Fall 2019

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The Canadian Geographer
Le Géographe canadien
Canadian Association of Geographers
Association Canadienne des Géographes

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Key Messages

- Respondent households threw out food 4.77 times/week and 5.89 food portions/week.
- Reducing monetary impact of food waste was identified as the most selected food waste reduction motivator.
- Perceived behavioural control was identified as an important determinant of food wasting behaviour.

To better understand food wasting behaviour, the theory of planned behaviour was used to inform the development of a survey which was administered to households in London, Ontario, Canada. Respondent households ($n = 1,263$) threw out avoidable food waste 4.77 times/week ($SD = 4.81$, $Mdn = 4.0$) and 5.89 food portions/week ($SD = 5.66$, $Mdn = 4.0$). When asked to choose one of three possible motivators to reduce food wasting behaviour, 58.9% selected reducing monetary loss as their first choice and this was significantly ($p < 0.001$) higher than both reducing environmental impact (23.9%) and reducing social impacts (17.2%). A linear hierarchical regression analysis ($R^2 = 0.30$, $p < 0.001$) on intention to avoid food waste demonstrated that perceived behavioural control ($p < 0.001$) and personal norms ($p < 0.001$) had the greatest positive impact on intention. A linear hierarchical regression analysis ($R^2 = 0.32$, $p < 0.001$) on self-reported food wasting behaviour showed that perceived behavioural control ($p < 0.001$) and personal attitudes ($p < 0.01$) resulted in less food wasting behaviour, while more children in a household ($p < 0.01$) resulted in more food wasting behaviour. Interventions that seek to strengthen perceived behavioural control and convey the monetary impact of food waste could help reduce its disposal.

Keywords: household food waste, theory of planned behaviour, household survey, perceived behavioural control

De la nourriture inutile : utiliser la théorie du comportement axé sur un objectif pour mieux comprendre le gaspillage de nourriture au sein des ménages

Pour mieux comprendre le phénomène de gaspillage de nourriture, nous avons utilisé la théorie du comportement axé sur un objectif pour concevoir une enquête qui a été réalisée auprès de ménages à London, en Ontario, Canada. Les ménages répondants ($n = 1,263$) jetaient des déchets de cuisine évitables 4.77 fois/semaine ($SD = 4.81$, $Mdn = 4.0$) et 5.89 portions de nourriture/semaine ($SD = 5.66$, $Mdn = 4.0$).

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The Canadian Geographer / Le Géographe canadien 2019, 63(3): 478–493
DOI: 10.1111/cag.12519

Lorsqu'on leur a demandé de choisir l'un des trois éléments de motivation possibles pour diminuer le gaspillage de nourriture, 58.9% ont choisi l'aspect financier comme premier choix, ce qui était sensiblement ($p < 0.001$) plus élevé que l'impact environnemental (23.9%) et les impacts sociaux (17.2%). Une analyse linéaire avec régression hiérarchique ($R^2 = 0.30$, $p < 0.001$) de l'attitude envers le gaspillage de nourriture a démontré que le contrôle comportemental perçu ($p < 0.001$) et les normes personnelles ($p < 0.001$) avaient une forte influence. En effet, une analyse linéaire avec régression hiérarchique ($R^2 = 0.32$, $p < 0.001$) du gaspillage de nourriture déclaré par les répondants a montré que le contrôle comportemental perçu ($p < 0.001$) et les attitudes personnelles ($p < 0.01$) entraînaient une diminution du gaspillage de nourriture, alors qu'un plus grand nombre d'enfants dans un ménage ($p < 0.01$) entraînait une augmentation du gaspillage de nourriture. Conséquemment, les interventions visant à renforcer le contrôle comportemental perçu et à faire connaître les impacts financiers du gaspillage de nourriture pourraient contribuer à la diminution de la quantité de nourriture jetée.

Mots clés : gaspillage de nourriture des ménages, théorie du comportement axé sur un objectif, enquête auprès des ménages, contrôle comportemental perçu

Introduction

An unintended consequence of our biological necessity to procure, prepare, and eat food to survive is that a portion of food intended for consumption becomes waste. Food waste represents lost utility and food management inefficiency, which is manifest in negative economic, environmental, and social impacts. Obversely, ameliorating this inefficiency can convert these impacts into possible societal benefits. In a systematic review of food waste quantification, van der Werf and Gilliland (2017) reported that food waste generation across the food supply chain of developed countries was, on average, 198.9 kg/capita/year and that each member of North American households generate an average of 160.0 kg/capita/year. Changing this human behaviour has recently become an area of significant academic and societal interest, with research focused on improving food waste measurement and better understanding why food is wasted, particularly at the household level.

Households represent the endpoint of the profit-driven food supply chain and present a complex set of food management behaviours. A better understanding of these behaviours can be used to help maximize efficiency of household food management and reduce food waste. Research to date has identified food literacy and socio-demographic factors as key behavioural determinants of household food waste generation.

Behavioural determinants of household food waste generation

Poor food literacy. People throw out food when it has spoiled or is otherwise unappealing (Williams et al. 2012; Halloran et al. 2014; WRAP 2014; Thyberg et al. 2015). This is an outcome of poor food literacy, which can be defined as a lack of knowledge, skills, and behaviours related to food provisioning (plan, manage, select), preparation, and eating (Vidgen and Gallegos 2014). For instance, many households inadequately plan meals (with regard to food provisioning) and grocery shopping (BIO Intelligence Service 2011; WRAP 2011; BCFN 2012; Romani et al. 2018). This poor planning can lead to the over-purchase, over-preparation, and over-serving of food (Munro and Marshall 1995; Pearson et al. 2013; WRAP 2014; Porpino 2016). At the retail level, households can inadvertently purchase packages containing too much food (so that some of it spoils) or from which it is difficult to extract food, ultimately leading to food waste generation (WRAP 2007b; Bolton 2012; Halloran et al. 2014; Göbel et al. 2015). Further, after food purchase, not knowing how and where (e.g., counter, fridge, freezer) to store food can lead to its premature spoilage and wastage (Göbel et al. 2015; Jorissen et al. 2015; Principato et al. 2015). Finally, some people have particular dietary habits that result in food waste, such as aversion to leftovers, intolerances for certain elements of a

set meal, or, as is often the case for children, general fussiness (Evans 2012; Neff 2015; Porpino 2016).

