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Food-related routines, product characteristics, and household food waste in the United States: A refrigerator-based pilot study

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ABSTRACT

U.S. households waste a substantial quantity of food and are advised to better manage purchasing and storage of perishable foods as a means to reduce food waste. However, little research exists concerning the contents and management of home refrigerators, which are central to most advice regarding home food waste reduction. We survey U.S. consumers about their home refrigerator inventories to assess the relationship between food-related routines and important considerations in the food discarding decision process, as well as the influence of food-related routines and product characteristics on the utilization of refrigerated foods. Our pilot study reveals that physical and institutional signals of food safety and quality drive consumer decision making about discarding food. We also find that refrigerator cleaning frequency, grocery shopping duration and frequently checking nutrition labels are among food-related routines that affect the utilization of refrigerated food. Additionally, "best by", "use by" and ambiguous date labeling significantly decrease the odds that food items are fully utilized.

1. Introduction

Food waste is a widespread and increasingly urgent global problem. In 2011, the Food and Agriculture Organization estimated that as much as 1.3 billion tons, approximately one third of food produced for human consumption, is lost[1] or wasted annually (Gustavsson et al., 2011). In developed countries, most food is wasted at the retail and consumption stage (Gustavsson et al., 2011; Kummu et al., 2012; Parfitt et al., 2010), producing quantities of waste comparable to total net food production in sub-Saharan Africa (Gustavsson et al., 2011). In the context of increasing global food demand, these staggering food waste estimates not only suggest significant economic opportunity costs, but also represent substantial negative social and environmental externalities, including but not limited to, wasted natural resources, greenhouse gas emissions, as well as unnecessary agricultural input use and biodiversity loss (Buzby et al., 2014; Kummu et al., 2012).

Recognizing the threat of food waste for global environmental sustainability, the United Nations' sustainable development goals include cutting global food waste in half by 2030 (United Nations (UN) General Assembly, 2015). In parallel, some countries, including the United States (U.S.), have formulated new targets and policies for reducing food waste, stimulating research into the extent and drivers of the problem. While consumer food waste is a major concern in the United States – in 2010, U.S. consumers were responsible for wasting 21% of the available food supply, some 45 million tons (Buzby et al., 2014) – research efforts in this domain are incipient (Gunders, 2012; Neff et al., 2015; Qi and Roe, 2016; Roe et al., 2018; Hoover, 2017) and have lagged behind research elsewhere, particularly in European countries (e.g. Stenmarck et al., 2016).

A major challenge for researchers focusing on consumer food waste in the U.S. has been a lack of comprehensive estimates of food-waste behaviors and quantities for individual households. As a result, an understanding of the influence of household-specific and demographic characteristics on food waste outcomes have, until recently, remained undocumented. However, in a new study, Yu and Jaenicke (2018) use food acquisition data in a stochastic production frontier model to estimate both the extent of household-level food waste and the effect of heterogeneous household characteristics on food waste outcomes. Their

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[1] Despite attempts to unify definitions of food loss and waste internationally (e.g. FAO, 2014), terminology differs across organizations and countries. We adopt the USDA definition, in which food loss "…represents the amount of edible food, postharvest, that is available for human consumption but is not consumed for any reason," whereas food waste "…is a component of food loss and occurs when an edible item goes unconsumed, such as food discarded by retailers due to blemishes or plate waste discarded by consumers." (Buzby et al., 2014, p. 1).

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estimates underscore the magnitude of the problem: the average U.S. household in their sample wastes over one third of the food it buys. Additionally, the authors find that healthier diets (due to a higher composition of perishable food, such as fruit and vegetables) and higher incomes are associated with higher levels of food waste, while household food insecurity and participation in food assistance programs are associated with lower levels of food waste (Yu and Jaenicke, 2018). While this study provides key estimates and correlates of U.S. household waste, structural approaches are needed to gain a deeper understanding of the drivers of food-waste behavior at the household level. To this end, structural models evaluated in Europe suggest that food-related routines[2] (e.g. shopping, cooking, and cleaning routines) are likely to play a major role (Stancu et al., 2016; Stefan et al., 2013). This idea is supported by Roe et al. (2018), who, in a study measuring plate waste in free-living conditions in the U.S., where subjects recorded plate waste data as part of their normal daily routine rather than in a meal setting designed by the researchers, find that plate waste figures are considerably lower than previously estimated and suggest that other aspects of household food-related activities, such as food preparation and discarding unwanted or spoiled food, are potentially larger culprits. While at least one study (Neff et al., 2015) reports the incidence of a variety of shopping and food preparation habits and routines in the U.S., none have assessed the relationship between such behaviors and food waste measurements in the U.S. specifically.

