Urban household food waste: drivers and practices in Toronto, Canada

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Abstract

Purpose – The purpose of this paper is to understand determinants of food waste through analysing patterns of practices including shopping, planning, consumption of leftovers and attitudes around best-before dates.

Design/methodology/approach – A survey and waste composition analysis of 142 households was conducted in the City of Toronto. Bivariate analyses and confirmatory factor analysis (CFA) using a structural equation model were used to identify relationships between per capita food waste, household socio-demographic characteristics and household food practices.

Findings – Constructs related to planning practices and best-before date practices were identified through the CFA. Household size and the best-before construct were negatively correlated with per capita food waste. The planning construct had no correlation, which may be attributed to the influence of the retail environment in encouraging unplanned purchases. The best-before construct was significantly correlated with the presence of children in the home, an indicator of the compromises that parents make in domestic provisioning to ensure healthy foods for their children, such as more caution in handling items after their best-before dates.

Originality/value – This is the first study of its kind that uses directly measured per capita food waste from a waste composition study in a structural equation model with a construct related to best-before dates to determine drivers of food waste. It is also the first to find that children in the home can have an indirect influence on food waste through the household's best-before practices.

Keywords Consumer behaviour, Factor analysis, Multivariate analysis, Surveys, Waste, Food

Paper type Research paper

1. Introduction

There is global consensus that food waste is a critical issue, impacting food security, contributing to loss of biodiversity, water scarcity, waste of energy and generating the greenhouse gas methane, which contributes to global climate change. The issue of consumer food waste is especially pertinent since households generate a significant amount of food waste (Parizeau *et al.*, 2015; Qi and Roe, 2016; van der Werf *et al.*, 2018). Gooch *et al.* (2019) estimate that households are responsible for 21% of avoidable food waste in Canada. This study defines food waste as avoidable (or edible) food waste, which includes "Any substance – whether processed, semi-processed, or raw – that is intended for human consumption" and food "that has spoiled and is therefore no longer fit for human consumption" (Food Loss and Waste Protocol, 2016). While there are different interpretations of what would be considered edible based on cultural

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norms, this study used a more open definition and included items such as carrot and apple peels as edible even though some people prefer not to eat these parts of food.

To address the large proportion of food waste originating from households, policies, strategies and education campaigns have been developed by numerous organizations and governments. The United Nations Sustainable Development Goals include a target for halving per capita food waste at the retail and consumer levels, which includes households (United Nations Development Programme, 2020). In Canada, the National Zero Waste Council (2018) created a national food waste strategy which included a suite of actions from harmonizing government policies to encouraging culture shifts through changing consumer behaviour. The Love Food Hate Waste Campaign, created by the Waste and Resources Action Programme (WRAP) in the United Kingdom to raise awareness and inspire action by consumers to reduce household food waste (WRAP, 2020), has been adopted by other countries including Canada (Love Food Hate Waste Canada, 2020), Australia (State of New South Wales, 2020) and New Zealand (Love Food Hate Waste NZ, 2020).

To develop effective policies and interventions that target consumer behaviour in reducing household food waste, it is important to understand the drivers and causes of household food waste. While many studies on household food waste apply the theory of planned behaviour and explore an individual's motivations, attitudes, moral norms and intentions on food waste (e.g. van der Werf *et al.*, 2019; Qi and Roe, 2016; Stancu *et al.*, 2016) this study uses concepts drawn from practice theory, which moves away from a focus on the responsibility of individuals for wasting food to making the practice of wasting the core unit of analysis (Hargreaves, 2011). Practices are routinized behaviours undertaken with little conscious deliberation (Evans, 2018). They are present at all stages of the passage of food into waste, beginning at the point of purchasing of food, and continuing through its storage, preparation, consumption and disposal. Elements that configure a practice are *materials*, *competencies* and *meanings* (Shove *et al.*, 2012). Material in the context of food and its wasting can include the retail infrastructure where households shop for food and food itself, particularly its characteristics of freshness, appearance and putrescibility. Examples of competencies include meal planning and shopping practices. An example of meaning is the role that food preparation plays in parents' "good provider" identity as food provisioners for their children. Ganglebauer *et al.* (2013) emphasize how food waste is related to a range of practices, which are themselves affected by broader contextual factors and values. For example, marketing promotions at the food retail level are for the most part outside of the consumers' control but can lead to unplanned purchases that may in turn lead to wasted food (Lee, 2018). This study also explores the relationships among individual practices to identify clusters of practices (Moreno, 2019). Finally, this research adds consideration of household characteristics in understanding the relationship between food waste and the material, competence and meaning elements of everyday food practices.

