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Food waste 'Warriors', 'Strugglers' and 'Slackers': Segmenting households based on food waste generation and sorting behaviours

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ABSTRACT

Food waste is a largely avoidable global issue with adverse environmental and economic impacts. Households are the main generators of food waste, with two main food waste behaviours contributing to the issue: generation and sorting. Online survey data from 939 households was used to segment households based on two measures of food waste generation (total food waste volume and the proportion of total food waste that is avoidable) and one measure of sorting behaviour (proportion of food waste sorted sustainably). Three segments were identified: 'Warriors' (39.6%), 'Strugglers' (19.6%), and 'Slackers' (40.8%). *Warriors* have low total and avoidable food waste and sort it sustainably (i.e. sorting into a kerbside organics bin, composting, and feeding to pets). *Slackers* have low food waste but sort little of it sustainably. *Strugglers* have high food waste and a medium level of sustainable sorting. These segments were profiled based on the Motivation – Opportunity – Ability framework with motivation based on the three goal-framing motivations (i.e. gain, hedonic, and normative goals) for reducing and sorting food waste between segments. These findings can help inform the design of interventions aimed at reducing and sorting food waste in specific segments of municipal populations.

1. Introduction

Annually, an estimated 931 million tonnes or 17 % of all food produced for human consumption globally is wasted at various consumption stages, which include retail, food service and households (UNEP, 2021). Particularly in high-income, upper middle-income, and lower middle-income countries, households are significant contributors to this food waste (FW). In 2019, households accounted for 61 % of the total estimated FW within these consumption stages (UNEP, 2021). These levels of FW are not only economic losses but are also unsustainable. The lost natural resources (i.e. land, water, energy) associated with this FW are significant as food production is resource-intensive (Schanes et al., 2018; Spang et al., 2019). Additionally, most FW produced by households is sent to landfill, resulting in increased greenhouse gas (GHG) emissions (Van Biene et al., 2021). Reducing consumers' household FW is an effective way of reducing natural resource use and GHG emissions (Cattaneo et al., 2021).

The United Nations' Food Waste Index describes FW as food and its associated inedible parts that are removed from the human food supply chain. This covers a variety of end destinations such as "landfill, controlled combustion, sewers, littering/discard/refuse, co/anaerobic digestion, compost/aerobic digestion, and land application" (UNEP, 2021). Collectively, the definition of FW as the end destination of food, and the provision of guidance on preferred behaviours by frameworks like the Food Waste Hierarchy (Papargyropoulou et al., 2014) suggests that behaviour related to FW are interconnected. This includes both those behaviours that occur prior to disposal (e.g. to prevent the occurrence of FW) and those directly related to disposal of FW (e.g. to sort between end destinations) (Diaz-Ruiz et al., 2018; Nguyen et al., 2022; Schanes et al., 2018). Food management behaviours related to the occurrence of FW include food planning, shopping, storing, preparation, cooking and consumption of leftovers, while the disposal-related behaviour include different types of disposal practices (i.e. how the FW is disposed of) (Principato, 2018).

Previous research has identified several psychosocial, behavioural and situational factors influencing FW generation (Attiq et al., 2021; Ghafoorifard et al., 2022; Roodhuyzen et al., 2017; Russell et al., 2017; Schanes et al., 2018) and disposal behaviours (Ladele et al., 2021; Nguyen et al., 2022). Lower FW generation is commonly associated with older age (Karunasena et al., 2021), strong personal norms against

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wasting food (Visschers et al., 2016), and the perceived control/ability to reduce FW (Graham-Rowe et al., 2015); while more sustainable disposal behaviours are associated with perceived benefits, recycling habits, and ability to compost (Nguyen et al., 2022). However, these studies also found heterogeneity in FW generation and disposal behaviours between households. Understanding heterogeneity in FW behaviours and the distinguishing characteristics of behavioural segments is important for designing and targeting information and interventions for behavioural change (Vittuari et al., 2023).

Few studies in the literature have utilised segmentation analysis to understand household FW behaviour. Previous segmentation studies have mainly identified consumer segments based on food-related behaviours (e.g. planning, shopping, storing, cooking, and consuming) (Aschemann-Witzel et al., 2018; Borg et al., 2022; Delley and Brunner, 2017; Richter, 2017; Romani et al., 2018), and attitudes/concerns towards FW (Annunziata et al., 2022; Flanagan and Priyadarshini, 2021). These segmentation studies have focused on the differences in characteristics between segments such as demographics, attitudes, and lifestyle, with a few studies incorporating self-reported FW volumes (Aschemann-Witzel et al., 2021; Borg et al., 2022; Coskun, 2021).

1.1. Food waste measures in segmentation analyses

Household FW consists of both avoidable and unavoidable FW (Papargyropoulou et al., 2014; WRAP, 2013). Avoidable FW is FW that is edible at some point prior to disposal. Unavoidable FW is inedible parts of food that are discarded as they are not suitable for human consumption (Papargyropoulou et al., 2014). The distinction between avoidable and unavoidable FW is important as it can provide insight into the degree to which prevention measures can be utilised and the proportion of FW that can be sorted out of landfill.

To date, segmentation studies have only considered avoidable FW, or the total amount of FW where avoidable and unavoidable FW are combined (without distinguishing between them). This lack of distinction of FW types can introduce bias in segmentation when trying to understand behaviours. Moreover, prior segmentation analyses have not considered FW disposal (i.e. sorting) behaviour, despite evidence indicating that disposal influences overall waste generation and its environmental impacts (Miliute-Plepiene and Plepys, 2015).

As summarised in Table 1, previous segmentation studies have used FW measures that are likely to have introduced bias. For example, previous studies only considered total FW and did not distinguish between avoidable and unavoidable FW, or they only considered FW that was edible at some point. Notably, several studies assumed that consumers associated the term 'FW' with avoidable FW (Aschemann-Witzel et al., 2021). Thus, avoidable and unavoidable FW have not been clearly distinguished in most previous studies. Addressing this limitation in segmentation analyses offers new and operationalizable insight on how to design and target interventions related to avoidable and unavoidable FW behaviours in households.

1.2. Households' motivation, ability and opportunity to reduce and sort FW

Previous studies investigating household FW behaviour have used different theoretical frameworks to guide their analyses. The Theory of Planned Behaviour (TPB) and the Motivation – Opportunity – Ability (MOA) framework have been frequently used (Vittuari et al., 2023). The TPB proposes that intention to engage in a behaviour is determined by attitudes toward the behaviour, subjective norms and perceived behavioural control (Ajzen, 1991). The TPB aims to explain intended behaviour, which is rarely the case for FW generating behaviour (Stancu et al., 2016). Therefore, several studies have expanded the model by including various behaviours related to FW generation (e.g. planning, shopping, consuming expired but edible food), and have found perceived behavioural control to be a useful variable in predicting these behaviours which in turn influence FW generation (Schmidt, 2019; Stancu et al., 2016; Stefan et al., 2013; Visschers et al., 2016).

The MOA framework is being increasingly used in consumer research on FW due to its consideration of non-cognitive aspects of a behaviour, including the 'Ability' and 'Opportunity' elements (van Geffen et al., 2020). The motivation element in the MOA framework encompasses attitudes, intentions, and norms that are included in the TPB (Vittuari et al., 2023). However, the MOA considers motivation in a more general sense and does not specify an underlying type of motivation. This is an important limitation as pro-environmental behaviours have been shown to be associated with distinct types of motivation including financial and environmental motives (Prelez et al., 2023). Further, motivational dynamics relevant to addressing FW issues have yet to be explored in FW behaviour studies.

One helpful approach for exploring behavioural motives is using the 'motives-as-goals' perspective, which proposes that actions are driven by the goals of individuals; thus, behaviours change when goals change (Covington, 2000). This perspective is central to the goal-framing theory (GFT) of Lindenberg and Steg (2007), which the present study uses as a framework to explore households' motivation to reduce and sort FW. The framework has been used to understand a range of behaviours, including pro-environmental behaviours such as green purchase behaviour (Liobikienė et al., 2017), green travel modes (e.g. walking, biking) (Geng et al., 2017), energy consumption (Brandsma and Blasch, 2019), homeowners' decision to environmentally improve on-site sewage systems, and environmentally sustainable banking (Taneja and Ali, 2021).

The GFT provides a powerful model of multi-goal preference

Table 1
FW amount included in previous segmentation analyses.

Segmentation study	Description	Avoidable/unavoidable distinction
Aschemann-Witzel et al. (2018)	Self-report of FW in five food categories (i.e. Fresh fruit and vegetables, Milk and dairy, Bread and other bakery products, Meat and fish, Prepared dishes/meals).	Not clear what was included in the FW amount.
Aschemann-Witzel et al. (2021)	Similar to Aschemann-Witzel et al. (2018).	It was assumed that consumers often referred to FW as edible. Thus, unavoidable FW was excluded.
Borg et al. (2022)	FW measured in kilograms and classified across 12 food categories.	No distinction.
Coskun (2021)	FW measured by four food categories adopted from Visschers et al. (2016): meat, dairy, bakery, and fruits and vegetables.	No explicit explanation but based on the original measurement, this was assumed to be avoidable FW.
Delley and Brunner (2017)	FW amount wasted by household in an average week for various food categories. The categories are provided.	No explanation was provided.

formation that assumes behaviours are goal oriented. The theory postulates that 'actors pursue several different goals simultaneously, whether these goals are chosen autonomously or triggered by their environment' (Lindenberg and Steg, 2007). The three goals underlying GFT include the *hedonic goal* 'to feel good', the *gain goal* 'to enhance one's resources', and the *normative goal* 'to act appropriately'. These goals may (or may not) be in harmony, which can lead to situations where the focal goal may be influenced by other goals in the background (Lindenberg and Steg, 2007). Specifically, a *hedonic goal frame* activates a sub-goal(s) associated with the way an individual feels in a specific situation (e.g. avoiding negative thoughts and events, seeking direct pleasure, seeking excitement, etc) (Lindenberg and Steg, 2007). In other words, the central realisation of this goal is an improvement in one's feelings. The time horizon of the hedonic goal frame is also very short. People in the hedonic goal frame are particularly sensitive to what increases and decreases their pleasure and affects their mood. A *gain goal frame* will make individuals sensitive to changes in their personal resources (Lindenberg and Steg, 2007). The time horizon for this goal frame is medium or long term and the central realisation is an increase (or avoiding a decrease) in one's resources. A *normative goal frame* activates a sub-goal(s) related to behaving in the 'right' way upon their personal norms or as determined by social or moral norms (e.g. protecting the environment, showing exemplary behaviour) (Lindenberg and Steg, 2007).

The 'ability' element of the MOA framework refers to the knowledge, skills and individual capacities to perform the behaviours (van Geffen et al., 2016). This factor is compatible with the 'perceived behavioural control' construct in the TPB. For example, to reduce avoidable FW, cooking skills are important so that individuals can estimate the required amount of food for a meal and can be creative with different ingredients so they won't go to waste. For sorting behaviour, this element can be interpreted as the control over FW disposal as other household members may be the ones disposing of FW (Nguyen et al., 2022).

