control group's steady progress points to the potential of self-monitoring and autonomy in problem-solving for supporting lasting behavioural change. This suggests that self-monitoring may serve as a low-cost, scalable strategy for promoting effective sustainable behaviour change in the long run.

From a methodological point of view, these findings highlight the importance of considering both the intensity and longevity of intervention effects. Further, the study highlights the importance of a control group in assessing the effectiveness of an intervention program, and not simply assessing the intervention group's reduction from baseline to

post-measurements (Shu et al., 2023).

5.3. Theoretical discussion

The Comprehensive Action Determination Model (CADM) (Klößner and Blöbaum, 2010a,b) is a valuable framework to interpret the behavioural mechanisms behind household food waste reduction (Fig. 6). As was intended, the intervention group decreased their food waste due to the intervention strategy. This may be explained by several aspects. Firstly, we encouraged intervention participants to use leftover ingredients for two weekly leftover dinners. This task was easy to execute as it requires no specific tools, funds, or skills, and is potentially applicable in any household. This ensured that situational conditions would be favourable for compliance and success. Secondly, Topic 1, “Leftover kitchen”, and Topic 3, “Storage and shelf life”, provided the participants with directly relevant tips and knowledge, reinforcing perceived behavioural control. Together, these elements targeted the participant’s situational influences, which are decisive in forming intentions for behaviour change (Fig. 6). Moreover, when individuals’ food-wasting habits clash with their personal norms, they may experience a psychological discomfort known as cognitive dissonance (Hamilton and Johnson, 2020), which motivates behaviour change. Online Topic 2, “Money-saving tips”, targeted awareness of needs and consequences and Topic 4, “Family chat”, targeted social norms, which are key in forming or reinforcing personal norms and, thereby, intentions (Fig. 6). Activating personal norms heightens one’s awareness of core values like environmental responsibility and ethics, reinforcing the moral obligation to act in line with these values (Klößner and Blöbaum, 2010a,b). Additionally, a heightened sense of moral obligation can boost perceived behavioural control, as individuals feel empowered and responsible for making a positive impact.

Further, enrolling in the *Too Good to Waste 7-week Challenge* with other participants may have constituted a social norm that food waste reduction was socially desirable, thereby increasing the likelihood of adopting food-waste reduction behaviours. When individuals feel a personal moral obligation and perceive social pressure to reduce food waste, their intention to change their behaviour becomes more robust (Klößner and Blöbaum, 2010a,b). Over time, as one consistently engages in a desired behaviour, it can become habitual. Thus, when our

intervention participants repeatedly checked for leftovers in their dinner preparation routine, we anticipated they were more likely to form a new habit and, therefore, continue or sustain their waste reduction in the long-term. The evidence in this study suggests however that a 4-week intervention was insufficient to establish durable habits. According to Lally et al. (2010), it takes an average of 66 days to form a new habit, and our active intervention period lasted only 28 days. Moreover, once the 7-week challenge came to an end, weekly messages from the experimenters and self-reports stopped. Without continued reinforcement, the participants’ routine use of leftovers in dinners and their general intentions to reduce food waste might have weakened. Future studies are recommended to test prolonged intervention periods of at least two months (Masotti et al., 2023), and/or to test the potential benefit of regular reinforcements after the active intervention period is over.

Further, our control group also decreased their food waste, first cautiously short-term, then more strongly long-term. As control group participants also signed up to the *Too Good to Waste 7-week Challenge*, a perceived social pressure to reduce food waste may partly explain their onset (but not significant) short-term reduction. Additionally, weekly self-reporting one’s food waste is a powerful eye-opener, awaking a person’s awareness (Quested et al., 2020; Reynolds et al., 2019), as was spontaneously disclosed by over 15 % of participants from each experimental group.

Conclusively, while our intervention strategy targeting favourable situational conditions (leftover dinners), perceived behavioural control (leftover dinners, recipes, storage and shelf life tips) and normative processes (7-week challenge, Family chat) was very efficient in the short term, evidence from this study suggests that a similar long-term waste reduction may be achieved by solely raising awareness of one’s food waste, for example through self-reports, and motivating personal norms formation, for example through participation in a food-waste challenge.