Other studies of food waste drivers that have used the same combination of methods and measurements for assessing household food waste quantities were not found in the literature. All others are slightly different in at least one respect. Most significantly, this study is a direct measurement study where household waste is measured physically rather than self-reported or approximated. Unlike many direct measurement studies that report food waste findings on a household basis and control for household size in multivariate models (e.g. Quested and Luzecka, 2014; van der Werf *et al.*, 2020), this study reports per capita food waste. In contrast to studies that examine avoidable food waste and limited amounts of non-food waste (e.g. Parizeau *et al.*, 2015), or avoidable solid food and liquid food waste (e.g. Quested and Luzecka, 2014), only avoidable solid food waste is examined. The method that is used for collecting food waste measurements was the kerbside waste composition study rather than kitchen diaries, which are known to under-report food waste compared to waste composition studies (Quested *et al.*, 2020; Giordano *et al.*, 2018). Food waste was measured in garbage and organic bin set-outs, which differs from kerbside studies that have counted only food waste in organic

bin set-outs (e.g. Parizeau *et al.*, 2015). Unlike studies that collect all waste from the home (Elimelech *et al.*, 2019), not just waste set out at kerbside, food waste sent to other disposal routes such as backyard composting or pets was not captured.

2. Literature review

Recent literature reviews on food waste drivers have identified a wide range of factors that can influence food waste (van Geffen *et al.*, 2020; Schanes *et al.*, 2018; do Carmo Stangherlin and de Barcellos, 2018). This research focuses on a subset of these factors, namely household socio-demographic characteristics, the retail infrastructure and practices related to meal planning, food shopping, use of leftovers and date labels. In reviewing studies that test for relationships with food waste, chosen studies included those that use direct measurement of food waste, in the form of waste composition studies, and self-assessment, in the form of kitchen diaries and only those that report significance tests. The literature review suggests a number of research hypotheses about drivers of food waste. In the hypotheses that are identified below, individual practices (e.g. eating food past the best-before date) are distinguished from clusters of related practices (e.g. a cluster of best-before practices could include avoiding throwing food out past the best-before date, checking if food is still good past the best-before date and eating some food past the best-before date anyway).

Among the key socio-demographic factors that have been found to influence food waste is household size. All but one (Koivupuro *et al.*, 2012) of the studies that measured waste per capita found a statistically significant negative relationship between per capita food waste and household size. Note that all relationships with food waste referred to as significant in this paper are for $\alpha = 0.05$. Koivupuro *et al.* (2012) found only a marginally significant relationship for household size ($p = 0.10$). Single-person households stand out as being the most wasteful in these studies. Single person households lack the ability to benefit from economies of scale that are present in larger households (Parizeau *et al.*, 2015) and are more sensitive to external circumstances. For example, they may not be able to purchase items in small enough package sizes and they have fewer people in the home to consume food in time before it spoils (Quested and Luzecka, 2014).

Table 1 summarizes other variables that have been found to be related to edible food waste. The most commonly studied socio-demographic variable is presence of children in the home. Some studies find no relationship between children and food wasted while others find a positive relationship. The positive findings could be due to the fact that children of all ages can be fussy eaters, resulting in more food waste (Quested and Luzecka, 2014) and parents with "good provider" identities may be encouraged to cook more than needed to ensure that their children have varied, healthy food and enough food (Visschers *et al.*, 2016). The finding of no significant relationship could be due to a counter-balancing effect in homes with children. Small children have lower calorific needs and require less food (Quested and Luzecka, 2014), providing less opportunity for waste. In other words, the presence of children could lead to both more food waste and less food waste simultaneously, resulting in a finding of no significant relationship with food waste.

Although household income has not been found significant in direct measurement studies (Koivupuro *et al.*, 2012; Williams *et al.*, 2012; Moreno, 2019), it is worth further consideration since several survey-based studies have found a significant, positive relationship with food waste (Soma, 2019; McCarthy and Liu, 2017; Stancu *et al.*, 2016; Stefan *et al.*, 2013). Similarly, although shopping choices among available retail infrastructure sites (e.g. wholesale, large grocery or convenience stores) have not been found significant with direct measurement (Giordano *et al.*, 2019; Koivupuro *et al.*, 2012), they have been in survey-based research where they are considered an important material aspect affecting food waste. For example, Lee (2018) found that retail choices affected over-purchasing of food and food waste in Korea

Variable	Significant	Not significant
Children	Parizeau *et al.* (2015) (+) WC; Grainger *et al.* (2018) (+) WC	Koivupuro *et al.* (2012) KD; Quested and Luzecka (2014) KD WC; Moreno (2019) KD; van der Werf *et al.* (2020) WC
Income		Koivupuro *et al.* (2012) KD; Williams *et al.* (2012) KD; Moreno (2019) KD
Retail infrastructure		Koivupuro *et al.* (2012) KD; Giordano *et al.* (2019) KD
Meal planning and shopping practice clusters		Moreno (2019) KD; van der Werf *et al.* (2020) WC
Meal planning	Quested and Luzecka (2014) (–) KD	Quested and Luzecka (2014) WC Elimelech *et al.* (2019) WC
Shopping list	Quested and Luzecka (2014) (–) KD	Giordano *et al.*, (2019) KD; Quested and Luzecka (2014) WC
Check at home		Quested and Luzecka (2014) KD WC
Shopping frequency	Giordano *et al.* (2019) (–) KD	Koivupuro *et al.* (2012) KD; Silvennoinen *et al.* (2014) KD; Quested and Luzecka (2014) KD WC
Unplanned purchases		Elimelech *et al.* (2019) (no indirect effect) WC
Use up leftovers	Quested and Luzecka (2014) (–) KD WC	
Throw food out past best before date	Quested and Luzecka (2014) (+) KD WC; Grainger (2018) (+) (sell by date) WC	Parizeau *et al.* (2015) WC

Note(s): Key: KD = kitchen diary; WC = waste composition; +/– = positive/negative relationship

Table 1. Summary of variables related to household food waste from previous research

while Soma (2019) found that retail choices affected self-reported food waste in Indonesia. In both cases, shopping at the largest types of food retail environments, such as supermarkets and hypermarkets, was associated with more food waste in the home. It has long been known that advertisements and promotions that are prominently featured at supermarkets encourage customers to buy more than they had planned (Wilkinson *et al.*, 1982; Abrat and Goodey, 1990) and numerous items are more likely to be sold in larger packages at supermarkets than in smaller stores, such as convenience stores (WRAP, 2012).