There is considerable confusion regarding food labelling. If consumers do not understand the meaning of food labels such as "best before" and "use by" dates, they tend to err on the side of caution, throwing away food before it is unsafe to eat (Pearson et al. 2013; Aschemann-Witzel et al. 2015). Consumers can be overly sensitive to high health-risk foods, such as fresh meats, and they often discard them before their "use by" date (Evans 2011; FUSIONS 2014; Porpino 2016).

Socio–demographic factors. Socio-demographic factors are key determinants of household food wasting behaviour. Gender may be a determinant of food waste generation (Koivupuro et al. 2012; Secondi et al. 2015), with males generally wasting more food than females. Age appears to be a strong determinant of food waste generation; children tend to waste more and seniors tend to waste less food (Quested et al. 2013; Melbye et al. 2016). Age also determines many responsibilities in the household, such as grocery shopping and meal preparation. Further, older people seem to be more food-literate from informal and formal food management and cooking education received during their formative years (Quested et al. 2013).

Household composition (size and type) is another strong food waste determinant (Koivupuro et al. 2012; Parizeau et al. 2015; Tucker and Farrelly 2016; Visschers et al. 2016). Not surprisingly, larger households, which often include children, generate more total food waste. However, smaller households appear to waste more food per capita than larger households. Household income may have some impact on food waste generation, although results have been inconsistent (Van Garde and Woodburn 1987; Graham-Rowe et al. 2014; Jorissen et al. 2015; Neff 2015).

Modelling household food wasting behaviour using the theory of planned behaviour

The theory of planned behaviour (TPB), which is designed to "predict and explain human behaviour in specific contexts" (Ajzen 1991, 181) has been used to model household food wasting behaviour (Stefan et al. 2013; Stancu et al. 2016; Visschers et al. 2016). The TPB posits that, if volitional, "people's intentions and behaviours follow reasonably and consistently from their beliefs no matter how these beliefs were formed" (Ajzen 2015, 127). A key premise is that volitional behaviour is largely predicated on one's intention to perform a given behaviour, and that one's intention embodies an individual's motivation and the amount of effort they are willing to expend to effect a particular behaviour (Ajzen 1991). The TPB further posits that there are three conceptually independent antecedents or determinants of intention. The strength of each of these antecedents coalesces into part of a person's intention to perform a certain behaviour.

Attitude is informed by a person's favourable or unfavourable opinion about a given behaviour and is really a mindset. In the case of wasting food, it is about whether people think it is an important issue, worthy of reduction efforts. It appears to be one of the strongest determinants identified in the literature, whether that be in the context of the TPB (Graham-Rowe et al. 2015; Visschers et al. 2016) or through other research (Brennan 2007; Baker et al. 2009; Koivupuro et al. 2012; Abeliotis 2014; Secondi et al. 2015; Thyberg et al. 2015). Studies suggest that consumers feel "bad" and are concerned about throwing away food, and this informs a negative attitude towards this behaviour (Evans 2012; Watson and Meah 2012; Abeliotis 2014).

Subjective norms refer to the social pressure a person feels to complete (or not complete) a given behaviour. That is, people's behaviours can potentially be influenced by society's expected behaviour, whether in the context of TPB (Graham-Rowe et al. 2015) or otherwise (Cappellini 2009; Cappellini and Parsons 2012; Bernstad 2014). This can extend to personal norms, or expectations people hold for themselves, and can be driven by moral values (WRAP 2011; Watson and Meah 2012; Principato et al. 2015; Secondi et al. 2015) or guilt (Watson and Meah 2012; Quested et al. 2013; Graham-Rowe et al. 2014; Parizeau et al. 2015), environmental and civic concerns (Williams et al. 2012; Principato et al. 2015; Melbye et al. 2016), or anticipated regret (Graham-Rowe et al. 2015). However, the wasting of food is a behaviour that is generally only seen by the generator, and Graham-Rowe et al. (2014) and Stefan et al. (2013) reported that subjective norms were unrelated to food wasting behaviour and only modestly influenced intention.

Finally, people's perceived behavioural control, or their belief in their ability to behave one way or

another, is a TPB antecedent that may influence food wasting intention and behaviour (Stefan et al. 2013; Graham-Rowe et al. 2015; Stancu et al. 2016; Visschers et al. 2016). Perceived behavioural control has impacts on intention related to situations such as the conflict between food provisioning and fussy eaters, unexpected meals outside the home, and large food packaging sizes (Evans 2012; Williams et al. 2012). The amount of this perceived behavioural control has ancillary impacts on the intention to reduce food waste (Graham-Rowe et al. 2014) and greater impacts on planning or shopping for food (Stefan et al. 2013).

Researchers have added other possible behavioural antecedents to the TPB model, such as self-identity (Aschemann-Witzel et al. 2015; Graham-Rowe et al. 2015), which can be viewed as "the extent to which the individual sees him/herself as the sort of person who would be willing to engage in the behaviour in question" (Graham-Rowe et al. 2015, 195); personal norms, a measure of personal morality (Visschers et al. 2016); the good provider identity, which can be manifest by needing to have plenty of food on hand for various expected and unexpected situations (Evans 2011; Graham-Rowe et al. 2014; Visschers et al. 2016); and household planning habits (Visschers et al. 2016).

Notwithstanding, there are some limitations and criticisms of the TPB model. Quested et al. (2013) noted that it is challenging to apply behavioural models, such as the TPB, to the wasting of food because it emanates from "multiple behaviours" rather than a single behaviour. Further, a prevailing criticism is that its determinants only deal with rational behaviour and do not fully consider irrational or non-cognitive determinants (Russell et al. 2017). There is, as Russell et al. (2017) points out, an "automaticity" to food wasting that is irrational behaviour, manifest as habit.

Study rationale and objectives

The rationale of our study was to build on existing research and expand our understanding of food wasting behaviour in a North American context, where little such research has been undertaken. We focused on avoidable food waste (WRAP 2009), that is food that was at one point edible (e.g., an apple, slice of bread), and which is henceforth referred to as food waste. The primary objective of this study was to model household food wasting behaviour in the city of London, Ontario using the TPB and other determinants. To meet this objective, we used a survey to measure: household food wasting behavioural determinants; self-reported weekly frequency and portions of food waste for six food types; the reasons why each food type was wasted; and the rank households assign to food waste reduction motivators. Additionally, we explicitly replicated the approach used in a study of household food wasting in Switzerland by Visschers et al. (2016), to facilitate comparison of findings from two contrasting geographical contexts.