5.4. Limitations and future research

This study utilised self-reported household measurements to evaluate the effectiveness of the intervention. Although self-reporting is the most common measurement method in food waste studies, it has limitations due to self-reporting bias (Vittuari et al., 2023b) and has recently been shown to capture 46 % only of the food waste as compared to an

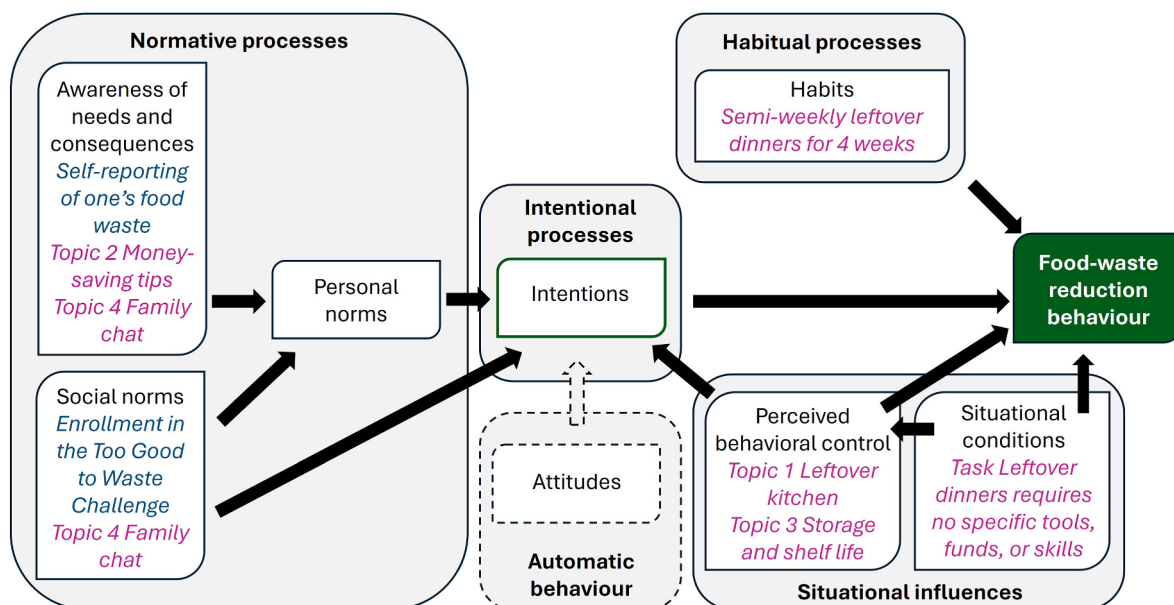


Fig. 6. Behaviour change determinants of the Too Good to Waste 7-week Challenge in a Comprehensive Action Determination Model (CADM) framework. Pink fonts indicate tasks of the intervention group. Blue fonts indicate elements concerning all participants. Adapted from C. A. Klößner and A. Blöbaum (2010; Klößner (2013)).

automated quantification tool (Sjölund et al., 2025). To mitigate this flaw, we applied the Pre-announcement strategy recommended by (van Herpen et al., 2019) which enhances focus on weekly waste habits and reduces overlooked discarded items. Further, amounts reported in grams in this paper are estimates from original reports expressed in number of serving spoons, number of items (potatoes, eggs, bread slices ...), or meat/fish portion units. It should be noted, however, that this paper does not aim to map the absolute amount of food waste in Norway; instead, we are interested in the relative variation in food waste before and after the intervention and across experimental groups. Future research may explore integrating more objective, automated and accurate measurement tools such as smart bins, image recognition systems, and weight sensors (Fang et al., 2023).

The study focused primarily on dinner-related food waste, which means potential reductions in waste from other meals were not captured. This could indicate that the intervention's overall effect was underestimated, as households may have adopted broader waste-reducing behaviours beyond dinner. Future research should investigate whether such spill-over effects may occur and how they contribute to total household food waste. The participants' sample presents a bias towards higher education, possibly linked to the participants' interest in joining a research study over 7 weeks, and a gender bias (80 % of women responding for the 230 households), possibly linked to the recruitment of participants who are responsible for grocery shopping and food preparation. Despite Norway's generally strong gender equality, women are still more often responsible for household chores, including food shopping and preparation, than men (Statistisk Sentralbyrå, 2023). The study utilised monetary rewards to encourage maintained participation throughout the 7 weeks, and later at follow-up, which may explain relatively low drop-out rates. Although stratified randomisation was used before the intervention, a difference was observed between the intervention and control groups in terms of food waste amounts at baseline. Future studies should consider stratifying participants not only by socio-demographic factors but also by baseline food waste levels. This would help ensure group comparability in both socio-demographics and food waste behaviour, improving the validity of intervention outcomes.