The literature suggests the following research hypotheses regarding socio-economic characteristics and retail infrastructure:

H1. Household socio-demographic characteristics are related to household food waste, with (a) household size and (b) income negatively related and (c) presence of children positively related.

H2. Choice of food purchasing location is related to food waste.

The relationship of food waste with meal planning and shopping practices has been studied extensively. Shopping practices thought to reduce food waste include making a shopping list, buying only items on the list, not buying in bulk and checking the inventory of food waste at home before shopping. These are often promoted as competencies for reducing household food waste in food waste awareness campaigns (e.g. Love Food Hate Waste Canada, 2020). Testing of individual meal planning and shopping practices has found mixed support for a relationship with food waste, as shown in Table 1, as has shopping frequency and throwing out food past the best-before date. The practice of infrequent shopping may lead to more food waste because of the materiality of food – perishable foods have to last longer between shopping trips. The practice of throwing out food because it is past its best-before date may

relate to competencies, meanings and material (the actual date label itself). Understanding that best-before labels designate dates beyond which food quality declines rather than dates beyond which the food must be thrown out can be considered a competency. However, the practice of managing food based on the labels may derive from the meanings attributed to the labels, and engagement with the actual label itself, which is increasingly included on more types of food. For some, using food after a best-before label can raise fears about the safety of the food rather than quality and those individuals are more likely to discard food after the label date (Neff *et al.*, 2019). Quested and Luzecka (2014) found that households with children are more likely to throw food out past the date on its label and suggest that food safety could be the reason. Previous research therefore suggests the following hypotheses about planning practices, shopping frequencies and practices around best-before dates:

H3. Competencies in individual planning practices before shopping and practices during shopping are negatively related to household food waste.

H4. Less frequent shopping is positively related to food waste.

H5. Individual practices of food consumption avoidance after the best-before date are positively related to household food waste.

H6. Presence of children in the household is positively related to practices of food consumption avoidance after the best-before date.

Creative use of leftovers is another competency that is often promoted in food waste awareness campaigns. As shown in Table 1, households that report using up leftovers tend to produce less food waste. Like date labels, use of leftovers is not only a competency but also has meaning. For example, Visschers *et al.* (2016) found that those who perceive higher risks in consuming leftovers self-report more food wastage. This link between leftovers and food waste forms the basis for the following hypothesis:

H7. Competencies in individual practices of using leftovers are negatively related to household food waste.

A final hypothesis is that clusters of competencies may be related to reducing food waste. Moreno (2019) hypothesized that participation in one type of food waste avoidance practice makes one more likely to participate in another similar practice. In other words, people may participate in "suites" of practices. Moreno (2019) and van der Werf *et al.* (2020) tested this hypothesis for meal planning and shopping practices but did not find a significant relationship. It is possible that the existence of a relationship depends on the number and types of practices included in a cluster and that a different clustering could produce a different result. Only two of the practices used in the clusters in the previous two studies were the same. It is also worth considering whether other types of clusters, such as for practices related to use of leftovers and best-before dates, have a relationship with food waste. These considerations suggest the following hypothesis:

H8. Clusters of competencies (namely related practices that are performed prior to and during shopping, related practices around the use of leftovers or related practices around the consumption of food past its best-before date) exist and are negatively related to food waste.

One variable excluded from Table 1 is age. It is a challenging variable since it is better at capturing individual characteristics rather than those of the household. In the context of the present study, Toronto is a city where 12% of the population lives in multi-generational households (Haider and Moranis, 2018), making it particularly difficult to assign a single age to a household.

3. Material and methods

3.1 Recruitment

Participants were recruited via door-to-door recruitment for single-family households in the Scarborough waste collection region of the City of Toronto, which is divided into eight neighbourhood collection zones. One cluster (blocks of contiguous streets) of 300–500 homes was randomly selected from each of the eight collection zones to increase the diversity of households by spreading the pool of potential participants across different neighbourhoods. Within each cluster, recruiters went door-to-door to ask residents to participate in the study between the hours of 2:30 p.m. to 8:00 p.m. on weekdays and 10:00 a.m. to 4:00 p.m. on Saturdays. Recruited participants signed an informed consent form with details on the objective, benefits and risks of the study. Recruitment took place in each cluster until a quota of 30 households was reached, for a total of 240 households.