Opportunity refers to the availability and accessibility of materials and resources needed to change behaviour (Vittuari et al., 2023). For example, the infrastructures and external factors that determine consumers' action to reduce and sort FW include the package size available to purchase and the kerbside waste collection system. Regarding the waste collection system for FW, the study area provided Food Organics and Garden Organics (FOGO) kerbside collection to all residents through a 240-L green bin (so-called FOGO bin) that is collected fortnightly as part of the waste management system (Blanchard et al., 2023; Landells et al., 2022). This system allows all types of FW and has been used for decades (GISA, 2021). Many councils also provide a 7-L kitchen collection tool (referred to as a 'kitchen caddy') and compostable bags that are free to pick up at the local library or council office. This initiative increases convenience for households in collecting FW before transferring it to the large FOGO bin. Therefore, many survey participants would likely be familiar with this system.

2. Research objectives

The present study builds on the existing literature by exploring heterogeneity in households' FW behaviour both in terms of generation and sorting of FW. We expand on previous segmentation studies by including two measures of FW volume: total volume and the avoidable proportion of FW volume, and measure of FW being diverted from landfill (i.e. sorting behaviour).

We profile the segments using the MOA framework (van Geffen et al., 2016). We incorporate the 'motives as goals' perspective (discussed in the previous section) by including three elements of the Lindenberg and Steg (2007) GFT - gain, hedonic, and normative goals. The 'ability' aspect of the MOA framework is accessed using perceived behavioural control items. The 'opportunity' is control for sorting behaviour as we conducted this study in Adelaide, South Australia. This location provided a unique context for exploring the role of sorting behaviour because all households in Adelaide metropolitan areas have access to kerbside FW collection.

To the best of our knowledge, this is the first segmentation analysis that incorporates the avoidable proportion of total FW volume in relation to the unavoidable proportion of FW. Additionally, this study is the first to include sustainable household disposal behaviour that diverts FW from landfill, contributing to a comprehensive understanding of FW behaviour in households. The results are expected to provide insight to identify target groups for prioritising intervention strategies aimed at reducing and diverting FW from landfill.

3. Material and Methods

3.1. Data collection and survey design

A cross-sectional online survey of household FW behaviour was conducted in Adelaide, South Australia, in April – May 2021. The survey was administrated and participant recruitment was managed by a professional market research company (Pureprofile), with quotas set for gender and age so that the sample closely matched the general Australian population. Eligible participants were 18 years and older and living in the metropolitan suburbs of Adelaide. Pureprofile recruited eligible participants from their online panels via email and offered monetary incentives for participation as part of their reward program. Participants were made aware of the research topic after their eligibility was determined (see information provided in Fig. A1, Appendix A). At this point, some potential participants might have chosen to opt out of the survey due to a lack of interest in the topic.

The questionnaire assessed a range of topics, including self-reported FW generation and disposal practices of households, and individual perceptions and beliefs related to reducing and sorting FW. Methods used to measure FW volume and determine the proportion of avoidable FW and the proportion of FW disposed of sustainably are described in detail elsewhere (Nguyen et al., 2022). Human Ethics approval was granted by the University of Adelaide (approval number H-2020–242).

The measurements of relevant constructs included in the present analyses are described below.

3.2. Measures

3.2.1. Measuring household FW volume, avoidable proportion and sorting behaviour

The survey instrument was designed to reduce limitations from self-reported estimates of household FW identified in the FW literature (Hebrok and Boks, 2017; van Herpen et al., 2019; Xue et al., 2017). All questions used to measure FW are provided in Appendix A.

Respondents were given a definition of FW (Fig. A2, Appendix A) and they were also provided with a list of different types of FW (Fig. A3). Respondents indicated ("yes" or "no") if their household produced each type of FW. For reporting their household FW, respondents could choose their preferred unit of measure and illustrations were provided to help determine the volumes (Fig. A4). For example, measurement units (and a relevant image) for solid FW included a 7-Litre kitchen caddy and a 4-Litre ice cream container (Fig. A5). Respondents were asked to estimate the total volume of FW that their household produced during a typical week (Fig. A6). We sought to use measurement units that would be widely recognised by participants. For example, the kitchen caddy is part of the waste management system in the study area and the descriptive analysis shows that more than half of our participants had a kitchen caddy in their homes (Table A1, Appendix A).

Next, for each selected FW category, respondents self-reported the proportion of total FW that the category accounted for (Fig. A7). After respondents completed the questions designed to quantify their household's total volume of FW, they were then asked to use a pie graph to indicate the proportion of their household FW sorted/discarded in

various destinations. The options included 1) general waste bin, 2) green organics bin, 3) recycling bin, 4) compost/worm farm, 5) feeding animals, and 6) sink and others (Fig. A8). This question was asked separately for total solid FW (Fig. A8) and for each of the 11 categories of FW (see Figs. A9 and A10 for examples). Solid FW and liquid FW were measured separately; however, liquid FW was out of scope for the analyses in this paper.

The proportion of avoidable FW was calculated by summing the volumes of the 'avoidable' FW categories (indicated in Table 3) and dividing this sum by the total FW generated. The sorting score was calculated by dividing the amount of FW sorted sustainably by the total FW generated. Sustainable destinations for disposal include sorting FW in the green organics bin, home compost bin and feeding animals (see Nguyen et al. (2022)).

3.2.2. Importance of reducing and sorting FW

Respondents were asked to rate the importance to their household of reducing and sorting FW. Respondents were asked: 'How important is reducing household FW to you/your household?' and 'How important is sorting and putting FW into the Green Organics bin to you/your household?'. Respondents indicated their agreement with statements related to reducing FW (Table 6) and sorting FW (Table 7) using a 7-point Likert scale (where 1 = strongly disagree and 7 = strongly agree).

3.2.3. Goal-framing theory motivation constructs

Following the Goal-framing Theory by Lindenberg and Steg (2007), items for measuring each of the three goals were developed for two behaviours: reducing FW and sorting FW. Respondents were asked: 'To what extent do you agree with each of the following statements related to what influences you (or would influence you) to reduce food waste?'. A similar question was asked for sorting FW. The items used to measure the three goals are shown in Table 6 (reducing FW) and Table 7 (sorting FW). All items were rated using a 7-point Likert scale (where 1 = strongly disagree and 7 = strongly agree).

3.2.4. Control over reducing and sorting FW

These constructs were developed based on items used in the literature (van Geffen et al., 2020; Visschers et al., 2016). Each of the two constructs measured control over reducing and sorting FW using two items. They are described in Tables 6 and 7 respectively and were rated using a 7-point Likert scale (where 1 = strongly disagree and 7 = strongly agree).

3.3. Statistical analyses

The aim of the segmentation analysis was to identify homogeneous groups of households based on FW volume, avoidable proportion of FW, and sorting behaviour. As the number of segments was not predefined, we employed an exploratory approach using the TwoStep Cluster Analysis procedure, which is a multivariate analysis technique consisting of two distinct stages (Dietrich et al., 2017). The first step is called *pre-clustering* where original cases are grouped in pre-clusters using the log-likelihood method. In the second step, the number of cluster solutions is selected based on Schwarz's Bayesian Information Criterion (BIC). The TwoStep Cluster Analysis procedure has been shown to perform better than traditional hierarchical and K-mean cluster techniques (Kent et al., 2014), and it has gained popularity in various fields since its introduction in Statistical Packages for Social Sciences (SPSS) (Tkaczynski, 2017). Three behavioural outcomes were included in the TwoStep procedure as clustering variables: the total volume of solid FW (L), the proportion of avoidable FW (%), the and proportion of FW sorted sustainably (%).

Segments identified by the TwoStep Cluster Analysis were profiled using Chi-Square tests with Bonferroni-adjusted p-values and ANOVA tests with post-hoc Tamhane's T2 tests to account for multiple pairwise comparisons. A range of variables was used to profile the identified segments, including respondents' demographic characteristics, household characteristics and categories of FW generated (e.g. fruit and vegetable scraps, meat, etc.).

The goal-framing motivations of Lindenberg and Steg (2007) (i.e. gain, hedonic, and normative goals) and control factors were compared between segments to understand the motivation of different segments to reduce and sort FW. Cronbach's alpha for each profiling constructs (i.e. goal motives and control) were used to identify the correlational structure within each aspect. We then computed the average score for each goal to retain the three goal constructs, as these represent the theoretically derived and empirically well-tested constructs developed from the GFT and TPB. All data analyses were performed in SPSS version 28. A 5 % level of significance was used for all analyses.

4. Results

4.1. Sample characteristics

Socio-demographic details and household characteristics of the sample are presented in Table A1, Appendix A. In total, 51 % of the survey participants were female; the mean age was 46 years old, with a standard deviation of 17 years; and 36 % had obtained a university education or more advanced education. The distribution in terms of gender, age, and income closely matched the broader Australian adult population, deviating by less than 5 % (Table A1).

4.2. Cluster groupings and comparisons of FW outcomes

Three distinct clusters were identified by the TwoStep Cluster Analysis with a silhouette measure of cohesion and separation of 0.50, indicating good cluster quality in cluster structure (Rousseeuw and Kaufman, 2009). The best cluster solution was automatically chosen by SPSS's TwoStep Cluster based on analysing the BIC. The number of clusters, pre-clusters, and their corresponding BIC values are provided in Table A2 and Fig. A11 of Appendix A. The Cronbach's alpha values for most constructs ranged from 0.6 to 0.7, indicating that they are considered acceptable in exploratory research (Hair Jr et al., 2021). Two constructs, namely 'Hedonic goal' and 'Normative goal' for sorting FW,

Table 2
Descriptive statistics for behaviours included in cluster analysis by cluster group.

Behavioural indicators	*'Warriors'* (39.6 %)		*'Strugglers'* (19.6 %)		*'Slackers'* (40.8 %)		Total (n = 939)		F/Welch's F*	P-value	ω^2/est. ω^2
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Food waste volume (L/household/week)	9.6 [a]	5.5	33.1[b]	9.4	9.0 [a]	5.3	14.0	11.4	551.536	<0.001	0.689
Proportion of avoidable food waste[p] (%)	24.5 [a]	23.3	39.7[b, c]	25.1	38.9[c]	26.6	33.3	26.0	40.691	<0.001	0.074
Proportion of food waste sorted sustainably[#] (%)	87.8 [a]	15.7	42.8[b]	33.8	15.2[c]	15.7	49.4	38.6	2017.494	<0.001	0.717

In each row, means not sharing the same subscripts differ significantly at α = 0.05 as indicated by post-hoc Tamhane's T2 multiple comparison tests.
[*] Welch's F statistic.
[p] Avoidable FW includes food that is edible prior to disposal point. These categories are described in Table 3.
[#] Sustainable FW behaviour includes sorting FW into the green organics bin, feeding animals, and composting.

had Cronbach's alpha values lower than 0.60; however, we retained these two constructs as they are important theoretically.

The means of the three clustering indicators are provided in Table 2. Overall, an average household generated approximately 14 L of FW a week, of which about a third is avoidable, and they sorted less than half of their FW sustainably. Cluster 1, named *'Warriors'*, included 39.6 % of respondents and included households that generated a moderate amount of total solid FW (9.6 L/household/week), with a relatively low proportion (24.5 %) of FW that was avoidable (i.e. preventable). This group sorted 87.8 % of their FW sustainably. Cluster 2, named *'Strugglers'* was the smallest segment, comprising 19.6 % of respondents. This segment generated the largest amount of total solid FW (33.1 L/household/week), of which nearly 40 % was avoidable. Strugglers sorted 42.8 % of their FW sustainably, which was about the average of all households in the sample (49.4 %). Cluster 3, named *'Slackers'* included 40.8 % of respondents, and generated a similar amount of FW as the *'Warrior'* segment (9.0 L/household). However, compared to *Warriors*, *Slackers* produced a larger share of avoidable FW (38.9 %) and sorted a lower share of their FW sustainably (15.2 %).