We hypothesized that the results of behavioural antecedents and determinants would be similar in a North American city and Switzerland (Hypothesis 1), but, based on data presented in van der Werf and Gilliland (2017), that self-reported food wasting quantities would be higher in the North American city (Hypothesis 2). As noted in Visschers et al. (2016), even though respondents reported throwing out an average of 5.33 ($SD = 15.40$, $Mdn = 1.09$) portions of food per week, respondent intention to not waste food was very high and was deemed the most important predictor of self-reported food waste. On that basis, we hypothesized that intention to not waste food would be the most important predictor of self-reported food wasting behaviour (Hypothesis 3). Visschers et al. (2016) reported that financial attitudes positively and significantly impacted the intention not to waste food and negatively and significantly impacted self-reported food waste; we therefore also hypothesized that reducing monetary impacts would be the predominant food waste reduction motivator among our survey respondents in London (Hypothesis 4).

Methodology

Research was undertaken in London, Ontario, a mid-sized Canadian city of approximately 390,000 inhabitants, which was selected because they were considering how best to deal with their residential food wastes. London has a six-business day curbside waste collection system for single family households that includes garbage and recyclables. Waste collection, disposal, and diversion are undertaken by a combination of municipal and contracted private sector teams. There is currently no curbside program to separately remove food wastes (unlike most large Ontario, Canada cities), although approximately 60,000 backyard composters have been

distributed throughout the city in the last 25 years (J. Stanford, pers. comm., May 15, 2017).

Survey design

Using TPB as a conceptual framework (Ajzen 1991), we developed a survey with 71 items, including questions from previously validated and well-used household/consumer food waste surveys, primarily from Visschers et al. (2016) but also from WRAP (2007a) and Stancu et al. (2016). The survey was administered online using Qualtrics survey software.

The survey introduction collected socio-demographic information (e.g., age, housing tenure, employment status, household income) and respondent responsibility related to food shopping and food preparation, adapted from WRAP (2007a), as well as for taking out waste and recycling on waste collection day. A question on the frequency of backyard composter usage was used as a proxy for pro-environmental behaviour.

Using an approach similar to Visschers et al. (2016), respondents were asked to self-report the estimated frequency and portions (i.e., handfuls) of edible (i.e., avoidable) food waste thrown out for any reason over the past week, by six food types: bread and baked goods, meat and fish, dairy, fruit and vegetables, dried food, and other food. Respondents could select from eight options (0, 1, 2, 3, 4, 5, 6, 7+ times per week). A follow-up question asked respondents to provide the most common reason their household throws out food (e.g., purchased too much) for each of the six food types. A second follow-up question asked respondents to rank three possible food waste reduction motivators: reduce amount of money wasted; reduce environmental impact of wasting food (e.g., climate change); and reduce social impact of wasting food (e.g., hunger).

The remainder of the survey used the TPB model (Ajzen 1991, 2015) to ask questions about food wasting intentions; intention's antecedents including attitudes (personal attitudes, financial attitudes, environmental attitudes, perceived health risk); subjective norms and perceived behavioural control; and non-TPB food wasting determinants including personal norms, good provider identity, and household planning habits (Figure 1). Questions about food wasting intentions, its antecedents and other possible determinants, except for environmental attitudes, were directly adapted from Visschers et al. (2016). A 7-point Likert scale was used, with higher scores representing greater agreement with a given question. These questions are included in the Appendix (Table A.1).

Survey dissemination and sample

An online Household Food Waste Survey was available for completion between May 23 and July 8, 2017. An accompanying letter of information and consent explaining the study was also provided. An opportunistic survey approach and concomitant comprehensive survey dissemination strategy were deployed to inform the entire city about this survey and encourage city-wide responses. This differed from Visschers et al. (2016) who sent their survey to randomly selected households. Various efforts were made to disseminate information about the survey as widely as possible to give all households the opportunity to respond. A print and digital flyer served as the key vehicle to present uniform information to potential respondents. It included a call to action and directed respondents to a website where they could complete the survey. An extensive social media campaign was launched that included sustained dissemination via the City of London's and authors' various social media platforms including Facebook, Twitter, and Instagram. A terrestrial media campaign included print and radio advertisements. Email contact was made to the chairpersons of all community associations within the city ($n = 25$) with a request to distribute survey information to their members via email or their social media platforms. Survey information (>500 flyers) was also distributed at various neighbourhood festivals and events throughout the city. The authors tracked and mapped survey responses across the city on a weekly basis, and this resulted in hand delivery of flyers in underrepresented areas across the City (ca. 1,000 flyers).

Survey respondent inclusion criteria included: 1) London households only, assessed by postal code; and 2) respondent completed the survey as presented in Qualtrics survey response output. This resulted in n=1,263 survey responses. The socio-demographic profile of the survey respondents and the City of London census metropolitan area (CMA) (Statistics Canada 2017) population average is presented in the Appendix (Table A.2). Respondents were largely female, with few children, employed, and living in a detached or semi-detached house. Survey respondents included more women and were

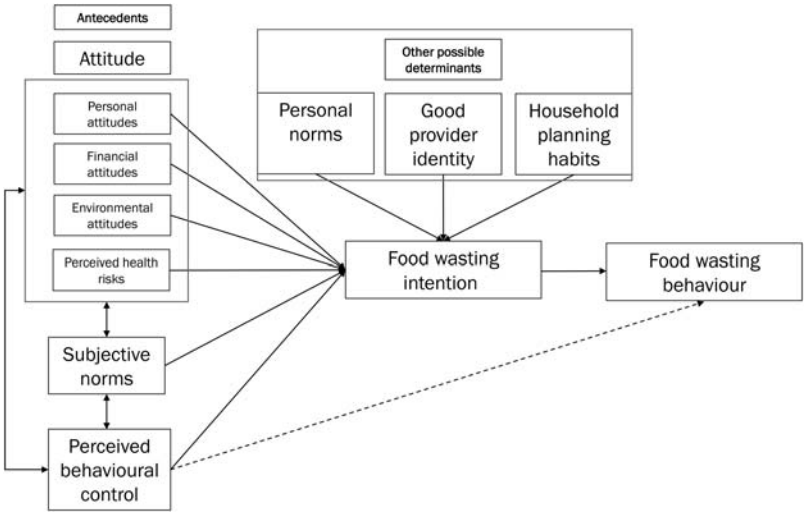

Figure 1
Theory of planned behaviour and other possible determinants model. SOURCES: Ajzen 1991; Visschers et al. 2016

younger than the population average. Further, our respondents included more two- to four-person households and fewer one-person households; more people living in detached or semi-detached homes and fewer in apartments; and fewer low-income households and slightly more households from all other income brackets, except greater than $100,000 households, when compared to census data (Statistics Canada 2017).