Furthermore, long-term results in this study are based on only 144 households and one week's waste report and are therefore less robust than the short-term results. The high attrition rate observed during the long-term follow-up may have introduced a self-selection bias. Participants who remained in the study could differ systematically from those who dropped out, potentially affecting the generalisability of the findings. Future research should aim to minimise attrition and explore strategies to assess and mitigate the impact of self-selection bias. Further, it is recommended that future studies extend the duration of long-term measurements to obtain a more robust dataset. Concerning long-term outcomes, the authors emphasise that future intervention studies should carefully account for potential changes in food waste behaviour that may be induced solely by the act of self-reporting. This phenomenon, referred to as measurement reactivity (Ottenstein et al., 2024), suggests that participants may alter their behaviour due to increased awareness or perceived scrutiny, even in the absence of an active intervention. Future studies should assess whether the observed outcomes are merely because of self-reporting. Studies may also explore whether the short-term effects could be sustained through periodic reminders, such as monthly prompts, until long-term follow-up.

This study applied the CADM theoretical framework to discuss behavioural mechanisms underlying food waste reduction. These theoretical interpretations were not derived from statistical modelling and should not be mistaken for empirical validations of pathways. Future household food waste research should further investigate the theory behind complex behavioural change mechanisms involved in both short-term and long-term effects.

5.5. Practical implications

Awareness raising of one's household food waste through self-report activities may be implemented in regular food-waste challenge campaigns via municipalities, workplaces, or schools. Community-level campaigns would simultaneously benefit from the motivating effects of perceived social norms. For boosted short-term waste reduction effects, these campaigns may directly suggest using leftovers and/or leftover ingredients in semi-weekly dinners and provide simple tips and information on diverse food waste topics.

To our knowledge, this is the first intervention study targeting household food waste conducted in Norway. The total sample of long-term participants achieved an average reduction in dinner food waste of 29 % from the baseline, equating to 146 g per household per week. Scaled to families with children in the Norwegian population, this translates to a potential annual saving of 5 tons of food from dinner alone. This provides valuable insights into behavioural change strategies within the Norwegian context and lays the groundwork for future national initiatives, organisations and policymakers.

6. Conclusion

This study investigates the effectiveness of a combined practical (leftover meals) and informational (online learning) intervention strategy in reducing dinner food waste in households with children. Short-term, the intervention led to significantly more reduction in dinner food waste with 39 % reduction compared to 22 % reduction in the control group. A year later, while the difference in reduction between the groups was no longer significant, both groups had reduced their total food waste and globally, the participants had reduced dinner food waste by -29 %. Interestingly, the fact that the control group also had reduced food waste indicates that increased awareness by mere self-reporting can slowly but efficiently drive behaviour change.

From a theoretical behaviour change mechanism perspective, the paper shows how targeting favourable situational conditions, perceived behavioural control, and normative processes, including awareness raising, may yield efficient short-term and/or long-term food waste reduction results.

Food waste organisations are recommended to promote the use of leftovers and leftover ingredients in family dinners, in combination with supportive information resources. Policymakers may ensure awareness raising of household food waste through self-report campaigns. Finally, future household food waste research should prioritise experiments with prolonged intervention periods and long-term follow-ups, further study the behaviour change mechanisms involved in short-term and long-term effects, and investigate how to sustain high-impact intervention effects over time.

CRedit authorship contribution statement

Kristine Myhrer Svartebekk: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mari Øvrum Gaarder:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Siv Kjølrsrud Bøhn:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis. **Christian Reynolds:** Writing – review & editing, Supervision, Conceptualization. **Valérie Lengard Almlil:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Ethical statement

The Norwegian Agency for Shared Services in Education and Research (Sikt) and Nofima's independent Ethical committee approved

the study protocol before the data collection (Refnr. 254094).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Microsoft Copilot and Grammarly to improve readability and language. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cfs.2025.100008>.

Data availability

Data will be made available on request.

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