3.2 Waste composition analysis

Household food waste was measured using a kerbside waste composition analysis after participant recruitment and surveys. As noted earlier, although kerbside studies miss some disposal routes, they are considered superior to the main alternative, namely kitchen diaries, where households are responsible for measuring food waste quantities themselves, and considerably better than self-assessment measurement techniques based on household surveys, which are known to under-report food waste substantially (Delley and Brunner, 2018; Quested *et al.*, 2011; Giordano *et al.*, 2019). Households were not notified about when their waste would be collected for analysis; sample collection took place on one of their regular waste collection days. All materials placed in garbage and organics bins set-out at the kerbside were collected except for hazardous materials or bulky items due to safety concerns. Samples were sorted individually into three categories: edible food waste, inedible food waste and non-food waste. Samples were collected from homes with at least one bin set-out; households with no bins set out were excluded. A total of 1,285 kg of garbage and 1,343 kg of organics were sorted from 164 homes that had set-out bins for collection.

3.3 Surveys

All participants recruited for the study responded to a brief questionnaire on household food-related practices and household socio-demographic characteristics. Both practices and household characteristics were drawn from the literature review (see Table 1). Practice-related questions asked about frequency of shopping and meal planning practices, management of leftovers, practices related to best-before dates and choice of retail destinations. Responses for all practices were recorded on a 5-point Likert scale measuring frequency of the practice. The surveys were conducted in-person and respondents were provided a $10 grocery store gift card after answering the survey.

3.4 Data analysis

Data from surveys and waste composition analysis was queried and analysed using a combination of Python and R. Household-level socio-demographic questions were grouped as follows and Chi-squared tests were performed on the responses against each socio-demographic variable: Household size – Single person, two people, three or more people; Children – With children, without children; Income – Lower income (less than $40,000), medium income ($40,000–$100,000), higher income (greater than $100,000). The income categories were based on the distribution of income in the City of Toronto's 2016 census, whereby lower income was the bottom 30%, middle income was the middle 40% and higher

income was the upper 30% of household incomes (Statistics Canada, 2017a). In order to meet the assumptions of the Chi-squared test regarding expected cell values, responses to practice-related questions with five-point Likert scale answers were aggregated into three groups as follows: "never/rarely", "sometimes" and "often/always".

In the City of Toronto, organics bins are collected weekly whereas garbage bins are collected every other week. Therefore, weekly household food waste generation rates were estimated for single family homes ($n = 164$) by adding together the amount of food waste measured in the green bin and half of the amount of food waste measured in the garbage bin. Households that did not have any edible food waste were excluded from analysis ($n = 13$), leaving a sample size of 151 households with waste composition data.

Per capita food waste was chosen as the variable of analysis rather than food waste per household. For all bivariate relationships between food waste and other variables, it is important to control for household size by using a per capita measure in order to avoid the identification of spurious relationships that occur because larger households always have more waste. As noted by Quested and Luzecka (2014), arguments can be made for choosing either measure when performing multivariate analysis as long as household size is included as an independent variable.

Respondents that did not report on household size were excluded ($n = 9$), reducing the sample size to 142. With the exception of the question on household income ($n = 91$), all other results presented in this paper as percentages are for a sample size of 142. Although the final sample size is relatively small, it is very close to that of a comparable study that used waste composition analysis and structural equation modelling (SEM) with a similar number of parameters (Elimelech *et al.*, 2019). Furthermore, the SEM model in this paper has 14 parameters, which according to the rule-of-thumb of 10 participants per parameter (Jackson, 2003), means that the minimum sample size of 140 (10×14) was met.

The weekly per capita food waste generation rates were not normally distributed (D'Agostino-Pon normality test: $p < 0.01$). Therefore, non-parametric tests (Mann–Whitney U and Kruskal–Wallis) were used for testing for relationships with each of the hypothesized determinants of waste. Relationships between those determinants and socio-demographic factors were tested using a Chi-squared test, but those results are not reported here unless they were statistically significant.

SEM was created for confirmatory factor analysis (CFA). Cronbach's alpha was used to assess the internal reliability of the constructs for the questions related to planning practices, management of leftovers and best-before dates. Constructs with an alpha value greater than 0.60 were included as factors in the model. Socio-demographic characteristics that were significant in bivariate analysis were dummy coded for the model. Per capita food waste was originally normalized with natural logarithm to reduce skew and kurtosis for the model; however, it was still not normally distributed (D'Agostino-Pearson normality test: $p < 0.01$) and therefore the non-normalized data was retained. The model was checked for goodness-of-fit indices, including the model Chi-square, Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Standard Root Mean Square Residual (SRMR).

3.5 Limitations

A limitation of this study is that the waste audit was for only one week. Household waste varies from week to week and throughout different seasons (Yousuf and Rahman, 2007). Therefore, the statistical power of a one-week waste audit is less than a multi-week waste audit. In addition, the sample size in this study was relatively small, reducing the power of the statistical tests.

4. Results

4.1 Socio-demographic profiles

Respondent households were typically comprised of three or more people (75%), had children present (53%) and nearly half (46%) were in the highest income bracket, above $100,000 (see Table 2). The sample had a higher percentage of households of three or more people compared to households in single family homes in the City of Toronto in 2016 (63%) and a lower percentage (4%) of single person households compared to Toronto (9%) (Statistics Canada, 2017b). The median income in single family homes in Toronto was $113,116, slightly higher than the median income of the sample (Statistics Canada, 2017c). Data on children in the home are only available for all homes in the city and show that 38% had children (Statistics Canada, 2017a), which is lower than this study's sample but to be expected since households in single family homes tend to have more children than families living in apartments.