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 25. The mean, standard deviation, and interquartile range (IQR) were calculated for self-reported food wasting frequency and portions, by food type and by the total amount of food. Response scores per psychological construct were summed into a single index. For instance, the responses to the four questions on intention to avoid food waste were summed into a single intention index (Table A.1). Cronbach's alpha was used to measure the internal reliability of the scales that were used to assess the psychological constructs of intention, attitudes, subjective norms, perceived behavioural control, personal norms, good provider identity, and household planning habits. If the internal reliability was greater than 0.6 (i.e., reasonable), the mean was calculated and used in subsequent analyses.

The Spearman rank correlation coefficient was used to assess the bivariate strength and direction of the association between psychological constructs and total food wasting frequency. Per Cohen et al. (2014), correlations are small (>0.1), medium (>0.3), or large (>0.5). The Friedman's test was used to assess differences in the medians of the ordinal variable food waste reduction motivators rank (i.e., 1–3). The Wilcoxon test for two related samples was used to determine the location of any significant rank differences. Two-step multiple regression models were developed to assess the relative effects of various predictors (i.e., Step 1 socio-demographic factors, Step 2 psychological factors) on intention to avoid food waste and perceived behavioural control. The same approach was used for the frequency of food wasting behaviour, except that a Step 3 was added to the model and this included the non-TPB psychological constructs (personal norms, good provider identity, and household planning habits). A two-sided p-value <0.05 was considered statistically significant.

With 21 variables of interest (Visschers et al. 2016), 80% statistical power, and assuming medium effect sizes and our interest in beta weights, a sample size of 125 was needed for our multiple regression analysis (Green 1991).

Table 1
Self-reported frequency and portions of food wasted, by food type (n = 1,263).

	Frequency/ household/week					Portions/ household/week				
	M	SD	Mdn	IQR	Households reporting no food waste	M	SD	Mdn	IQR	Spearman rank correlations
Bread and baked goods	0.79	1.09	0.00	1.00	636	1.17	1.64	1.00	2.00	0.83
Meat and fish	0.63	1.07	0.00	1.00	787	0.76	1.22	0.00	1.00	0.85
Dairy (e.g., milk, cheese, and yoghurt)	0.51	0.92	0.00	1.00	840	0.72	1.28	0.00	1.00	0.84
Fruit and vegetables	1.58	1.49	1.00	2.00	324	1.91	1.85	2.00	3.00	0.78
Dried food (e.g., cereal)	0.33	0.86	0.00	0.00	1,023	0.38	1.00	0.00	0.00	0.80
Other food	0.95	1.27	1.00	2.00	620	1.01	1.44	0.00	2.00	0.83
Total	4.77	4.81	4.00	4.00	139	5.89	5.66	4.00	6.00	0.85

Results

Descriptive results

As depicted in Table 1, households reported that they threw out food waste a mean of 4.77 times (SD = 4.81) and 5.89 portions (SD = 5.66) in the week prior to completing the survey. The frequency and portions of food wasted were strongly correlated by food type ($r_s = 0.78–0.85$) and overall ($r_s = 0.85$). Fruits and vegetables, followed by other food and bread and baked goods were the most common foods thrown out, with dried food the least common. Approximately 11% of households reported throwing out no food waste and this ranged from 25.7% for fruit and vegetables to 81.0% for dried food.

Survey respondents reported on why different food types were thrown out (Table 2). Buying too much was the leading reason for bread and baked goods, dairy, fruit and vegetables, and other food, while for meat and fish it was because it was past its best before date, and for dried food because it was spoiled. The mean was calculated across all food types and showed that the primary reasons for throwing out food were from buying too much, food spoilage, and food that is past its best before date. The amount of food never thrown out ranged from 13.7% for fruit and vegetables to 60.3% for dried food.

Survey respondents were asked to rank three possible food waste reduction motivators. Reducing the amount of money wasted (n = 723, 58.9%)

Table 2
Reasons why various food types were thrown out (%).

		Reason					
	n	Bought too much	Spoiled	Past best before	Left over/made too much	Other	Never throw out
Bread and baked goods	1,253	52.9	8.9	4.2	6.2	4.2	23.6
Meat and fish	1,241	23.5	8.4	26.3	5.6	1.7	34.5
Dairy	1,249	37.0	24.5	2.1	3.8	1.5	31.1
Fruit and vegetables	1,250	69.0	1.8	3.0	4.6	8.0	13.7
Dried food	1,239	10.0	13.9	5.3	8.1	2.4	60.3
Other food	1,216	23.4	11.4	15.4	12.8	3.5	33.6
M		36.0	11.5	9.4	6.9	3.6	32.8
SD		21.8	7.6	9.6	3.3	2.4	15.6

appeared to be the key motivator and this was significantly higher ($p < 0.001$) than reducing both environmental ($n = 294$, 23.9%) and social ($n = 211$, 17.2%) impacts. Reducing environmental impact was significantly higher than reducing social impacts.

Using a 7-point Likert scale, survey respondents indicated a high intention to not waste food (Table A.1). Further, they had moderate-high negative attitudes about wasting food, from personal, financial, and environmental perspectives with their subjective norms also opposed to wasting food. Respondents did not appear overly concerned about or perceive health risks from eating leftovers or foods past their best before dates. Respondents perceived that they had a moderate level of control over food wasting in their households. The respondents had average household planning habits, in terms of planning meals, making grocery lists, and sticking to them.