Table 3 provides a comparison across segments of the share that each FW category contributes to the total volume of household FW. The same three categories (all 'unavoidable') comprised the largest share of FW for all three segments: Fruit and vegetable scraps/peels/stems; Offcuts/bones/skins of meat and poultry; and Other inedible items or by-products of food and beverage preparation (e.g. tea bags, coffee grounds) and paper towels. For several FW categories, the percentage contribution to total FW differed significantly between segments, particularly when comparing the *Warriors* to the other two segments. Compared to the other segments, a higher percentage of *Warriors'* total FW was attributed to Fruit and vegetable scraps/peels/stems and a smaller percentage was attributed to avoidable FW categories including 'Meat, fish, seafood', mixed leftovers, bread and cereals, and dairy products.

Table 4 presents a comparison of the sustainable sorting efficiency score (%) for each food category across the three segments. For most categories, *Warriors* sorted the highest proportion of FW sustainably (47–91 %), followed by *Strugglers* (31–58 %), and *Slackers* (15–31 %).

4.3. Comparison of food waste behaviour segments

4.3.1. Socio-demographic and household characteristics

Statistically significant differences between segments were found for several socio-demographic and household characteristics (Table 5), including age, household income, household composition and dwelling type. Neither gender nor education level (i.e. attainment of a university degree) differed between segments.

Warriors are mostly families with adults only (45 %) or families with children (29 %) living in a detached house, and nearly 50 % are aged 55 years and over (Table 5). Households in the *Warriors* segment comprised a significantly higher proportion of respondents aged $\geq$ 65 years, had fewer people in their household, on average, and a higher share was in the lowest income quintile, compared to *Strugglers*; and were more likely to live in a detached house and less likely to live in a flat/unit/apartment, compared to *Slackers*.

Of all segments, *Strugglers* had the largest household size on average, and had a relatively higher share of families with children (47 %) and lower share of single person households (6 %). Compared to *Warriors*, a higher proportion of *Strugglers* (similar to *Slackers*) were aged 18–34 years. Statistically significant differences in household income were also found across segments, with a significantly lower proportion of *Strugglers* in the lowest income quintile, compared to *Warriors*, and a higher proportion in the highest income quintile, compared to *Slackers*.

Slackers, similar to *Warriors*, are mostly families with children (36 %) or adults only (32 %). However, compared to *Warriors*, a lower share of *Slackers* resides in detached houses and a higher share live in flats/units/apartments.

4.3.2. Goal-framing motivations and control over reducing and sorting FW amongst segments

Table 6 provides a comparison across segments of the importance ratings, goal scores (gain, hedonic, and normative) and constraint/control scores regarding reducing household FW. All three segments indicated that reducing FW was important for their households (i.e. all mean scores are above the mid-point of the scale). However, importance scores differ significantly between all segments, with importance ratings highest among *Warriors,* followed by *Strugglers*, and *Slackers*. The means of gain and control scores differ significantly between segments. The

Table 3
Contribution (%) of different food waste categories to total food waste volume by segment.

FW category	'Warrior' (39.6 %)		'Struggler' (19.6 %)		'Slacker' (40.8 %)		Total (n = 939)		F/Welch's F*	P-value	ω^2/est. ω^2
	M	SD	M	SD	M	SD	M	SD			
Avoidable											
Uneaten vegetables including fresh and frozen products (e.g. rotten fruits and vegetables)	8.4	10.3	9.4	10.2	9.8	12.6	9.2	11.3	1.482	0.228	0.001
Meat, fish, seafood (e.g. mince, fish fillet) and eggs	2.2 [a]	4.2	4.6[b]	6.0	4.3[b]	7.7	3.5	6.2	18.194	<0.001	0.027
Hard dairy products (e.g. cheese, butter)	1.1 [a]	3.7	2.8[b]	6.9	2.2[b]	5.0	1.8	5.0	9.031	<0.001	0.016
Soft dairy products (e.g. yogurt, sour cream)	1.7 [a]	4.5	3.5[b]	6.3	3.3[b]	6.1	2.7	5.6	11.511	<0.001	0.019
Bread and cereals (e.g. bread, rice, pasta, couscous, breakfast cereals, pasta)	4.7 [a]	7.9	7.8[b]	11.0	6.6[b]	9.2	6.1	9.2	8.134	<0.001	0.015
Mixed leftovers from cooked meals, chilled or frozen ready meals, takeaway/home delivered meals	5.6 [a]	9.4	9.7[b]	11.5	10.7[b]	14.5	8.5	12.3	20.046	<0.001	0.035
Sugar, chocolate, confectionery, crisps and ice-cream	0.7 [a]	2.6	1.9[b]	5.1	2.0[b]	5.0	1.5	4.3	12.719	<0.001	0.019
Unavoidable											
Fruit and vegetable scraps/peels/stems (e.g. potato peels, apple core)	48.5 [a]	27.0	32.6[b]	25.9	29.3[b]	23.0	37.6	26.7	57.388	<0.001	0.110
Offcuts/bones/skins of meat and poultry (e.g. chicken bones and skins, pork fats)	11.3	15.1	11.4	12.2	12.0	13.6	11.6	13.9	0.265	0.767	−0.002
Fish skeletons/offcuts, seafood shells and eggshells	4.6	6.0	6.0	7.7	5.2	9.8	5.1	8.1	2.651	0.072	0.002
Other inedible items or by-products of food and beverage preparation (e.g. tea bags, coffee grounds) and paper towels	11.2 [a]	13.2	10.3 [a]	11.2	14.6[b]	17.7	12.4	15.0	6.877	0.001	0.013

In each row, means not sharing the same subscripts differ significantly at $\alpha = 0.05$ as indicated by post-hoc Tamhane's T2 tests. Effect size: small $\omega^2 = 0.01$; medium $\omega^2 = 0.06$; large $\omega^2 = 0.14$.

* Welch's F statistic.

Table 4
Proportion (%) of household food waste sorted sustainably for different food waste categories across segments.

FW category	'Warrior' (39.6 %)		'Struggler' (19.6 %)		'Slacker' (40.8 %)		Total (n = 939)		F/Welch's F*	P-value	ω^2/est. ω^2
	M	SD	M	SD	M	SD	M	SD			
Avoidable											
Uneaten vegetables including fresh and frozen products (e.g. rotten fruits and vegetables)	91.0 [a]	20.8	57.5[b]	39.6	31.4[c]	37.4	60.2	41.9	260.398	<0.001	0.399
Meat, fish, seafood (e.g. mince, fish fillet) and eggs	67.5 [a]	40.4	45.0[b]	42.1	21.9[c]	32.7	43.5	42.7	59.537	<0.001	0.211
Hard dairy products (e.g. cheese, butter)	64.7 [a]	44.3	40.7[b]	40.8	19.2[c]	30.6	39.5	42.7	32.247	<0.001	0.206
Soft dairy products (e.g. yogurt, sour cream)	46.8 [a]	45.9	32.2[b]	39.4	15.7[c]	30.1	30.1	40.5	21.726	<0.001	0.107
Bread and cereals (e.g. bread, rice, pasta, couscous, breakfast cereals, pasta)	76.7 [a]	36.6	49.7[b]	42.7	24.2[c]	36.4	49.4	44.4	99.798	<0.001	0.265
Mixed leftovers from cooked meals, chilled or frozen ready meals, takeaway/home delivered meals	71.0 [a]	38.8	45.8[b]	43.1	18.3[c]	30.9	42.7	43.4	115.382	<0.001	0.284
Sugar, chocolate, confectionery, crisps and ice-cream	49.3 [a]	45.8	31.1 [a]	40.2	14.5[b]	29.6	29.0	40.4	16.072	<0.001	0.132
Unavoidable											
Fruit and vegetable scraps/peels/stems (e.g. potato peels, apple core)	90.7 [a]	20.8	55.2[b]	39.6	30.7[c]	36.7	59.8	41.8	379.160	<0.001	0.416
Offcuts/bones/skins of meat and poultry (e.g. chicken bones and skins, pork fats)	68.7 [a]	40.3	40.8[b]	41.8	19.5[c]	30.6	44.7	43.3	137.386	<0.001	0.255
Fish skeletons/offcuts, seafood shells and eggshells	76.0 [a]	37.2	41.3[b]	43.2	18.9[c]	31.1	49.1	44.6	162.653	<0.001	0.323
Other inedible items or by-products of food and beverage preparation (e.g. tea bags, coffee grounds) and paper towels	68.1 [a]	40.1	39.9[b]	42.8	14.9[c]	27.9	42.0	43.6	188.218	<0.001	0.300

In each row, means not sharing the same subscripts differ significantly at $\alpha = 0.05$ as indicated by post-hoc Tamhane's T2 tests. Effect size: small $\omega^2 = 0.01$; medium $\omega^2 = 0.06$; large $\omega^2 = 0.14$.
* Welch's F statistic.

hedonic goal has the highest average mean for all three segments, followed by the gain goal, and the normative goal. Relative to other segments, the *Warriors* have the highest mean score for the gain goal and for control over FW, and both *Warriors* and *Strugglers* have the higher scores for the hedonic and normative goals compared to *Slackers*.

All segments except for *Slackers* indicate that sorting FW is important for their households (Table 7). With respect to attitudes regarding sorting FW, the mean levels of agreement are significantly different between segments (similar to reducing FW), with *Warriors* having the highest agreement, followed by *Strugglers* and *Slackers*. The means of all goals are significantly different between segments (Table 7), with the *Warriors* having the highest mean scores, followed by *Strugglers*, then *Slackers*.

5. Discussion, research implications and future research

Interventions aiming to encourage households to reduce and sort FW, are likely to be more effective when tailored to address the unique characteristics of behaviourally distinct segments. The present study is the first to include the avoidable proportion of FW and sorting behaviour, along with FW volume, as clustering indicators. Additionally, the segments were profiled based on three elements of the MOA framework,

Table 5
Demographic characteristics of respondents and household characteristics by segment.