4.2 Quantity of food wasted in households

The waste composition analysis found that the average amount of edible food waste per person was 1.2 kg per week. Single person households wasted more food (1.9 kg/week/person, $n = 6$) than two-person (1.0 kg/week/person, $n = 30$) and three-plus person households (1.1 kg/week/person, $n = 106$) (Kruskal–Wallis: $p = 0.04$), supporting H1a. The presence of children (Mann–Whitney U: $p = 0.15$) did not appear to have an effect on per capita waste, nor did household income (Kruskal–Wallis: $p = 0.52$), meaning that neither H1b nor H1c were supported.

4.3 Planning and shopping practices

The most common planning or shopping practice that respondents follow *often or always* was checking what is at home before shopping (70%) (Figure 1) followed by making a shopping list (44%), planning for meals before shopping (46%) and estimating how much of each item they would need before shopping (43%). A smaller proportion of respondents *often or always* buy only items on their shopping list (22%). The amount of food wasted per capita was not statistically significantly different between respondent groupings for each of these practices (Kruskal–Wallis: $p = 0.20$ to 0.67).

While planning practices may have helped reduce food waste to some degree, their effects are likely decreased by lack of competency in planning, namely by engaging in unplanned practices. As 96% of respondents shop at supermarkets, they are also subject to a retail environment and structure that is not conducive to planning practices. About 56% of respondents reported they *rarely or never* buy only items on their shopping list and 50% *often*

Table 2. Respondents based on socio-demographic characteristics

	Respondent households
Household size	$n = 142$
1 person	6 (4%)
2 people	30 (21%)
3 or more people	106 (75%)
Presence of Children	$n = 142$
Yes	67 (47%)
No	75 (53%)
Annual household income	$n = 91$
<$40,000	10 (11%)
$40,000–$100,000	39 (43%)
>$100,000	42 (46%)

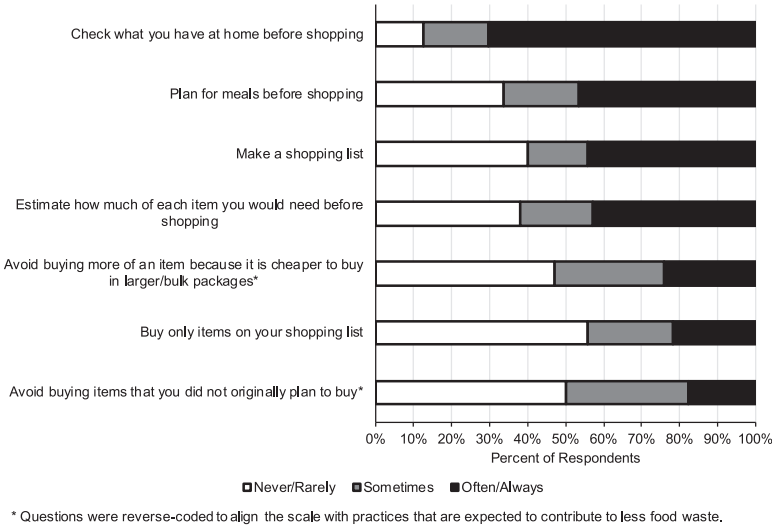

Figure 1.
Summary of survey responses related to planning practices

or always buy items they did not originally plan to buy. The relationship of food waste with unplanned purchases was marginally significant (Kruskal–Wallis: $p = 0.051$). Additionally, 47% of respondents buy more of an item because it is cheaper to buy in larger/bulk packages *often or always* but food waste did not differ by how respondents answered this question (Kruskal–Wallis: $p = 0.23$). In sum, the results show that hypothesis H3 is not supported for any of the planning or shopping practices, except marginally for a relationship between food waste and unplanned purchases.

For respondents that answered that they buy items that they did not originally plan to buy ($n = 137$), among the most popular reasons for doing so were those related to the retail environment. About 71% bought an unplanned item due to an advertisement or promotion in store, 39% said that the item looked good at the time and 22% said that the item in the store looked interesting or new. Other reasons included forgetting the item on the shopping list (24%) or a suggestion from someone else (7%).

4.4 Retail infrastructure

Respondents were asked to select up to three choices where they normally shop or obtain their food. The vast majority of respondents mentioned that they shop at large chain grocery/department stores (96%). Other common retail types were wholesale retailers (49%) and local grocery/specialty retail stores (42%). Less common choices were backyard/balcony gardens (6%), farmers' markets (4%), online grocery delivery (3%) and corner/convenience stores (0.7%). There was no support for the retail infrastructure hypothesis (H2): the relationship between food waste and where a household obtained its food for any of the locations mentioned above was not significant (Mann–Whitney U: $p = 0.06$ to 0.48).

Approximately half of respondents do one main shopping trip per week with occasional top-ups (49%). Another 40% make smaller shopping trips a few times per week or buy food as they need it. Eleven per cent of households do not have a consistent pattern of shopping for food. Food wasted per capita was not significantly different between respondents that reported shopping once per week versus those that shop more frequently or as they need to (Mann–Whitney U: $p = 0.34$), meaning that there was no support for hypothesis H4.