There were many significant bivariate Spearman rank correlations between self-reported food wasting frequency and the TPB, and other psychological constructs included in our survey (Table 3). In particular, the frequency of food wasting was strongly and negatively correlated with perceived behavioural control and intention to avoid food waste. Intention had a strong positive correlation with perceived behavioural control and personal norms. Perceived behavioural control was also moderately and positively correlated with subjective norms, personal norms, the good provider identity, and household planning habits.

Multiple linear regression

Model 1 of the linear regression on intention to avoid food waste resulted in a low model fit and showed that older age and backyard composter usage had a positive and significant impact on the intention to not waste food, while income had a negative and significant impact (Table 4). The addition of TPB and non-TPB constructs, as part of Model 2, improved model fit considerably. In particular, greater perceived behavioural control, stronger personal norms, and household planning habits were positively associated with intention. Age, while still significantly related to intention, was a more moderately related variable, as were personal attitudes, financial attitudes (positive), and perceived health risks (negative). Backyard composter usage was no longer significantly related to intention. The Model 2 explained variance was considerably higher than that of Model 1 ($R^2 = 0.30$ vs. $R^2 = 0.04$).

The Model 1 results of the linear regression on perceived behavioural control resulted in a low model fit and showed that older age, backyard composter use, and respondent responsibility for food purchase had a positive and significant impact, and the number of people in a household and higher income had a negative and significant impact on perceived behavioural control (Table 5). As with intention, the addition of TPB and non-TPB constructs, as part of Model 2, improved model fit considerably. In particular, subjective norms, intention, and personal norms had the strongest significant positive impact, while the good provider identity, perceived health risks, and number of people in a household had a significant negative impact on perceived behavioural control. The Model 2 explained variance was considerably higher than that of Model 1 ($R^2 = 0.44$ vs. $R^2 = 0.13$, respectively).

The Model 1 results of the linear regression on self-reported household food wasting frequency show that a lower age, a greater number of people in the household, a greater number of children in the household, not using a backyard composter, and to a lesser extent housing type (i.e., townhouses significantly greater than apartments and other housing) and income, were significantly related to more self-reported food wasting (Table 6). Model 2, which included TPB constructs, considerably improved the model's fit and increased the explained variance ($R^2 = 0.32$ vs. $R^2 = 0.14$, respectively). Perceived behavioural control and more positive personal attitudes were significantly and negatively related, and the number of children and environmental attitudes were positively associated with food wasting frequency. Non-TPB constructs and intention were added in Model 3 but did not change the model's explained variance. Intention was negatively related, while backyard composter use was no longer significantly related to food wasting frequency.

Discussion

We were able to meet our objectives by successfully replicating a methodology very similar to that by Visschers et al. (2016) to model household food

Table 3
Spearman rank correlations between psychological constructs related to household food waste (n = 1,263).

		1	2	3	4	5	6	7	8	9	10	11
1	Frequency of food wasting per household	1										
2	Intention to avoid food waste	−.509**	1									
3	Personal attitudes	−.371**	.486**	1								
4	Financial attitudes	−.131**	.270**	.294**	1							
5	Environmental attitudes	−.063*	.224**	.308**	.244**	1						
6	Perceived health risks	.289**	−.297**	−.226**	−.070*	−.132**	1					
7	Perceived behavioural control	−.566**	.566**	.382**	.146**	.186**	−.274**	1				
8	Subjective norms	−.217**	.224**	.111**	.121**	.064*	−.138**	.394**	1			
9	Personal norms	−.359**	.536**	.643**	.358**	.337**	−.266**	.390**	.126**	1		
10	Good provider identity	.236**	−.225**	−.061*	−.070*	−.120**	.168**	−.331**	−.161**	−.108**	1	
11	Household planning habits	−.220**	.355**	.328**	.183**	.171**	−.077**	.311**	.115**	.329**	−.114**	1

*$p < .05$, **$p < .01$.

wasting behaviour in London, Ontario. In the following sections we discuss and compare our results with studies by Visschers et al. (2016) and other researchers to identify how to strengthen the use of the TPB to measure household food wasting behaviours and which psychological construct(s) should be considered when developing food waste reduction interventions. We explore the TPB intention-behaviour relationship and whether perceived behavioural control is better suited to be the key predictor of food wasting behaviour.

Comparison of food waste predictors with Visschers et al. (2016)

The amount of self-reported food waste portions in our findings (Table 1) was marginally higher than in Visschers et al. (2016), confirming Hypothesis 2. The mean of many psychological constructs including intention, personal attitudes, perceived health risk, perceived behavioural control, social norms, and personal norms were higher in Visschers et al., suggesting more strongly held views than in our findings (Appendix; Table A.3). Conversely, mean survey responses in our study were higher for financial attitudes and marginally higher for good provider identity and household planning habits. However, the rank of the various common constructs, including high-ranking ones such as intention, personal norms, and social norms were quite similar, while low-ranking ones, including good provider identity, household planning habits, and perceived health risks, were identical. The key difference was personal attitudes, which had a higher mean and ranked much higher in Visschers et al., while financial attitudes had a higher mean and ranked higher in our findings. The foregoing suggests that while the means were different, relative respondent opinions were similar between the two studies, confirming Hypothesis 1.

Comparing bivariate relationships between self-reported food wasting behaviour and psychological constructs, we found the same four constructs (intention, personal norms, personal attitude, perceived behavioural control) had significant negative moderate-to-strong relationships, as in the study by Visschers et al. (2016). Nevertheless, our findings diverged somewhat from those of Visschers et al., with the strongest relationships being between perceived behavioural control and closely after that intention, rather than the other way around. Our findings indicate that perceived behavioural control may be as strong a predictor as intention, if not stronger.

The results of regression analyses were also compared with Visschers et al. (2016). Socio-demographic variables had a modest impact on the intention to not waste food, in both studies. These variables offered more robust predictive capacity for food wasting behaviour in Visschers et al.'s study than in our findings, with age, gender, and education having significant impacts, although children in the household was a common and significant positive predictor in both studies. For intention to not waste food, the three highest significant predictors in both studies included

Table 4
Hierarchical linear regression analysis on intention to avoid household food waste.