More generally, U.S. studies focusing on consumer food waste awareness, attitudes and behavior rely on self-reported perceptions about food waste outcomes, possibly yielding biased results (Neff et al., 2015; Qi and Roe, 2016). Additionally, given the type of data used, and their focus on consumer awareness and attitudes, these studies give cursory attention to the influence of product characteristics, such as food type and product packaging. Of particular concern is date labeling, which, thanks to local variability in labeling practices across the United States and widespread confusion about the meaning of date label phrases, leads to a considerable amount of household food waste nationally (Leib et al., 2013, 2016; Rethink Food Waste Through Economics and Data (ReFED, 2016; Wilson et al., 2018). Overall, there is clearly a need to investigate the influence of food-related routines and product characteristics on household decision making and consequent food-waste behavior. Such an investigation will contribute to efforts in identifying and addressing key drivers of consumer food waste in the United States.

In response to this need, we use a web-based survey of U.S. household refrigerator inventories and related shopping behaviors to assess the relationship between food-related routines and product characteristics on measures of household food consumption and food-discarding decision making. Refrigerator inventories provide a practical window into household food consumption and waste behavior because refrigerated foods typically comprise a sizeable portion of perishable food items in a household. Furthermore, consumer campaigns to reduce food waste provide advice concerning how best to use refrigerators to support waste reduction (e.g. United States Environmental Protection Agency (EPA, 2016). Our specific objectives are to assess:

(1) The relative importance of various considerations (e.g. expense, odor, date label phrase, among others) for household decision making about whether to keep or discard food,
(2) The relationship between household food-related routines and the importance of various considerations in household decision making about whether to keep or discard food, and
(3) How household food-related routines and product characteristics (specifically, product type and labeling characteristics) relate to utilization of food items.

The remainder of this paper is structured as follows. section 2 offers a description of the data and analytical methods used. Results are presented in section 3 and discussed in section 4. section 4 also offers a reflection of the paper's limitations and makes recommendations for future research.

2. Methods

2.1. Data

2.1.1. Survey participants and design

This study uses data from the State of the American Refrigerator survey, which is designed to measure consumer behavior with regard to food purchasing, preparation, cold storage and disposal. Design and implementation of the online survey was performed using Qualtrics software. Recruits were asked to consider taking a survey being conducted to "…understand the purchase, storage, use and discard of food in U.S. consumers' refrigerators," and were offered compensation for participation. Inclusion criteria included that recruits (a) were the primary or co-primary grocery shopper in the household, (b) cooked/prepared food at home at least once a week, (c) had access to the household refrigerator when answering the survey, and (d) were 18 years of age or older. The survey was approved by the local Institutional Review Board. All respondents provided informed consent.

The survey targeted adults from across the continental United States and was offered to lists of recruits interested in participating in surveys of all types maintained by vendors affiliated with Qualtrics. Respondents participated in a brief baseline survey and were invited to participate in a follow-up survey approximately one week later (the gap between surveys ranged from 5 to 18 days, with a mean of 6.6 ± 1.2 days). Only respondents who successfully responded correctly to questions designed to monitor participant attentiveness were included in the analyses. Of the 307 individuals who successfully completed the baseline survey, 169 (55%) responded to the follow-up. Table 1 summarizes the demographic characteristics of the baseline and follow-up samples respectively.