	'Warriors' (39.6 %)	*'Struggler'* (19.6 %)	*'Slacker'* (40.8 %)	Total (n = 939)	χ^2/F	P-value	V/ω^2
Gender (female)	*51.1 %*	*48.4 %*	*51.2 %*	*50.6 %*	*0.450*	*0.798*	*0.022*
Age groups (years), %					*82.224*	*<0.001*	*0.209*
18–24	6.2 [a]	15.2[b]	14.6[b]	11.4			
25–34	12.6 [a]	17.9[b]	24.8[b]	18.6			
35–44	14.0	20.1	20.4	17.8			
45–54	17.7	20.1	16.7	17.8			
55–64	19.4[a]	14.7[a, b]	11.7[b]	15.3			
65+	30.1[a]	12.0[b]	11.7[b]	19.1			
University degree (yes), %	36.3	37.0	34.5	35.7	*0.438*	*0.804*	*0.022*
Household income ($AU/year)					*20.295*	*0.009*	*0.104*
$0 – $38,900	23.9 % [a]	13.0 % [b]	19.3 % [a, b]	19.9 %			
$38,901 – $69,500	26.6 %	21.7 %	24.0 %	24.6 %			
$69,501 – $109,300	24.5 %	29.3 %	26.1 %	26.1 %			
$109,301 – $168,700	18.0 %	23.4 %	24.3 %	21.6 %			
$168,701 or above	7.0 % [a, b]	12.5 % [b]	6.3 % [a]	7.8 %			
Household size (persons), mean (SD)	2.6 (1.2) [a]	3.3 (1.3) [b]	2.8 (1.3) [a]	2.8 (1.3)	19.603	*<0.001*	0.038
Dwelling types					*17.684*	*0.024*	*0.097*
Separate/detached house	80.4 % [a]	74.5 % [a, b]	70.0 % [b]	75.0 %			
Semi-detached row or townhouse	11.0 %	11.4 %	12.0 %	11.5 %			
Flat, unit, apartment	7.8 % [a]	13.6 % [a, b]	17.2 % [b]	12.8 %			
Rural Property	0.5 %	0.5 %	0.3 %	0.4 %			
Household composition					41.292	*<0.001*	0.148
Single person household	16.7 % [a]	6.0 % [b]	17.0 % [a]	14.7 %			
Family with children	29.3 % [a]	46.7 % [b]	35.5 % [a]	35.3 %			
Family, only adults (18 +)	44.9 % [a]	37.5 % [a, b]	32.4 % [b]	38.1 %			
Shared household, non-related	5.4 %	6.5 %	9.4 %	7.2 %			
Having a kitchen caddy	*77.7 % [a]*	*61.4 % [b]*	*30.5 % [c]*	*55.3 %*	*173.115*	*<0.001*	*0.429*

In each row, means not sharing the same subscripts differ significantly at $\alpha = 0.05$ as indicated by Chi-square test or post-hoc Tamhane's T2 tests.

Table 6
Motivations and constraints for reducing FW by segment.

Statement	'Warrior' (39.6 %)		'Struggler' (19.6 %)		'Slacker' (40.8 %)		Total (n = 939)		F/Welch's F*	P-value	ω^2/est. ω^2
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Importance of reducing FW	***6.0*** ^{a}	***1.0***	***5.7*** ^{b}	***1.3***	***5.0*** ^{c}	***1.5***	***5.6***	***1.4***	***51.911***	***<0.001***	***0.099***
Gain goal (Cronbach's α = 0.62)	***5.5*** ^{a}	***1.0***	***5.3*** ^{b}	***1.1***	***5.1*** ^{b}	***1.1***	***5.3***	***1.0***	***18.330***	***<0.001***	***0.036***
I can save money for my household by avoiding FW	6.0	1.0	5.8	1.1	5.6	1.2	5.8	1.1			
I can afford to waste food in order to make my life easier [R]	2.4	1.4	3.0	1.5	3.1	1.6	2.8	1.5			
I don't think the food I throw away costs much money [R]	3.1	1.7	3.0	1.5	3.3	1.5	3.2	1.6			
Hedonic goal (Cronbach's α = 0.68)	***5.8*** ^{a}	***1.0***	***5.6*** ^{a}	***1.1***	***5.4*** ^{b}	***1.1***	***5.6***	***1.1***	***15.941***	***<0.001***	***0.031***
I feel bad when I throw food away	6.0	1.1	5.8	1.1	5.6	1.3	5.8	1.2			
I derive pleasure and satisfaction when there is no FW in my household	5.7	1.2	5.5	1.3	5.2	1.3	5.4	1.3			
Normative goal *(Cronbach's α = 0.68)*	**5.2** ^{a}	**1.0**	**5.1** ^{a}	**1.0**	**4.8** ^{b}	**1.1**	**5.0**	**1.1**	**13.022**	**<0.001**	***0.025***
It is morally wrong to waste food	5.6	1.4	5.4	1.3	5.3	1.3	5.4	1.3			
The people I care about believe that FW is a big issue	4.9	1.4	4.7	1.5	4.4	1.4	4.6	1.4			
Throwing away food has an environmental impact and I am concerned about it	5.3	1.3	5.2	1.3	4.8	1.4	5.1	1.4			
Control over reducing FW (Cronbach's α = 0.62)	***5.5*** ^{a}	***1.3***	***4.5*** ^{b}	***1.6***	***4.2*** ^{b}	***1.4***	***4.8***	***1.5***	***53.772***	***<0.001***	***0.101***
Busy lifestyles make it hard to avoid wasting food [R]	3.3	1.6	4.3	1.6	4.2	1.5	3.9	1.6			
Other household members make it impossible for me to reduce the amount of food wasted in my household [R]	2.6	1.5	3.7	1.6	3.5	1.7	3.2	1.6			

In each row, means not sharing the same subscripts differ significantly at α = 0.05 as indicated by post-hoc Tamhane's T2 tests. Effect size: small $\omega^2 = 0.01$; medium $\omega^2 = 0.06$; large $\omega^2 = 0.14$.
All items were assessed on 7-point Likert scales; higher values correspond to stronger agreement with the statement. FW = Food waste.
[R] reverse-coded items; * Welch's F statistic.

Table 7
Motivations and constraints for sorting FW by segment.

Statement	*'Warrior'* (39.6 %)		*'Struggler'* (19.6 %)		*'Slacker'* (40.8 %)		Total (n = 939)		F/ Welch's F*	P-value	ω^2/est. ω^2
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Importance of sorting FW into the Green organics bin	***5.8*** ^{a}	***1.4***	***5.3*** ^{b}	***1.6***	***4.1*** ^{c}	***1.9***	***5.0***	***1.8***	***99.039***	***<0.001***	***0.177***
Gain goal (Cronbach's α = 0.65)	***5.5*** ^{a}	***1.1***	***4.7*** ^{b}	***1.2***	***4.4*** ^{c}	***1.0***	***4.9***	***1.2***	***112.497***	***<0.001***	***0.186***
By using the green bin for FW, my rubbish bin stays cleaner and does not need to be taken out as frequently	5.5	1.6	5.0	1.4	4.5	1.5	5.0	1.6			
It's not beneficial for me to put FW into the Green organics bin [R]	2.3	1.6	3.0	1.7	3.3	1.5	2.8	1.7			
It takes too much time and effort to sort FW into the green bin [R]	2.2	1.4	3.3	1.8	3.7	1.6	3.0	1.7			
It is expensive to buy supplies (e.g. compostable bags, kitchen caddy, etc.) to sort into the green bin [R]	3.1	1.7	4.0	1.8	4.1	1.6	3.7	1.8			
Hedonic goal (Cronbach's α = 0.37)	***5.5*** ^{a}	***1.2***	***4.8*** ^{b}	***1.2***	***4.4*** ^{c}	***1.2***	***4.9***	***1.3***	***83.880***	***<0.001***	***0.150***
I feel good when I sort and dispose of FW correctly into the green bin	5.8	1.2	5.4	1.4	5.0	1.4	5.4	1.4			
I do not want to deal with the smell and the mess of food when sorting FW [R]	2.8	1.8	3.9	1.9	4.2	1.7	3.6	1.9			
Normative goal (Cronbach's α = 0.40)	***5.5*** ^{a}	***1.1***	***5.2*** ^{b}	***1.2***	***4.7*** ^{c}	***1.1***	***5.1***	***1.2***	***44.418***	***<0.001***	***0.085***
Putting FW into the green bin is the right thing to do	6.1	1.3	5.7	1.2	5.4	1.3	5.7	1.3			
Most people who are important to me sort FW and put them into the Green organics bin	4.9	1.5	4.6	1.7	4.0	1.6	4.5				
Control over sorting FW (Cronbach's α = 0.58)	***5.5*** ^{a}	***1.3***	***4.5*** ^{b}	***1.6***	***4.2*** ^{b}	***1.4***	***4.8***	***1.5***	***100.091***	***<0.001***	***0.164***
I have no control over FW as other people in the house are the ones disposing of FW [R]	2.2	1.4	3.4	1.8	3.3	1.7	2.9	1.7			
I do not have sufficient information regarding FW going into the green bin [R]	2.7	1.7	3.7	1.9	4.3	1.7	3.6	1.9			

In each row, means not sharing the same subscripts differ significantly at α = 0.05 as indicated by post-hoc Tamhane's T2 tests.
All items were assessed on 7-point Likert scales; higher values correspond to stronger agreement with the statement or higher frequency of recycling habit. FW = Food waste.
[R] reverse-coded items; * Welch's F statistic.

with motivation categorised using the GFT. Three unique segments were identified based on FW generation and sorting behaviours. Those segments were then profiled by demographic and household characteristics and goal frames. The three segments, in order of potential targets for FW interventions are *Strugglers* (19.6 %), *Warriors* (39.6 %), and *Slackers* (40.8 %).

5.1. Segments

5.1.1. Strugglers

Strugglers was the smallest segment by size (19.6 %) but the FW volume they generated was, on average, three times higher than the other two segments. Additionally, *Strugglers* produced the highest proportion of preventable FW (e.g. uneaten fruits and vegetables, bread and cereals, etc). They participated in sorting, but more than half of their FW still ended up in landfill.

Some similarities in both FW generation and household characteristics (e.g. balanced gender, families with children, larger household size) can be observed between our *Strugglers* segment and Borg et al.'s *Over Providers* segment. Borg et al. (2022) profiled Australian households using FW bin audit data and also found similar types of motivations such as being motivated to 'do the right thing' and 'set a good example'. This, together with our finding that the *Strugglers* segment is moderately motivated to reduce and sort FW sustainably despite perceiving limited control due to a busy lifestyle with kids and other household members, suggests that this segment could be prioritised for the most efficient targeting of FW volume reduction. A potentially effective channel to influence this segment's behaviour could be through their children, such as via a curriculum-aligned program (Benyam et al., 2018; Boulet et al., 2022). An example of this is the school-based Food Education and Sustainability Training (FEAST) program that is designed to educate children about sustainability, FW and nutrition using hands-on cooking activities (Karpouzis et al., 2021).

Another potential approach to promote behaviour change is by targeting parents. *Strugglers* perceived low control over changing their behaviour to reduce and sort FW. Parents with children living in the household are particularly busy and meal plans can be disrupted by and depend on the children's appetite, selective eating behaviour, and changing preferences (Kansal et al., 2022; van Geffen et al., 2016). Information about reducing and sorting FW can be delivered through parental magazines, specific TV programs, or social media channels that reach families with children. Further, waste-reduction tools that were created with families in mind can also be helpful. For example, tools such as the 'Eetmaatje' measuring cup for rice and pasta, which considers the water absorption of dry food, or the 'Use It Up' tape that reminds households what should be eaten first, can be beneficial (OzHarvest, 2022; van Dooren et al., 2020). These tools can assist parents in estimating serving portions and making more informed decisions about FW reduction in their households.

5.1.2. Warriors

Warriors was the second largest segment (39.6 %) and consisted of households that produced the least amount of FW which was largely unavoidable (e.g. fruit and vegetable scraps). They were highly motivated to reduce and sort FW. Many *Warriors* are older and near retirement age, or retired, and their households are smaller in size and with adults only.