4.5 Management of leftovers and best-before dates

Five questions in the survey asked about consumption and disposal of leftovers and four about consuming or disposing of food before and after best-before dates. The most common practice that respondents follow *often or always* was eating leftovers as another meal without alteration (70%), followed by using leftovers as part of another meal (35%), giving leftovers away to other people (6%), feeding leftovers to animals (5%) and throwing out leftovers (11%) (see Figure 2). In addition, many respondents reported that they *often* or *always* eat everything before the best-before date (56%), smell or check if foods past their best-before dates are good (59%) or throw away food past the best-before date (47%). Fewer respondents (23%) *often* or *always* eat food anyway if it is past its best-before date.

With two exceptions, practices associated with consuming leftovers and food past the best-before date were not correlated with the amount of food wasted per person (Kruskal–Wallis: $p = 0.10$ to 0.91). The first exception was that households that *never or rarely* throw away leftovers wasted less food (0.93 kg/week/person) than those that reported *sometimes* (1.34 kg/week/person) and *often or always* (1.32 kg/week/person) (Kruskal–Wallis: $p = 0.03$). The second exception was that households that *never or rarely* throw away food past the best-before date leftovers wasted less food (0.70 kg/week/person) than those that reported *sometimes* (1.27 kg/week/person) and *often or always* (1.25 kg/week/person) (Kruskal–Wallis: $p < 0.01$). In other words, both H7 and H5 are supported for certain types of individual leftovers and best-before practices, but not for others.

Households with children appear to be more cautious with best-before dates and throw away food past the best-before date more often than households without children with marginal significance (Chi-squared: $p = 0.051$) and thus marginal support for H6.

4.6 Confirmatory factor analysis

A SEM was constructed for CFA between food waste, household food practices and socio-demographic characteristics. Three constructs were examined for inclusion in the model:

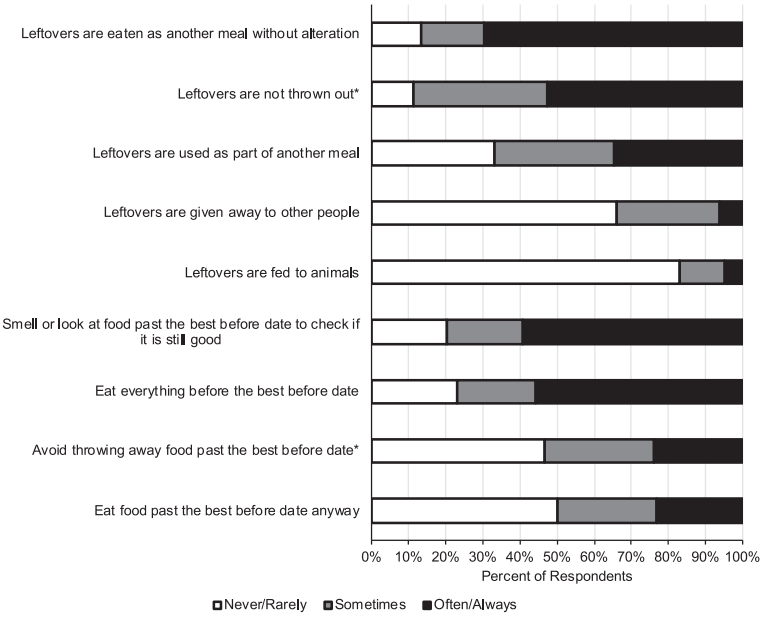

Figure 2.
Summary of survey responses related to management of leftovers and best before dates

planning, leftovers and best-before dates. Planning practices included meal planning and shopping practices. As noted earlier, elements of this construct have been employed in previous direct measurement studies (Moreno, 2019; van der Werf *et al.*, 2020) and were adapted for the current study by using the six indicator variables shown in Figure 3. Bulk purchasing was omitted from the construct because it has more of a savings rather than a planning focus. All of the variables from Moreno's (2019) four-variable construct were included and two were the same as those found in van der Werf *et al.*'s (2020) four-variable construct. Cronbach's alpha was 0.61 for the planning practices and therefore it was included as a construct.

For the management of leftovers, there are no examples of constructs in direct measurement studies but a self-assessment survey-based study (Stancu *et al.*, 2016) identified a leftover reuse construct that was significantly correlated with food waste and, as previously noted, Quested and Luzecka (2014) found that use of leftovers was related to household food waste. The first three leftovers indicator variables from Figure 2 were used to create a leftovers construct. The practices of feeding leftovers to animals and giving leftovers away to other people were excluded, since they were reported by so few respondents. However, since Cronbach's alpha for leftovers was only 0.38, the construct was not included in the SEM.