2.1.2. Survey measures

The baseline survey contains a set of questions for each of nine categories of food stored in the participant's refrigerator (vegetables; fruit; dairy and eggs; meat, poultry and fish; beverages; prepared or leftover foods; condiments, sauces and jarred foods; snacks and candy; other). For example, "Please count the number of vegetable items in your refrigerator(s) and enter that number…" For each category, respondents reported the number of food items and gave details about one food randomly chosen by the survey software, including product characteristics (i.e. product type and labeling features) and remaining quantity. Due to programming constraints, follow-up questions could not be administered for chosen items in every food category. For this reason, one randomly selected item was chosen from four of the nine food categories (vegetables; fruit; dairy and eggs; meat, poultry and fish) for follow-up. Detailed questions about the selected item[3], such as intended use and whether the item was bought on sale, were also included in the baseline survey. A single question was asked to determine

[2] Stancu et al. (2016) distinguish habits and routines by referring to the former as automatic responses to cues. However, they fail to clarify which household food-related behaviors constitute an 'automatic response' as opposed to those that constitute a routine behavior. For the purposes of this paper, the terms 'habits' and 'routines' will be used interchangeably and are intended to refer to the composite habitual and routine behavior displayed by households in relation to food acquisition, preparation, storage and disposal.

[3] For clarity, randomly selected items in each food category are referred to as "chosen items" (e.g. strawberries for the fruit category, chicken for the meat category), whereas the one food item selected for follow-up from the subset of chosen items is referred as the "selected item".

Table 1
Respondent demographics, unweighted[a].
Source for U.S. data: United States Census Bureau (2018).

Variable	Baseline n = 307	Follow-up n = 169	U.S. (2018)
Race			
White	65.1%	66.3%	76.6%
Black/African American	14.3%	13.0%	13.2%
Other	20.5%	20.7%	10.2%
Age			
Under 35	22.8%	20.7%	45.9%
35 to 64	48.9%	46.2%	38.3%
65 and older	28.3%	33.1%	15.8%
Gender			
Male	28.0%	32.0%	49.0%
Female	72.0%	68.0%	51.0%
Highest education level			
High school diploma or less	20.5%	24.9%	53.3%
Some college or Associate`s degree	41.0%	37.3%	21.8%
Bachelor`s degree	25.7%	24.3%	15.9%
Graduate or professional degree	12.7%	13.6%	9.0%
Annual household income[b]			
Less than $50 000	60.9%	62.7%	33.7%[b]
$50 000 to $99 999	29.6%	27.8%	30.5%[b]
$100 000 or more	9.4%	9.5%	35.8%[b]
Average household size (std dev)	2.1 (1.4)	2.0 (1.3)	2.53
Average number of children < 18 years old per household (std dev)	0.4 (0.9)	0.4 (0.9)	0.58

[a] Due to rounding, some categories may not sum to 100 percent.
[b] Refers to previous year's income (2017).

the subjects' intention to use the selected item, ("Do you think you will consume the rest of the < selected item > ? If no, why not? Select all that apply."). Eleven possible reasons for discarding that food item were list as response options as was the response "Yes, I will consume the rest of the item." Additionally, respondents reported their shopping routines, refrigerator characteristics, and sociodemographic characteristics. The complete questionnaire is presented in the supplementary material.

The follow-up survey asked respondents about the remaining quantity and actual or likely outcome of the selected item (e.g., if the item would be consumed or discarded). Respondents were also presented with nine considerations in deciding to keep or discard food and asked to rate each according to a five-point Likert scale ranging from "very important" to "very unimportant." Moreover, the follow-up contained questions about refrigerator cleaning and grocery shopping routines.

2.1.3. Data modification for analysis

Seven observations were dropped because at least one of the baseline attention questions had not been answered. Dropped observations also failed to identify a selected food item in the follow-up survey and displayed missing information across most of the other follow-up variables (resultant n = 162).

Several categorical variables were consolidated into fewer response categories in order to avoid large standard errors and omitted categories in subsequent regression analyses. Table A1 in the appendix records the original and modified coding for all variables used.

New variables were also constructed from the data. To mirror covariates used by Yu and Jaenicke (2018), proxy indicators of food insecurity and diet healthfulness were generated. The former makes use of the observation that expenditure on food as a share of total household income is larger for food insecure households (Rose and Charlton, 2002). Thus, the food insecurity proxy is a dummy variable = 1 if the household is simultaneously in the lowest recorded income bracket (< $ 24,999 per annum) and has a weekly grocery expenditure per adult equivalent[4] that exceeds the median. Top-coding of item quantities prohibited the measurement of diet healthfulness in terms the number of fruit and vegetables as a proportion of total refrigerated food items. Consequently, the healthy diet indicator is a dummy variable indicating whether the household had more than ten items of fruit and/or vegetables in their refrigerator during the baseline survey.