Warriors share some key similarities in self-reported FW level, demographics (i.e. older respondents), and strong motivations to reduce FW with segments identified in other studies: *Considerate Planners* (Borg et al., 2022), *Guilty food wasters* (Richter, 2017), and *Thrifty altruists* (Vittuari et al., 2020). The finding that older respondents reported the lowest amount of FW generated has been attributed to various factors, including a combination of upbringing, food-related management skills and available time (Karunasena et al., 2021; Quested et al., 2013). Older consumers have also been previously found to have greater concern about FW (Flanagan and Priyadarshini, 2021; Hebrok and Boks, 2017). Considering our results, we conclude that in general, older people tend to not only waste less, but most of their household FW appeared to be unavoidable and was sorted sustainably. While this segment may not need new interventions, maintenance of the existing infrastructure which supports their current sustainable FW behaviours should be ensured.

5.1.3. Slackers

Slackers produced the smallest amount of FW (similar to *Warriors),* but the proportion of preventable FW (e.g. mixed leftovers) was significantly higher, which is concerning as this was the largest segment (40.8 %). Slackers were the youngest segment and lived in households with fewer members. They have the lowest motivation to reduce and sort FW; in particular, sorting received a low importance score. Gain and hedonic motives for sorting were significantly lower in importance than the other two segments. *Slackers* were not broadly comparable with any segments identified in previous studies, although some specific traits can be described. For example, in terms of producing a low level of FW and being unmotivated to reduce FW, *Slackers* can be compared to *'Convenience and price-oriented low income'* (Aschemann-Witzel et al., 2021) and *'the consumerist'* (Delley and Brunner, 2017). They were described as uninvolved or less involved with food, focused on price, and prefer convenience foods.

Considering the large proportion of avoidable FW for this segment, we suggest two potential approaches to the intervention for this segment. Firstly, a focus on reducing avoidable FW and emphasising the cost savings that could result from preventing the avoidable FW which comprises a large proportion of their total FW. Second, with the aim of increasing diversion of FW from landfill, the intervention could also focus on encouraging and increasing the perceived importance of sorting.

This segment is not self-motivated to act on the FW issue and perceives lower personal control over reducing and sorting FW. As such, interventions designed to amplify their normative and gain goals may be effective. Nudge techniques, which can subtly alter consumer behaviour without restricting choices, imposing financial consequences, or requiring cognitive effort, could be particularly beneficial (de Visser-Amundson and Kleijnen, 2020; Thaler and Sunstein, 2009). Previous studies suggest several forms of nudge interventions could help to reduce FW, including 1) social norms-based messaging strategies, 2) reminders (i.e. providing feedback on how they perform compared to other people in the area), and 3) pre-commitment (i.e. encouraging individuals to commit to reduce a specific amount of FW in advance) (Barker et al., 2021; de Visser-Amundson and Kleijnen, 2020). A combination of nudges could also be effective (Qi et al., 2022).

Therefore, for sorting behaviour, a synergy of the social norm and default option nudges might be optimal. For instance, owning a kitchen caddy has been positively correlated with sustainable FW sorting (Bernstad, 2014; Nguyen et al., 2022). The kitchen caddy serves as a tangible reminder of a social norm, signalling that it's a "normalised behaviour" and a widespread practice (Bernstad, 2014; de Visser-Amundson and Kleijnen, 2020). In our sample, nearly 70 % of the *Slackers* do not possess a kitchen caddy (Table 5), and the acquisition of which usually requires a visit to the local government office. This "opt-in" mechanism demands cognitive effort and time. Thus, providing *Slackers* with a kitchen caddy and compostable liner by default, accompanied by simple usage instructions, might encourage its adoption as a socially desirable practice in the community.

Moreover, employing reminder nudges in addition to the kitchen caddy could be beneficial. These could be in the form of feedback about their choices (e.g. highlighting that a significant portion of their FW is avoidable, leading to financial setbacks) or by underscoring social norms through framing (von Kameke and Fischer, 2018). Feedback on their FW sorting behaviour compared to average households in the locality could also be effective (Barker et al., 2021; Lehner et al., 2016).

Additionally, considering that the *Slackers* are typically younger and may be influenced by peers and social media influencers, using youthful influencers, or leveraging social media to promote FW reduction and sorting as "normalised behaviour" could be influential. Initiatives like social media challenges (e.g. #foodwastepreventionchallenge) that involve commitments such as "I will reduce" can harness the power of peer influence and public commitment.

5.2. Can participating in sustainable sorting practices potentially reduce household FW?

The results of our segmentation analysis, which considered both FW sorting and generation behaviours, provide a more nuanced understanding of FW behaviours. The results show significant differences in sorting behaviour between households that produce similar amounts of FW. For instance, while *Warriors* and *Slackers* produced comparable

amounts of FW, *Warriors* had the highest proportion of FW sorted sustainably and *Slackers* the lowest. Meanwhile, *Strugglers*, who produced the most FW, had a sorting efficiency score in between the other segments. Our findings further suggest that motivation to sort (i.e. perceived importance of sorting FW) and perceived behavioural control may play a key role in sorting behaviour. The high proportion of preventable FW in the *Slackers* segment, and generally lower motivations and perceived importance of sorting and reducing FW, suggests that if these respondents were sufficiently motivated to sort FW, their total FW may be lower. Further, both *Strugglers* and *Slackers* perceived lower behavioural control than *Warriors*.

The heterogeneity in FW sorting behaviour among segments that generate similar levels and proportions of preventable FW suggests that sorting behaviour and motivations are important to fully understand household FW behaviour. Previous studies report that sustainable sorting practices have an inverse association with the generation of FW or household residential waste. In particular, the introduction of kerbside FW collection in Sweden resulted in reduced household waste (Miliute-Plepiene and Plepys, 2015), and home composting was found to be associated with less FW (Kunszabó et al., 2022). Overall, previous studies suggest that interventions aimed at increasing sustainable disposal behaviour could lead to reductions in overall FW generated, and the results of our study emphasise the importance of addressing factors such as motivation/perceived importance and perceived behavioural control when designing such interventions.

6. Research implication, limitation and future research

This study identified segments of the population with distinct FW behaviour and sociodemographic characteristics and provided insight on interventions which can be targeted at specific groups to optimise intervention outcomes. The results show three groups (or 'types' of households) that can be found in societies where FOGO collection is available. The present study has methodological, policy and societal implications. Firstly, the segmentation process can be used as a blueprint for similar studies in other contexts or regions. The methodology can be refined based on the accuracy and efficacy of this segmentation. Secondly, policymakers can design targeted policies for each segment. For instance, they might focus on resource provision for Strugglers, motivational campaigns for Slackers, and recognition or reward systems for Warriors. Finally, understanding these segments helps society at large recognise the diversity of challenges and behaviours related to FW. This can inform public discourse, community initiatives, and even corporate social responsibility initiatives.

However, the study has limitations which present opportunities for future research. First, participants were provided with information (i.e. a pre-amble as shown in Fig. A1) outlining the purpose of the study. Therefore, like most surveys, there is a chance of self-selection bias, for example, if participants who were not interested in the FW topic chose to opt out of the study after they read the pre-amble. Second, we aimed to include meaningful FW indicators (i.e. total volume, and avoidable proportion of FW and focused and focused on sorting behaviour, which produced limited information on food management behaviours (e.g. planning, storing) which are also relevant to sustainable FW outcomes. Food-related behaviours (e.g. planning, storing) have been used extensively in previous studies for segmenting. Future research can use our two measures for FW volume together with both food-related behaviours and disposal behaviours to gain a broader picture of FW behaviours. Third, the study relied on self-reported data which may differ from results of a direct bin audit. Fourth, the main measurement unit (i.e. the kitchen caddy) is uniquely applicable to this study area, with many participants already familiar with the tool. Future research should carefully assess the suitability of this instrument for their specific context, and select a unit that is most widely recognised. Finally, we have yet to be able to conclude a clear relationship between minimising and sorting FW. Measurement of perceptions of households on how sustainable sorting influences their FW levels remains relatively unexplored.

7. Conclusions

Households are the focal point for addressing FW issues both in terms of volume reduction and diversion of FW away from landfill. Interventions aiming to address unsustainable household FW behaviour need to be tailored to be more effective. The results of our study revealed three household segments (i.e. *FW Warriors, Strugglers, and Slackers*) with heterogeneous FW behavioural outcomes. *Strugglers,* which are approximately 20 % of households, produce a large amount of FW, of which a high proportion can be prevented or sorted sustainably. This group is motivated to reduce and sort FW but is constrained, particularly due to responsibilities and time constraints often faced by families with children. Thus, interventions targeting this group may have a greater impact than interventions targeting other segments. The *Slacker* segment is the largest group by size; although they produce a relatively low volume of FW, a high proportion of it is preventable FW and is disposed of unsustainably. They are slightly motivated to reduce FW but not to sort FW. This group also perceived the lowest control over their FW disposal behaviour. Therefore, to change the FW of this segment, interventions should consider strategies for increasing FW-related motivation and perceived behavioural control. Lastly, the *Warriors* are motivated to reduce and sort FW, producing a low amount that is largely unavoidable. While this segment may not need new interventions, maintenance of the existing infrastructures which support their current sustainable FW behaviours should be ensured.

CRediT authorship contribution statement

Trang Thi Thu Nguyen: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Lenka Malek:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Wendy J. Umberger:** Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. **Patrick J. O'Connor:** Writing – review & editing, Supervision.

Declaration of Competing Interest

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.

Data availability

Data will be made available on request.

Acknowledgements

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Appendix A

Figs. A1–A11, Tables A1 and A2.