	Model 1			Model 2		
	B	SE	β	B	SE	β
(Constant)	22.778	0.854		8.751	1.53	
Age	0.587	0.134	0.16***	0.238	0.124	0.065*
Housing tenure	−0.14	0.238	−0.021	−0.104	0.217	−0.016
Number in household	0.157	0.205	0.036	0.206	0.184	0.047
Number of children in household	−0.433	0.256	−0.077	−0.153	0.225	−0.028
Employment status	−0.034	0.148	−0.007	−0.106	0.132	−0.024
Income	−0.333	0.113	−0.094**	−0.022	0.104	−0.006
Backyard composter use	0.343	0.099	0.103**	0.01	0.091	0.003
Personal attitudes				0.097	0.047	0.073*
Financial attitudes				0.073	0.034	0.062*
Environmental attitudes				0.022	0.056	0.011
Perceived health risks				−0.093	0.029	−0.085**
Perceived behavioural control				0.178	0.027	0.218***
Subjective norms				0.024	0.049	0.013
Personal norms				0.24	0.04	0.218***
Good provider identity				−0.023	0.025	−0.025
Household planning habits				0.133	0.027	0.139***
Model statistics	$R^2 = 0.04$, F (7,1187) = 8.86, $p < 0.001$			$R^2 = 0.30$, F (16,1072) = 29.89, $p < 0.001$		

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 5
Hierarchical linear regression analysis on perceived behavioural control to avoid household food waste.

	Model 1			Model 2		
	B	SE	β	B	SE	β
(Constant)	26.426	3.761		11.876	3.42	
Age	0.777	0.159	0.174***	0.428	0.137	0.096***
Housing tenure	0.128	0.278	0.016	0.023	0.239	0.003
Number in household	−0.717	0.259	−0.134**	−0.517	0.219	−0.097*
Number of children in household	−0.424	0.31	−0.062	−0.402	0.259	−0.06
Employment status	0.298	0.172	0.054	0.349	0.145	0.064*
Income	−0.283	0.132	−0.065*	−0.053	0.115	−0.012
Responsibility for food shopping	0.588	0.252	0.088*	0.283	0.21	0.043
Responsibility for food preparation	−0.293	0.254	−0.045	−0.086	0.212	−0.013
Responsibility for waste management	−0.176	0.159	−0.033	−0.166	0.132	−0.031
Back yard composter use	0.741	0.115	0.184***	0.357	0.099	0.089***
Intention				0.215	0.033	0.176***
Personal attitudes				0.163	0.051	0.1***
Financial attitudes				−0.052	0.038	−0.036
Environmental attitudes				0.111	0.061	0.044
Perceived health risks				−0.124	0.032	−0.093***
Subjective norms				0.565	0.051	0.261***
Personal norms				0.11	0.044	0.081*
Good provider identity				−0.248	0.027	−0.22***
Household planning habits				0.112	0.03	0.095***
Model statistics	$R^2 = 0.13$, F (10,1173) = 19.04, $p < 0.001$			$R^2 = 0.44$, F (19,1069) = 45.18, $p < 0.001$		

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 6
Hierarchical linear regression analysis on self-reported household food wasting frequency.

	Model 1			Model 2			Model 3		
	B	SE	β	B	SE	β	B	SE	β
(Constant)	5.919	2.805		12.909	2.819		12.973	2.911	
Gender	−0.684	0.373	−0.055	−0.597	0.351	−0.048	−0.537	0.359	−0.043
Age	−0.457	0.118	−0.138***	−0.121	0.113	−0.036	−0.11	0.116	−0.032
Housing type	0.438	0.222	0.057*	0.518	0.209	0.066*	0.517	0.211	0.066*
Housing tenure	−0.226	0.213	−0.038	−0.225	0.202	−0.037	−0.22	0.205	−0.036
Number in household	0.417	0.197	0.105*	0.242	0.185	0.06	0.281	0.187	0.069
Number of children in household	0.826	0.234	0.162***	0.71	0.217	0.139**	0.683	0.219	0.134**
Employment status	0.073	0.129	0.018	0.177	0.12	0.043	0.182	0.123	0.044
Income	0.291	0.1	0.09**	0.114	0.097	0.035	0.098	0.098	0.03
Backyard composter use	−0.422	0.086	−0.141***	−0.165	0.083	−0.055*	−0.159	0.084	−0.052
Responsibility for food preparation	−0.064	0.156	−0.013	−0.072	0.144	−0.015	−0.064	0.147	−0.013
Responsibility for waste management	−0.018	0.127	−0.005	−0.041	0.117	−0.01	−0.035	0.119	−0.009
Personal attitudes				−0.158	0.043	−0.128***	−0.15	0.044	−0.121**
Financial attitudes				−0.01	0.031	−0.009	−0.002	0.032	−0.002
Environmental attitudes				0.156	0.051	0.083**	0.161	0.052	0.084**
Perceived health risks				0.083	0.027	0.083**	0.074	0.027	0.073**
Perceived behavioural control				−0.266	0.024	−0.353***	−0.247	0.026	−0.325***
Social norms				0.011	0.045	0.007	0.017	0.046	0.01
Personal norms				−0.051	0.036	−0.05	−0.03	0.038	−0.029
Intention							−0.091	0.029	−0.096**
Good provider identity							0.017	0.024	0.02
Household planning habits							0.009	0.025	0.01
Model statistics	$R^2 = 0.14$, F (11,1147) = 18.02, $p < 0.001$			$R^2 = 0.32$, F (18,1052) = 28.43, $p < 0.001$			$R^2 = 0.32$, F (21,1033) = 24.63, $p < 0.001$		

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

perceived behavioural control and personal norms, whereas financial attitudes were higher in the Visschers et al. study and household planning habits were higher in our study. The three highest significant predictors of self-reported food wasting behaviour were perceived behavioural control, number of children in the household, and personal attitude in our study, but intention, perceived behavioural control, and good provider identity in Visschers et al.'s findings. This comparison reiterates the divergence between the two studies, identified in bivariate relationships, suggesting that Hypothesis 3 was not met. Further, in our study, perceived behavioural control was the most significant predictor of self-reported food wasting behaviour for each food waste type, whereas it was intention in Visschers et al.'s study. This finding indicates that in our study, perceived behavioural control is a more important predictor of food wasting behaviour than intention.