2.2. Analysis

Results were analyzed in Stata (version 15.1). To address the first objective of this paper, frequencies were used to gauge the relative importance of various considerations in deciding to keep or discard refrigerated food.

Next, nine separate ordered logistic regressions were estimated to evaluate the relationship between household food-related routines and the relative importance of various considerations in deciding to keep or discard refrigerated food (objective 2). However, likelihood ratio tests revealed that seven of the nine models violated the proportional odds assumption and ordered logistic regression models were deemed unsuitable. To address this problem, five-point scales rating importance were converted to binary indicators (somewhat or very important = 1; otherwise = 0) and binary logistic models were estimated instead. Wald tests were used to assess the joint significance of coefficients for multilevel categorical covariates.

Lastly, binary logistic regressions were used to estimate how household food-related routines and product characteristics (specifically, product type and labeling characteristics) relate to whether selected items were fully utilized by the follow-up survey (objective 3). Again, joint hypotheses regarding multilevel categorical covariates were tested using Wald tests. All regression analyses included sociodemographic characteristics as explanatory variables.

3. Results

This section presents results in accordance with the paper's objectives. Firstly, descriptive statistics for key behavioral variables are presents in subsection 3.1. Thereafter, results relevant to objectives 1 and 2 are grouped in subsection 3.2, and results relevant to the third objective are presented in subsection 3.3. Where applicable, the following phrases are adopted with regards to statistical significance: highly significant, $p < 0.01$, and significant, $p < 0.1$.

3.1. Description of key behavioral variables

Table 2 reports frequencies for variables comprising food-related routines and other shopping and food disposal characteristics used in subsequent models.

Approximately two-thirds of the respondents clean their refrigerators often or very often. Just over half of the respondents frequently check nutrition labels, while about 70% (n = 162) frequently check expiration dates, suggesting that date labels are likely to be influential in respondents' decisions to buy and discard food. Most respondents (˜57%) shop once a week or more for groceries, with typical shopping trips lasting more than thirty minutes, inclusive of travel time, for approximately half of the respondents. A substantial proportion of respondents (˜88%) use their own car to perform shopping trips, and about 43% of respondents rely exclusively on supermarkets for most of their grocery shopping. Many of the respondents (71%) performed a grocery shop between the baseline and follow-up survey. Finally, a minority of respondents have or use any composting or food waste disposal services (˜12%) or have any pets or animals that regularly eat unwanted food scraps (16%).

[4] Adult equivalents were calculated using the OECD standard (see World Bank, 2014).

Table 2
Descriptive statistics for key behavioral variables.

Variable	% n = 162
Food-related routines	
Refrigerator cleaning frequency	
Never/rarely	6.8
Sometimes	29.0
Often/very often	64.2
Grocery shop frequency	
Once a month or less	7.4
2 to 3 times a month	35.8
Once a week or more	56.8
Grocery shop typically 30 min. or more? (Y = 1)	51.2
Frequency of checking nutrition labels	
Never/rarely	19.8
Sometimes	25.9
Often/always	54.3
Frequency of checking expiration date	
Never/rarely	11.7
Sometimes	18.5
Often/always	69.8
Other shopping & food disposal characteristics	
Did a grocery shop since baseline survey? (Y = 1)	71.0
Majority grocery shopping done at supermarket only? (Y = 1)	43.2
Use own car to do shopping? (Y = 1)	88.3
Compost/food waste disposal service? (Y = 1)	11.7
Pets/animals that eat unwanted food? (Y = 1)	16.0

3.2. Household food-discarding decision making

3.2.1. Relative importance of various considerations in food-discarding decision making

Fig. 1 summarizes the relative importance of nine considerations in deciding to keep or discard refrigerated food. Except for compostability, most respondents (> 50%, n = 162) rated all considerations as either somewhat or very important. Topmost considerations are the odor and appearance ("looks safe to eat") of food items, with 86% and 76% of respondents respectively rating them as very important. Notably, food label characteristics are rated third (whether the date on the food package has passed) and fifth ("date label phrase") most important when deciding to keep or discarded refrigerated food. Among the least important motives are compostability and whether the food item can be discarded without causing one's home to smell ("odor when discarded").