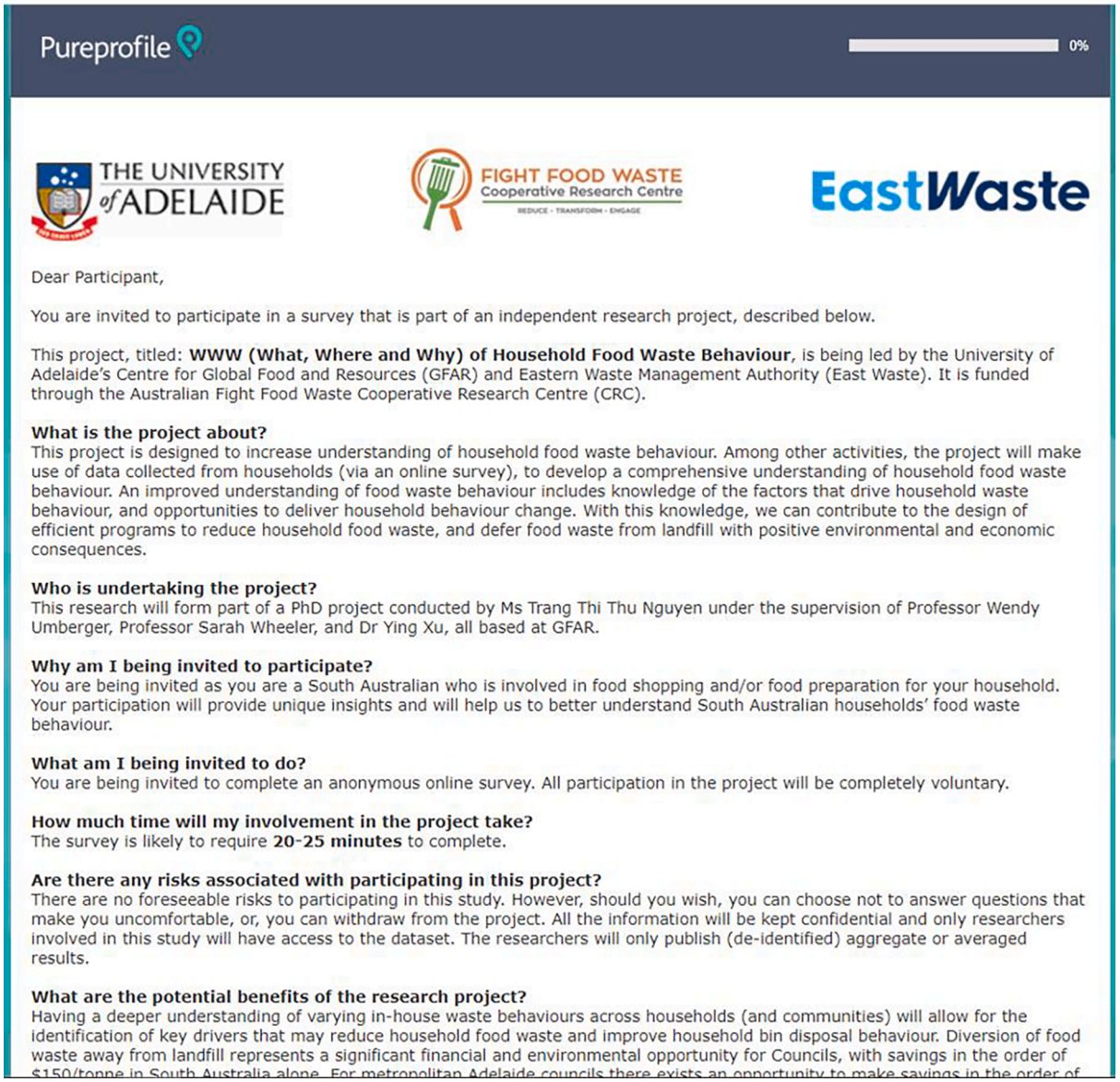

Fig. A1. Study's pre-ample shown to participants in the online survey.

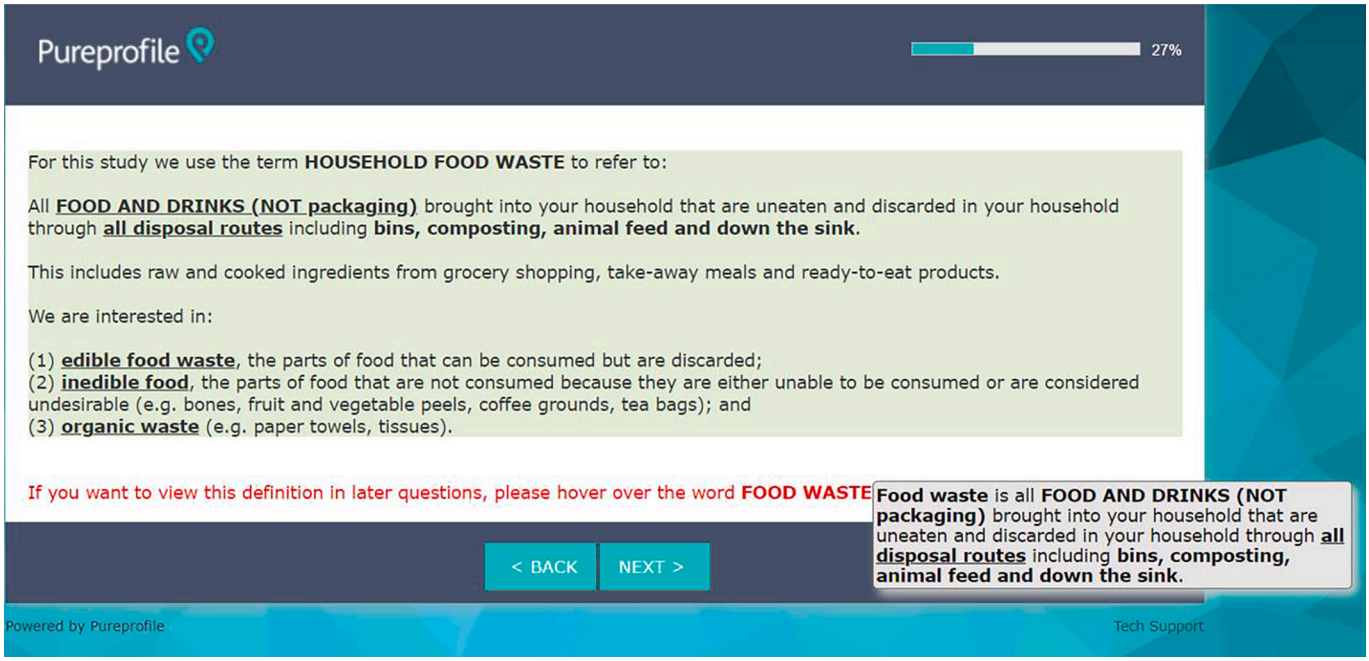

Fig. A2. Food waste definition shown to respondents in the online survey.

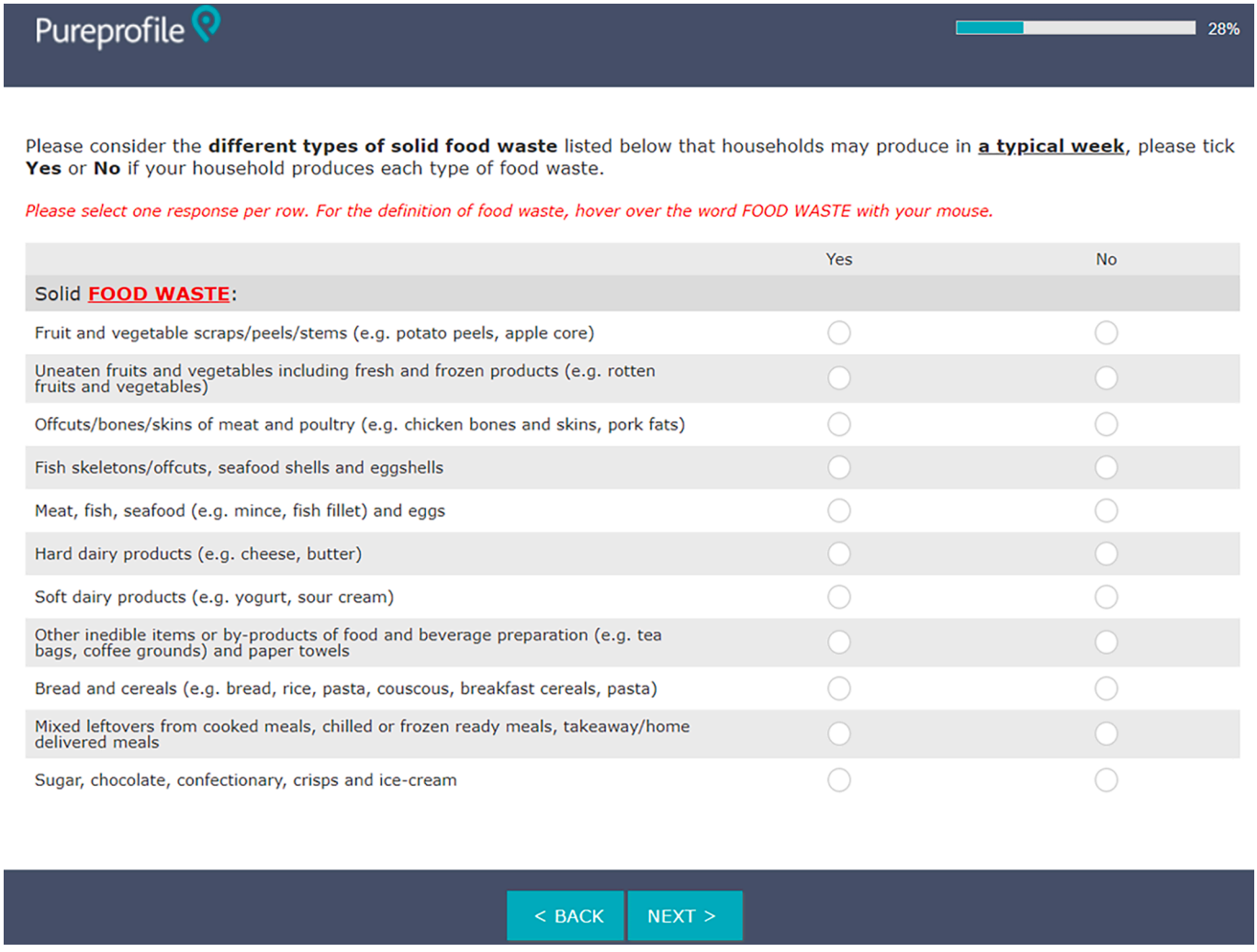

Fig. A3. List of different types of food waste that households may produce in a typical week.

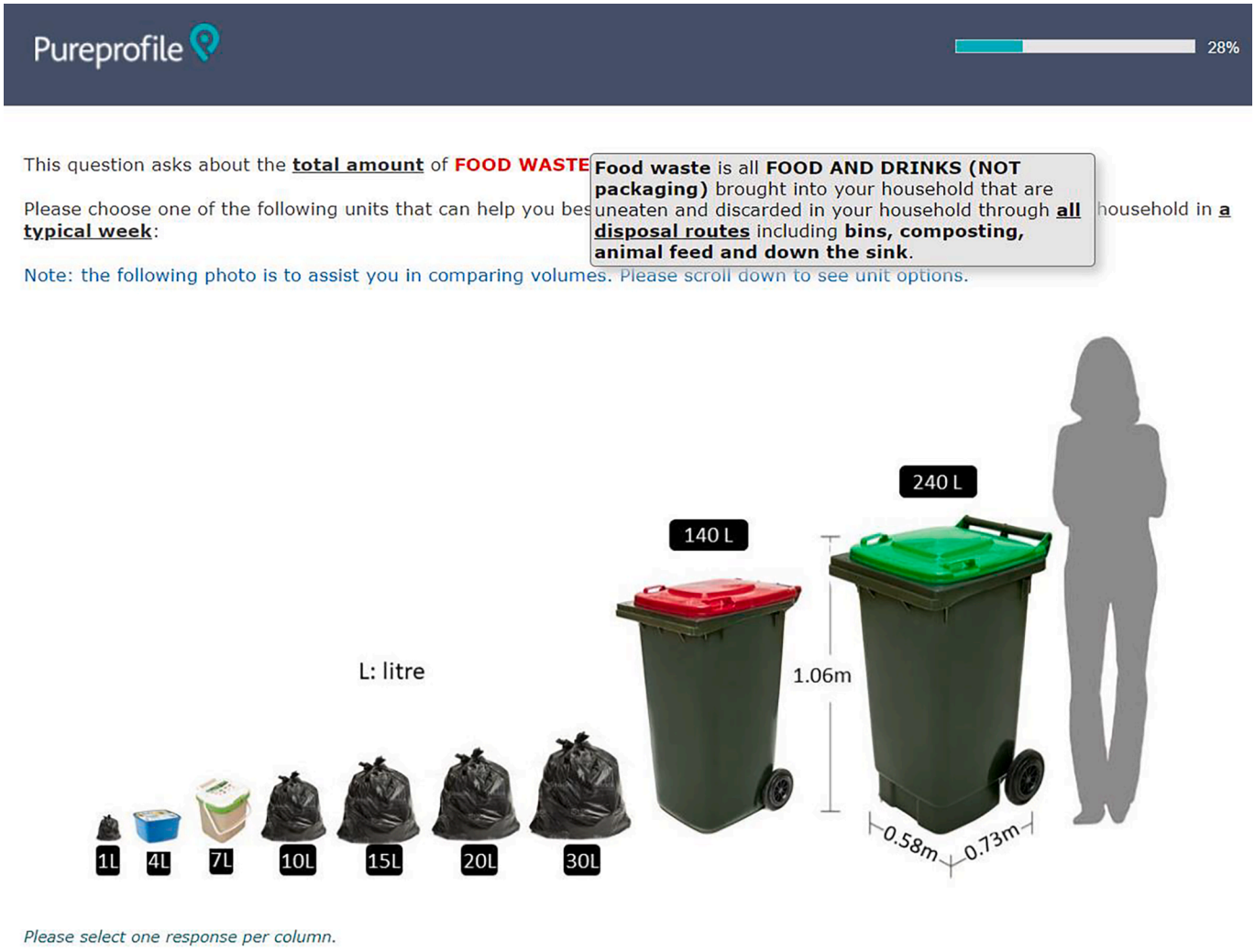

Fig. A4. Photo in the online survey to assist respondents in comparing volumes. Respondents can hover over the word **FOOD WASTE** to view the definition.