A third cluster of practices are those related to consuming and disposing of food before and after the best-before date. This finding of a bivariate relationship between food waste and throwing food waste out past the best-before date and findings from previous research about the significance of best-before dates (Quested and Luzecka 2014) suggested that the creation of best-before construct was warranted. The construct initially included the four best-before indicator variables shown in Figure 2. Cronbach's alpha was 0.58 for the best-before practices, which was slightly below the recommended threshold of 0.60. Upon assessing the results of the reliability analysis, the practice of eating everything before the best-before date

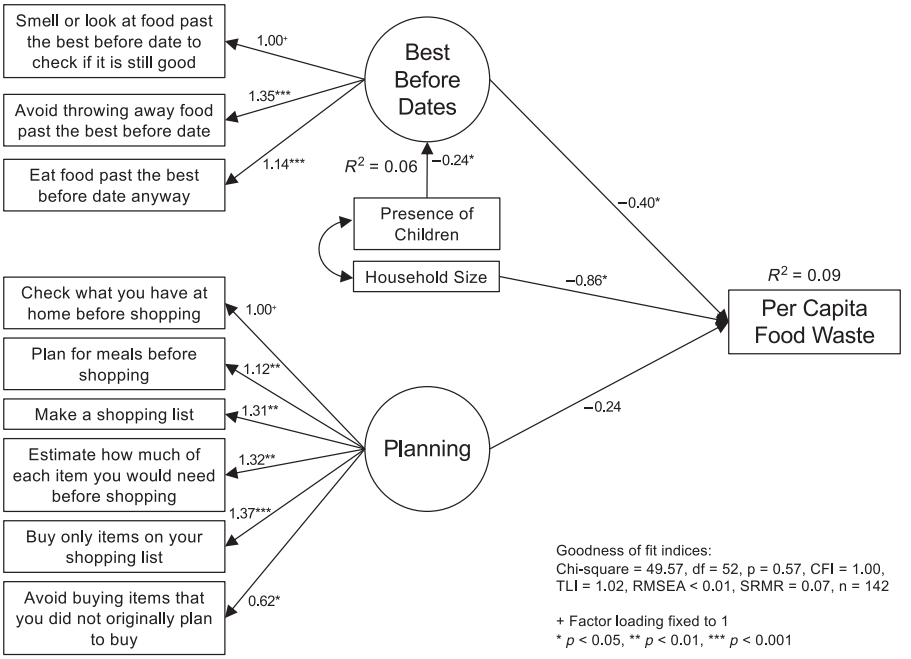

Figure 3.
Structural equation model between per capita food waste, household food practices and socio-demographic characteristics

did not align well with the scale. Cronbach's alpha increased to 0.76 with that practice dropped and therefore a best-before construct was added.

Household size was dummy coded with 0 as single-person households and 1 as multiple-person households. The planning construct, best-before construct and household size were linked with per capita food waste. The presence of children (dummy coded as 0 for households with no children and 1 as households with children) was connected with the best-before construct. Covariance between presence of children and household size was allowed. Although income was found in bivariate analysis to be marginally related to leftover use, it was not included in the model because of a sample size constraint. Only 91 respondents provided income data, meaning that the number of observations in the model would have been reduced by 35%.

The goodness-of-fit indices for the SEM were considered satisfactory. The construct reliability was above the 0.70 threshold for the best-before construct (0.89), but not for the planning construct (0.60). The average variance explained was above 0.50 for the best-before construct (0.52), but below for the planning construct (0.22).

The variance explained for per capita food waste was low ($R^2 = 0.09$). However, the model confirmed that the best-before construct ($p = 0.02$) and household size ($p = 0.02$) were significantly correlated with per capita food waste. The planning construct ($p = 0.38$) did not correlate with per capita food waste. The model also confirmed a significant correlation between presence of children and the best-before construct ($p = 0.01$). The identification of two constructs from the CFA and the significant relationship between one of these constructs and food waste partially supports hypothesis H8.

5. Discussion and conclusions

Like other direct measurement studies, this study found very few socio-demographic and practice variables to be related to household food waste in bivariate tests. Household size was one of the significant variables, being associated with a decrease in per capita food waste as household size increases, particularly for single-person households versus other household sizes. It is a variable that appears significant in numerous studies, whether the measurement of food waste is by means of waste composition data, as it was in this study, or from kitchen diaries and whether food waste includes or excludes beverages, as this study did. From a practice theory perspective, it may be more challenging for single-person households to consume food before it spoils due to the large pack sizes that are typically offered in retail settings (material) and they may not have the skills or knowledge in food storage or preservation to extend the shelf-life of food (competencies).

The only other significant variables in the bivariate analysis were competencies in two food waste disposal practices – not throwing out leftovers and not throwing out food past its best-before date. These were also significant in a previous direct measurement study by Quested and Luzecka (2014). Reasons for the paucity of bivariate relationships may lie in the complexity of relationships among drivers of food waste. In a qualitative study, Hebrok and Heidenstrøm (2019) found that while long-term meal planning is considered a desirable competency, it was actually detrimental for reducing food waste in that it reduced flexibility in the household to adapt to changing circumstances, such as an unanticipated night out. Evans (2011) too mentions how unexpected events can disrupt meal planning and argues that food wasting is often a result of households "negotiating the contingencies of everyday life".

Using a multivariate SEM with CFA, the question of the clustering of practices was examined via two constructs: planning and best-before dates. The CFA confirms that planning practices for reducing food waste such as meal planning and shopping practices are performed as a cluster of practices. However, they are not associated with less food waste, as determined previously by Moreno (2019) and van der Werf *et al.* (2020), using different

planning practice constructs. This contrasts with evidence about planning practices from self-assessment surveys that respondents employing clusters of practices perceive that they waste less food (e.g. van der Werf *et al.*, 2019; Stefan *et al.*, 2013).