Thus, the key difference between our study and that of Visschers et al. (2016) appears to be related to the greater strength of perceived behavioural control as a predictor of both intention and self-reported food wasting behaviour. This was further supported by the linear hierarchal regression on perceived behavioural control, in which more of the variance was explained as compared to intention. This speaks to a potential weakness of only using intention as a predictor of self-reported household behaviour. Arguably, no one intends to deliberately dispose of food waste and this was manifest as the highest psychological construct mean in both studies. Perceived behavioural control may function as a survey respondent proxy for household (i.e., group) intention and/or behavioural efficacy, and therefore may serve as a better predictor of this behaviour.

Food waste predictors in other studies

The TPB has also been used in other studies to model food wasting behaviour, and the results generally concur with the violability of this

intention-behaviour relationship. Stefan et al. (2013) used a modified TPB survey to ask Romanian consumers about their food wasting habits and found that it did not explain survey respondent food wasting behaviours well. While moral attitude had a significant positive impact, and lack of concern had a significant negative impact on intention to not waste food, subjective norms and perceived behavioural control had no impact. Their results showed that planning, and especially shopping routines, explain most of the variance in food wasting behaviour, while intention to not waste food, the lynchpin of the TPB, did not have a significant impact on reported food waste. Stefan et al. (2013, 379) explains this by suggesting that food waste is embedded in food provisioning routines and not "driven by conscious intentions." Graham-Rowe et al. (2015) used an extended TPB model in surveys that measured intention and behaviour to reduce household fruit and vegetable waste. In the baseline survey, demographics, TPB, and additional predictors (self-identify, anticipated regret, moral norms, descriptive norms) explained up to 73% of the variance in intention to reduce fruit and vegetable waste. Intention, but not perceived behavioural control, was a significant predictor of behaviour, although the amount of variance explained was quite low (5%). They suggest the additional predictors augment the predictive capabilities of the TPB. Stancu et al. (2016) used an extended TPB in a survey to predict intention to not waste food and food wasting behaviour. The additional predictors used were related to various food planning and procurement routines and household food-related skills. Their model explained 45% of the variance of intention to not waste food and 43% of food wasting behaviour. Attitudes and injunctive norms explained most of the variance of intention, while moral norms and perceived behavioural control had no impact. Perceived behavioural control, leftover use routines, and shopping routines explained most of the variance of food wasting behaviour, with intention making a low contribution.

In the context of our study, the foregoing research shows that intention has a limited impact on predicting food wasting behaviour and that personal attitudes, personal and subjective norms, and food management predictors such as household planning habits and good provider identity are better predictors of this behaviour. All of these predictors were significant antecedents of perceived behavioural control in our study (Table 5).

Implications for intervention development

Visschers et al. (2016) suggest that food waste reduction interventions should concentrate on intention, perceived behavioural control, and the good provider identity, whereas Stefan et al. (2013) and Romani et al. (2018) recommend they be built around consumer food planning and shopping routines, while also attempting to integrate a change in consumer attitudes. Our findings generally concur, although we suggest that perceived behavioural control could potentially be exchanged with intention as the key TPB determinant of behaviour, and that intervention development focus on strengthening its significant antecedents. This means developing interventions that seek to bolster subjective and personal norms as well as personal attitudes that wasting food is not right and needs to be curtailed. It also means raising people's food literacy by providing them with information that would allow them to improve their household planning habits. This would, in turn, help them reduce the over-purchase of food that is, in part, embodied by the good provider identity.

Reducing monetary impact was significantly and clearly the preferred food waste reduction motivator for most survey respondents, confirming Hypothesis 4. There is some evidence of a disconnection between selecting this motivator and respondent financial attitudes. In bivariate analyses, financial attitudes were only moderately related to personal norms; in regression analyses these attitudes were only modestly, but significantly, related to intention; and they were not at all related to perceived behavioural control or self-reported food wasting frequency. Respondents generally reported "bought too much" as the key reason why the six food types are thrown out. Re-establishing this connection should be an integral part of intervention development. It means educating people about the value of their household food waste and using this information to prime innate personal and subjective norms to not waste money. This can be complemented by providing clear and actionable food literacy information that is focused on saving money by not wasting food.

Limitations

There are two key limitations of our study. Firstly, our survey sample was opportunistic and not a randomly selected sub-set of the population; however, we argue that only people that want to complete surveys will, and that transcends the approach used to elicit respondents. We used a comprehensive and multi-faceted approach to attract a diversity of respondents and were successful in that regard. Secondly, we relied on self-reported food wasting behaviour. This is fraught with challenges, such as observer bias, because it does not measure actual behaviour but rather a survey respondent's assessment of their household's behaviour. This can be overcome by collecting curbside household waste samples on their waste collection day and manually sorting out and weighing food waste. Indeed, future research should compare actual behaviour with self-reported behaviour and further assess the impacts on TPB constructs on actual behaviour.

Conclusions

We successfully modelled household food wasting behaviour in the city of London, Ontario. Perceived behavioural control appeared to be the dominant predictor of self-reported food wasting behaviour in this study and interventions should focus on strengthening this determinant.

This can be accomplished through further activation of personal attitudes and personal and subjective norms, as well as increasing food literacy that focuses on managing the good provider identity and enhancing household planning habits. While much of the behaviour that leads to food wasting is arguably rational, priming the irrational and innate behaviour to save money can be a powerful tool to motivate households to reduce their food waste.

Acknowledgements

This work was funded by Social Sciences and Humanities Research Council of Canada (Grant #430-2017-01113). The authors acknowledge Mr. Jay Stanford, Director, Environment, Fleet & Solid Waste, City of London, Ontario, Canada for assistance in distributing this survey and supplying the table of contents graphic; and Mr. Martin Zivack and Ms. Angela Piaskoski for research assistance.

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Appendix

Table A.1
Survey items per construct, including mean, standard deviation, corrected item−total correlation (r pbis) per item, as well as internal reliability (Cronbach's α).