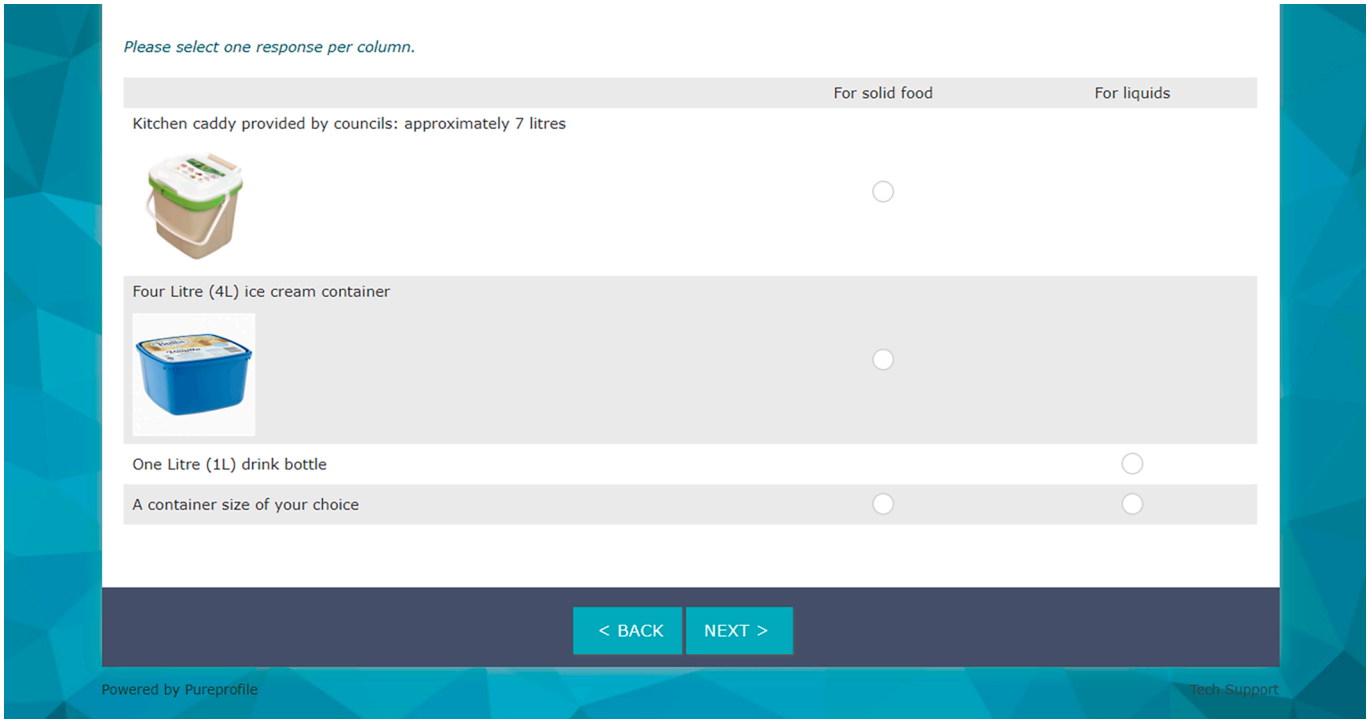

Fig. A5. Photos of measurement units are shown in the online survey.

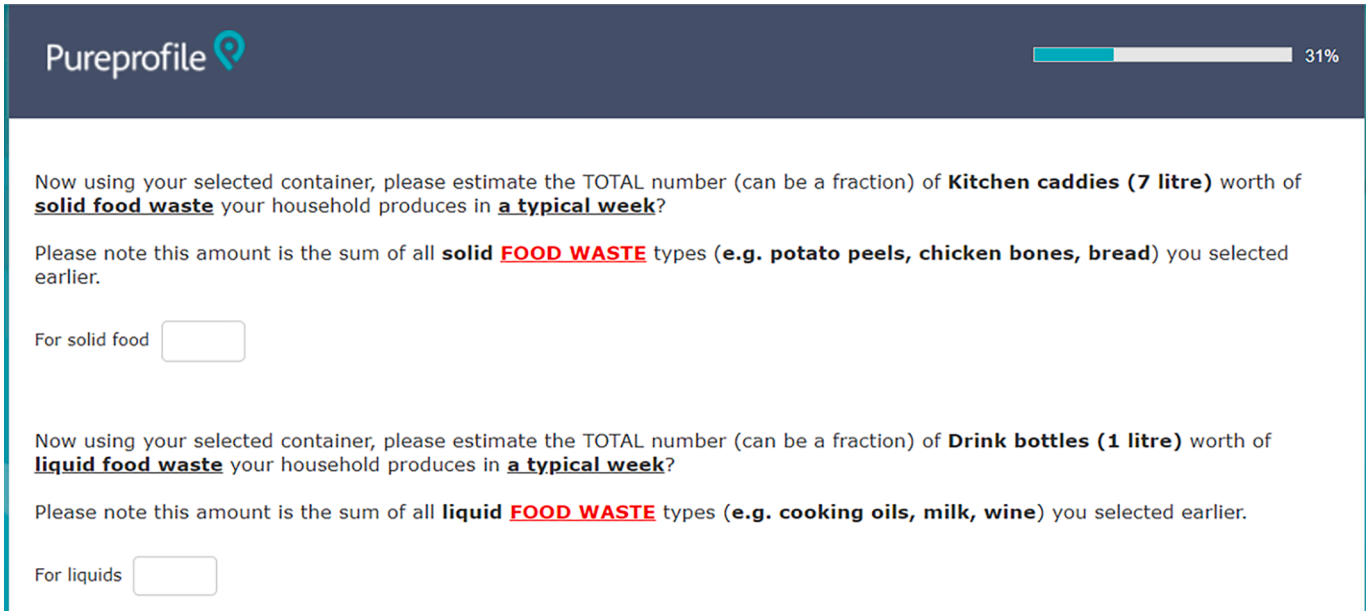

Fig. A6. Questions asked respondents to self-estimate their FW based on previously selected measurement units.

Pureprofile 33%

Now we ask about the **percentage contribution** of each type of food waste to the total amount.

You mentioned earlier you have the following solid types of **FOOD WASTE** in a **typical week**.

Please estimate the percentage contribution of each of the following categories to the **total solid food waste volume** your household produces in **a typical week**:

Fruit and vegetable scraps/peels/stems (e.g. potato peels, apple core)	40 %
Uneaten fruits and vegetables including fresh and frozen products (e.g. rotten fruits and vegetables)	5 %
Offcuts/bones/skins of meat and poultry (e.g. chicken bones and skins, pork fats)	10 %
Fish skeletons/offcuts, seafood shells and eggshells	5 %
Meat, fish, seafood (e.g. mince, fish fillet) and eggs	5 %
Hard dairy products (e.g. cheese, butter)	5 %
Soft dairy products (e.g. yogurt, sour cream)	5 %
Other inedible items or by-products of food and beverage preparation (e.g. tea bags, coffee grounds) and paper towels	10 %
Bread and cereals (e.g. bread, rice, pasta, couscous, breakfast cereals, pasta)	8 %
Mixed leftovers from cooked meals, chilled or frozen ready meals, takeaway/home delivered meals	5 %
Sugar, chocolate, confectionary, crisps and ice-cream	2 %
	Total: 100

Fig. A7. Questions asked respondents to indicate percentage of each FW type.

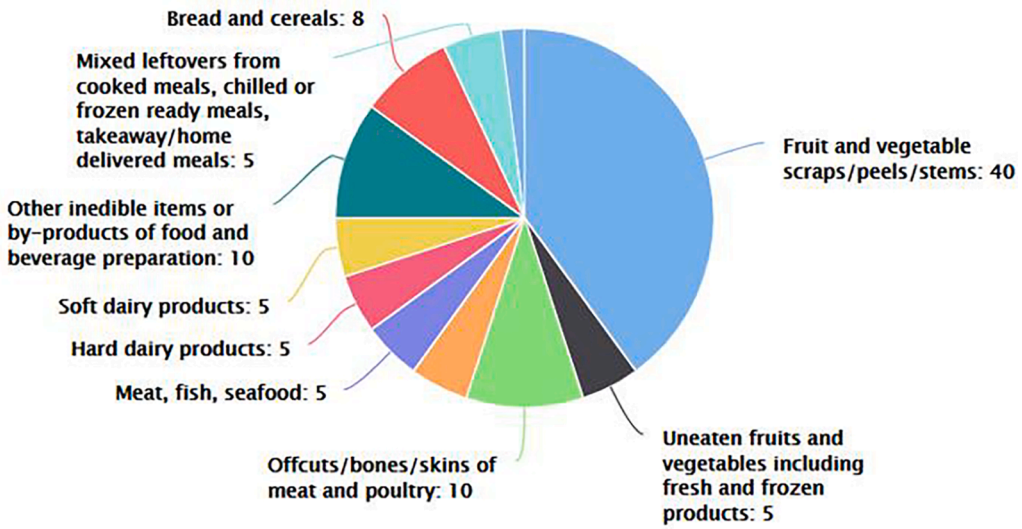

Fig. A8. Questions asked respondents to indicate proportions of FW disposed of into different destinations.

Please estimate the percentage of your household **total solid FOOD WASTE (e.g. potato peels, chicken bones, bread)** that goes to each of the following **destinations** in **a typical week**.

Please only consider the food and NOT the packaging.

General waste (Red/Blue) bin	10	%
Organic waste (Green) bin	40	%
Recyclable waste (Yellow) bin	5	%
Worm farm/home composting	30	%
Feeding pets/chickens	10	%
Pour down the sink/in-sink disposal unit or toilets	5	%
Other, please specify	0	%
	Total: 100	

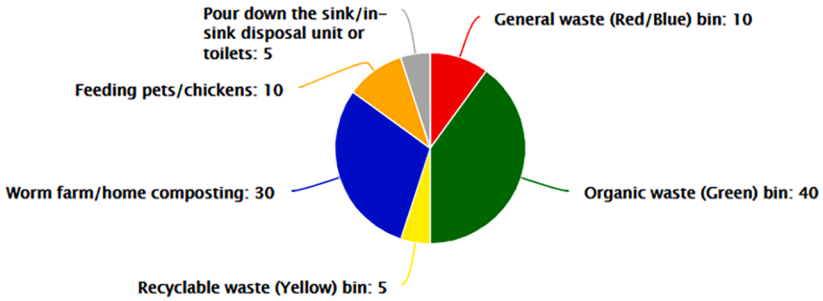

Fig. A9. Questions asked respondents to indicate proportions of each FW category disposed of into different destinations (example for Fruit and vegetable scraps).