The behaviour-outcome gap (Setti *et al.*, 2018) could be a possible reason for the lack of significance of competencies in the planning practices. Planning practices occur in the first phase of the household food waste cycle that ends with food disposal and encompasses storing, preparing and eating in between. Setti *et al.* (2018) argue that the time between shopping for items in the first phase and the outcome of disposing of food in the final phase represents a gap in which complex inter-related food behaviours can occur that raise uncertainty about the consequences of food choices for food wasting. Another consideration is unplanned purchases, driven by a retail environment that encourages impulse buying (a material element) and the desire of consumers to get the best value for their money (a meaning element). While use of planning practices was reported by a large number of respondents in this study, so were unplanned purchases. These conflicting practices further demonstrate the complexity of the drivers of household food wasting behaviours, as well as the importance of material elements such as the retail environment in contributing to food waste, and the influence of meaning elements such as wanting to get the best deal, despite best efforts at competencies such as planning. These findings indicate that the current design of household food waste interventions that emphasize the use of meal planning to reduce food waste need to be augmented with policies and interventions at the retail environment to mitigate competing goals such as taking advantage of sales. Actions such as phasing out "buy one get one free" offers in grocery stores in favour of individually priced packs can help consumers resist the temptation to overbuy; however, the success of such an intervention has not been evaluated (Aschemann-Witzel *et al.*, 2016).

The leftovers construct tested with the CFA failed the reliability test and was not included in the SEM. The CFA did identify a cluster of practices related to consuming food after its best-before date. The best-before construct had a significant negative correlation with food waste. These best-before competencies might be thought of as a line of defence against previous poor food choices, whereby a consumer may have made unplanned purchases or over-purchased but extends the life of those purchases by using best-before labels, a material element, as information about quality rather than as a directive for disposing of food. However, not all segments of the sample view best-before dates as a quality standard. Although food waste is not directly related to the presence of children in the home, there was an indirect relationship through the best-before construct. The relationship between having children in the home and the best-before construct is negative, meaning that households with children are more likely to use the best-before date as a directive to dispose, possibly because of concerns about safety. Literature around domestic provisioning and negotiating conflicting social anxieties (Watson and Meah, 2012) has found that parents are often faced with conflicting directions and compromises to ensure healthy foods for children and in domestic provisioning, a meaning element. The caution in handling items after their best-before dates for households with children is particularly important and understandable considering that children are seen as more vulnerable. Although another recent study of best-before dates found no relationship with children (Neff *et al.*, 2019), that study was based on a different measure, namely frequency of discarding food after its best-before date, rather than a cluster of measures. Therefore, it is important to consider not just the material and competency elements of best-before labels when planning interventions, such as label standardization and consumer education, but also the meaning element in understanding consumers' concerns and fears that may work against the gains in material and competency.

In conclusion, this paper adds to the evidence of how practices and socio-demographic factors relate to food waste based on a direct measurement study. Since household food waste accounts for nearly one-quarter of the food waste produced in Canada (Gooch *et al.*, 2019), it is

important to understand how much food is wasted and why it is wasted so that appropriate policies and interventions can be developed. Measuring food waste directly from households via a waste composition study is considered as one of the most accurate methods of quantification, as other methods such as kitchen diaries and surveys are known to under-report amounts (Quested *et al.*, 2020; Giordano *et al.*, 2018).

The practice theory concepts of material, competence and meaning and their interactions were found to be useful in analysing drivers of food waste. Two individual competencies, namely not throwing out leftovers and not throwing out food past the best-before date, were found to be correlated with food waste per capita. Meaning is intertwined with competency in practices related to best-before dates and in the relationship between the best-before construct and children in the home. Although the material infrastructure for shopping, namely types of stores where shopping takes place, was not related to food waste, stimuli within the retail environment were cited as the most frequent reasons for unplanned purchases and the best before label itself is a material nudge that shapes consumer behaviour.

Household size was the only one of three socio-demographic factors that directly correlated with food waste per capita and the relationship was negative. This finding of significance is consistent with the majority of the previous research on household size. The non-significant findings for income and presence of children in the home are also consistent with the majority of previous research. This study is the first to identify an indirect relationship between food waste and a socio-economic variable, specifically presence of children in the home. The relationship was mediated by a cluster of best-before competencies.

A confirmatory factor analysis identified constructs related to planning and best-before dates. Although the construct representing the planning cluster of practices did not correlate with food waste, which may be due to conflicting practices such as unplanned purchases, the best-before dates construct demonstrated a significant negative correlation. This is the first study to show that practices around best-before dates are performed as a cluster and that the construct itself has a significant relationship with food waste. This study provides evidence to support calls by researchers and organizations for improved messaging and standardization of the wording of best-before dates (Aschemann-Witzel, 2016; National Zero Waste Council, 2018; Neff *et al.*, 2019), which could be enacted through revising date-labelling policies and consumer interventions to reduce confusion on the interpretation of date labels. Messaging should focus particularly on households with children, which appear to have the highest level of concern about best-before dates.

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