Questions per construct	M	SD	Cronbach's α	M	SD	r_{pbis}
Intentions	5.99	1.48	0.94			
I try to waste no food at all.				6.13	1.43	0.86
I always try to eat all purchased foods.				6.02	1.45	0.87
I try to produce only very little food waste.				5.86	1.51	0.85
I aim to use all leftovers.				5.95	1.52	0.81
Attitudes						
Personal attitudes	5.30	1.71	0.76			
It is unnecessary to waste food: it can always be used in some way.				5.15	1.66	0.60
It is immoral to discard foods while other people in the world are starving.				4.81	1.83	0.64
It upsets me when unused products end up in the waste bin or garburator.				5.93	1.41	0.57
Financial attitudes	5.54	1.79	0.61			
I think that wasting food is a waste of money.				6.47	0.96	0.30
I cannot afford to pay for foods that are then discarded.				4.81	1.93	0.37
Saving money does not motivate me to discard less food.*				5.34	1.89	0.41
I rarely think about money when I throw away food.*				5.51	1.79	0.52
Environmental attitudes	5.81	1.66	0.6			
Throwing out food does not have an environmental impact.*				6.25	1.34	0.45
I rarely think about the environment when I throw away food.*				5.37	1.82	0.45
Food safety attitudes	2.83	1.88	0.64			
I believe that the risk of becoming ill as a result of eating food past its "best before" date is high.				3.53	1.80	0.41
I am not worried that eating leftovers results in health damage.*				3.14	2.19	0.38
I think that consuming leftovers is harmless.*				1.98	1.43	0.42
I think that one can perfectly safely eat food products whose "best before" dates expired a few days.*				2.68	1.64	0.53
Perceived behavioral control	5.24	1.83	0.78			
I find it difficult to prepare a new meal from leftovers.*				5.39	1.77	0.48
I find it difficult to make sure that only small amounts of food are discarded in my household.*				4.97	1.83	0.62
I find it difficult to plan my food shopping in such a way that all the food I purchase is eaten.*				4.88	1.95	0.62
I have the feeling that I cannot do anything about the food wasted in my household.*				5.74	1.52	0.51
Other household members make it impossible for me to reduce the amount of food wasted in my household.*				5.23	1.90	0.53
Subjective norms	5.68	1.64	0.83			
People who are important to me find my attempts to reduce the amount of food wasted unnecessary.*				5.51	1.76	0.72
People who are important to me disagree when I try to reduce my food waste.*				5.85	1.50	0.72
Personal norms	5.77	1.46	0.87			
I feel bad when I throw food away.				6.17	1.27	0.60
I feel obliged not to waste any food.				5.73	1.45	0.80
It is contrary to my principles when I have to discard food.				5.60	1.52	0.79
I have been raised to believe that food should not be wasted and I still live according to this principle.				5.59	1.54	0.71
Good provider identity	3.51	1.94	0.63			
It would be embarrassing to me if my guests ate all the food I had prepared for them. They would probably have liked to eat more.				2.95	1.90	0.27
I regularly buy many fresh products although I know that not all of them will be eaten.				3.14	1.89	0.29
I like to provide a large variety of foods at shared mealtimes so that everyone can have something he or she likes.				3.68	1.84	0.47

(*Continued*)

Table A.1
(*Continued*)

Questions per construct	M	SD	Cronbach's α	M	SD	r_{pbis}
I always have fresh products available to be prepared for unexpected guests or events (e.g. illness).				3.17	1.79	0.36
When I am expecting guests, I like to buy more food than is necessary because I am a generous host.				4.60	1.80	0.53
Household planning habits	4.36	1.88	0.79			
When I have made a shopping list, I always keep strictly to it.				3.88	1.82	0.56
I am a person who likes to plan things.				5.32	1.61	0.54
Before I prepare food, I always consider precisely how much I need to prepare and what I will do with the left overs.				4.51	1.82	0.63
I always plan the meals in my household ahead and I keep to this plan.				3.71	1.82	0.68

*Item was reverse coded. A 7-point Likert scale was used, with higher values corresponding to greater agreement with the statement.

Table A.2
Socio-demographic profile (%) of survey respondents (S) (n = 1,263) and city population (P).

Gender	S	P	People in household	S	P	Household income	S	P	Housing type	S	P
Female	79.9	51.5	1	15.6	30.1	<40,000	21.5	29.0	Apartment	16.6	29.4
Male	19.4	48.5	2	41.0	34.8	$40–60,000	19.3	17.3	Detached/semi-detached	70.5	59.7
Other	0.7	-	3	16.5	14.8	$60–80,000	17.8	14.0	Townhouse	9.2	10.5
			4	18.8	13.1	$80–$100,000	13.7	11.2	Other	3.7	0.4
			5	6.5	7.2	>$100,000	27.7	28.4			
			6+	1.6							
Age			**Children in household**			**Employment status**			**Housing tenure**		
18–24	5.7	9.5	0	67.4	60.6	Unemployed	3.4	-	Live rent free	3.3	-
25–34	23.6	17.1	1	12.4	17.9	Student	5.5	-	Pay rent	25.4	-
35–44	21.1	15.8	2	15.1	14.9	Stay at home parent	4.8	-	Pay mortgage	45.8	-
45–54	18.4	18.2	3	4	6.6	Work part-time	12.9	-	Own home outright	24.9	-
55–64	18.7	17.5	4	0.7		Work full-time	55.2	-	Other	0.6	-
65+	12.5	22.0	5+	0.3		Retired	18.2	-			-

Table A.3
Comparison and ranking of respondent scores on the various psychological constructs.

	City of London, Ontario N = 1,263			Visschers et al. (2016) N = 796		
Construct	**Rank**	**M**	**SD**	**Rank**	**M**	**SD**
Intention	1	5.99	1.48	1	6.57	0.78
Personal attitudes	5	5.30	1.71	2	6.22	1.04
Financial attitudes	4	5.54	1.79	6	4.64	1.49
Environmental attitudes	-	5.81	1.66	-	-	-
Perceived health risks	9	2.83	1.88	9	2.56	1.21
Perceived behavioral control	6	5.24	1.83	5	5.68	1.05
Subjective norms	3	5.68	1.64	3	6.09	1.27
Personal norms	2	5.77	1.46	4	5.96	1.16
Good provider identity	8	3.51	1.94	8	3.44	1.27
Household planning habits	7	4.36	1.88	7	4.32	1.4