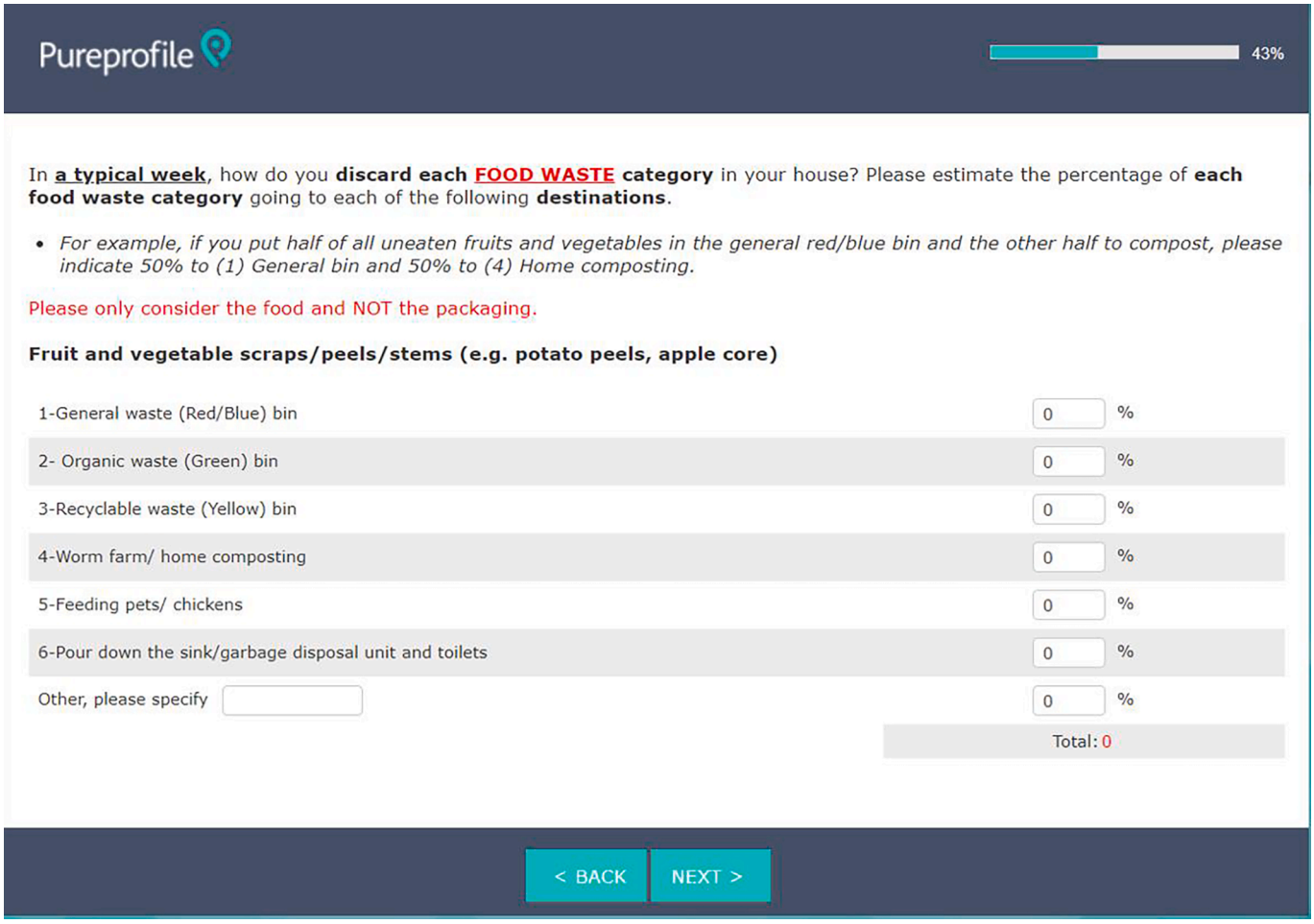

Fig. A10. Questions asked respondents to indicate proportions of each FW category disposed of into different destinations (examples for Uneaten fruits and vegetables).

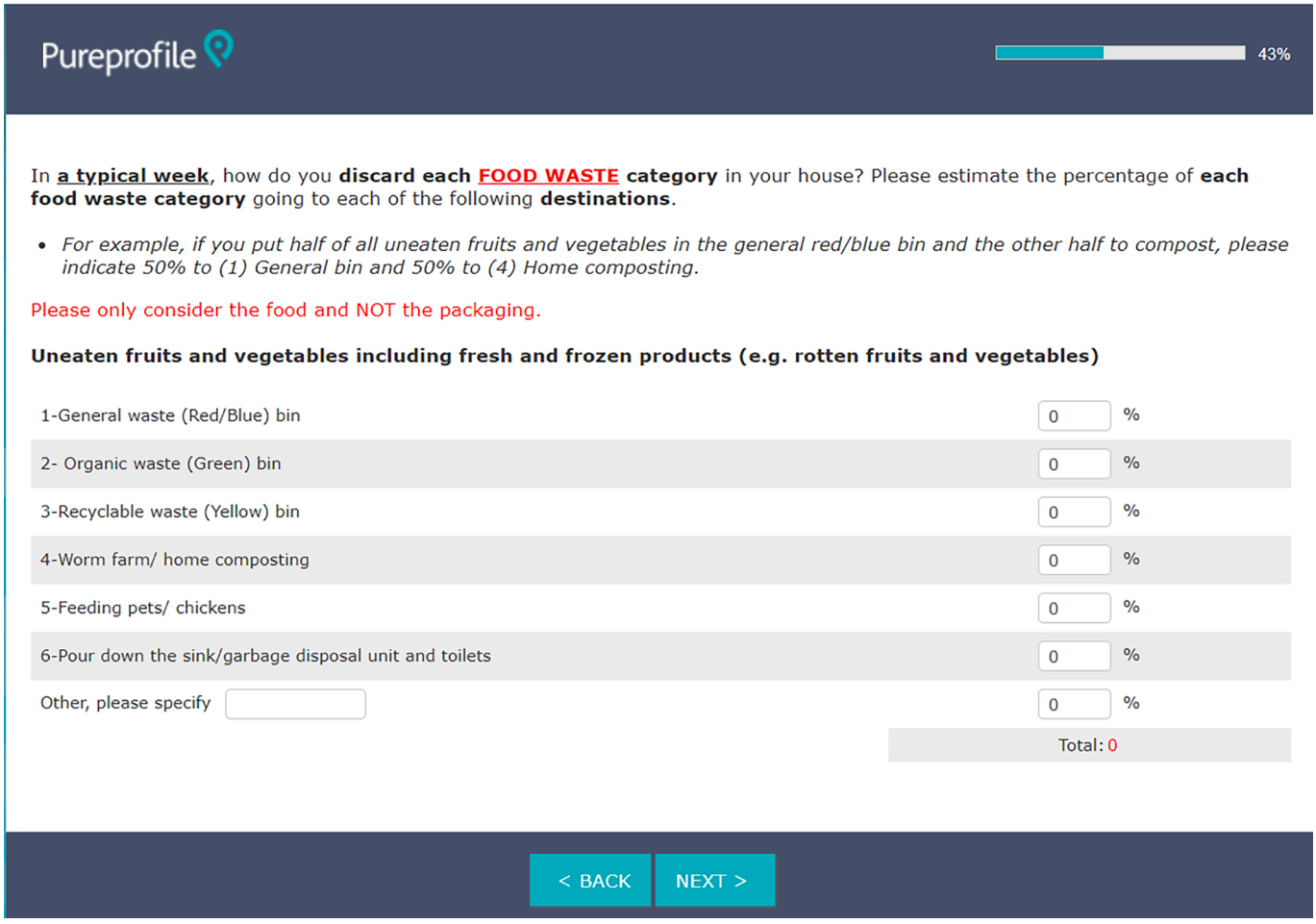

Fig. A11. Final cluster solution provided by the SPSS's TwoStep cluster method.

Table A1
Sample representativeness of gender, age and income and other descriptive statistics.

Variable	Our sample (%) (n = 939)	Australian national population 2020 (%) (n = 25,697,298)
Gender		
Male	49.1	49.6
Female	50.6	50.4
Other	0.3	–
Age range		
18–24	11.4	9.0
25–34	18.6	14.9
35–44	17.8	13.4
45–54	17.8	12.6
55–64	15.3	11.6
≥65	19.1	16.3
Annual household income		
$0 – $24,500	7.9	10.0
$24,501 – $38,900	12.0	10.0
$38,901 – $52,900	13.1	10.0
$52,901 – $69,500	11.5	10.0
$69,501 – $88,500	12.7	10.0
$88,501 – $109,300	13.4	10.0
$109,301 – $134,800	12.2	10.0
$134,801 – $168,700	9.4	10.0
$168,701 – $222,300	5.4	10.0
$222,301 or above	2.3	10.0
Education level		
Below year 10	2.6	
Year 10	5.0	
Year 11	6.4	
Year 12	15.1	
Certificate (III or IV)	19.3	
Diploma or Advanced Diploma	16.0	
Bachelor Degree	21.6	
Graduate Certificate or Graduate Diploma	5.2	
Postgraduate Degree (Master or PhD)	8.8	
Food shopping and preparation responsibilities		
Do the majority of both food shopping and food preparation	53.5	
Either do the majority of one activity and share another, or share both of the activities	39.9	
Share either one activity	6.6	
Do not do any	1.5	
Household composition		
Family, only adults	38.3	
Family with children	35.4	
Single person household	14.7	
Shared house, non-related	7.2	
Other	4.3	
Housing type		
Detached house	75.0	
Flat/unit/apartment	12.8	
Semi-detached row/townhouse	11.5	
Rural property	0.4	
Other	0.3	
Having a kitchen caddy	55.3	

Table A2
Number of pre-clusters and their BICs provided by the SPSS's TwoStep Cluster Analysis.

Auto-Clustering				
Number of Clusters	Schwarz's Bayesian Criterion (BIC)	BIC Change[a]	Ratio of BIC Changes[b]	Ratio of Distance Measures[c]
1	1992.164			
2	1581.242	−410.922	1.000	1.284
3	1270.258	−310.984	0.757	2.203
4	1151.509	−118.749	0.289	1.072
5	1043.438	−108.072	0.263	1.387
6	976.949	−66.488	0.162	1.513
7	946.946	−30.003	0.073	1.244
8	930.874	−16.072	0.039	1.474
9	933.180	2.306	−0.006	1.002
10	935.581	2.401	−0.006	1.071
11	940.544	4.964	−0.012	1.160
12	950.487	9.942	−0.024	1.098
13	963.196	12.709	−0.031	1.157
14	979.749	16.553	−0.040	1.427
15	1003.635	23.886	−0.058	1.123

a. The changes are from the previous number of clusters in the table.
b. The ratios of changes are relative to the change for the two cluster solution.
c. The ratios of distance measures are based on the current number of clusters against the previous number of clusters.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2023.105000.

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