3.2.2. The relationship between household food-related routines and the importance of various considerations in food-discarding decision making

Eight binary logistic regressions assess the relationship between household food-related routines and whether various considerations are thought to be important in household decision making about keeping or discarding food (Table 3)[5] . Measures of food-related routines, other shopping and food disposal characteristics, as well as respondent and household characteristics are included in regression models as covariates. All regression coefficients are expressed in terms of log odds.

Likelihood ratio statistics (LR χ^2) and associated p-values indicate that models 2 through 8 have overall statistical significance at the 10% level, while model 1 yields $p = 0.11$. Some variables in models 3, 4, 7 and 8 lack a coefficient estimate or standard error due to instances quasi-complete separation (i.e. cases where the outcome variable has little or no prevalence for certain levels of a categorical variable). In these cases, the outcome is almost perfectly predicted by some level of the categorical variable and maximum likelihood estimates tend to infinity. To deal with this problem, Stata drops observations for which the categorical variable predicts the outcome perfectly or almost perfectly. Hence, we also see that the number of observations in models 3, 4, 7 and 8 differ from the other models. However, the other maximum likelihood estimates reported in these models remain valid.

3.2.2.1. Household food-related routines and other shopping and food disposal characteristics. Controlling for respondent and household sociodemographic characteristics, food-related routines have no explanatory power in models 2 ("plan to use soon") and 8 ("looks safe to eat"). However, using one's own car to do grocery shopping and having access to compost or food waste disposal services significantly decreases the probability that a food item's appearance is considered important in deciding whether to keep or discard that item (model 8).

In explaining whether expense is an important consideration (model 1), frequency of refrigerator cleaning and checking expiration dates are jointly significant. Occasional refrigerator cleaning has a negative effect compared to rare/no and frequent cleaning ($p < 0.05$; result not shown in Table 3), while frequent and occasional checking of expiration dates have a positive effect compared to rare/no checking ($p < 0.10$).

Frequency of checking expiration dates is also jointly significant in explaining the importance of both label-related considerations (models 3 and 4). Furthermore, checking expiration dates often/always has a significant and positive effect on the importance of the "odor when discarded" consideration (model 6). The importance of date label phrasing (model 4) and "odor when discarded" (model 6) as food-discarding considerations are also positively affected by having pets or animals that regularly eat unwanted food scraps. Whether a food item has passed the date on its packaging (model 3) is more likely to be an important consideration for frequent refrigerator cleaners compared to infrequent refrigerator cleaners ($p < 0.1$), but is less likely to be an important consideration for those that use their own car to do grocery shopping compared to those that use other forms of transportation ($p < 0.1$).

Compared to less frequent shopping routines, grocery shopping once a week or more has a statistically positive effect on the likelihood that "odor when discarded" is an important consideration (model 6). Grocery shopping frequency also has joint significance in explaining the importance of the "trust store food quality" consideration (model 7). This consideration is also jointly affected by refrigerator cleaning frequency, with frequent refrigerator cleaners more likely to consider "trust store food quality" important compared to infrequent refrigerator cleaners ($p < 0.05$). On the other hand, longer typical shopping trip duration (30 min or more) and having access to compost or food waste disposal services negatively affect whether the "trust store food quality" consideration is considered important ($p < 0.05$).

As is to be expected, access to compost or food waste disposal services has a highly significant and positive effect on the importance of the compostability consideration (model 5). Frequency of checking nutrition labels is also jointly significant in explaining the importance of compostability, with increasing frequency associated with a positive and highly significant effect. On the other hand, occasional refrigerator cleaners are less likely than infrequent refrigerator cleaners to consider compostability important. Compared to shorter typical shopping trips, grocery shopping for 30 min or more has a highly significant and negative association with the importance of compostability.

3.2.2.2. Respondent and household characteristics. Respondents' level of education has joint significance in all models presented in Table 3, except for model 8 ("looks safe to eat"). Levels of education above high school is significantly and positively associated with the importance of most of the food waste considerations reported in Table 3. Exceptions include models 5 ("compostability"), 6 ("odor when discarded"), and 7 ("trust store quality"), in which levels of education beyond high school have a negative or no statistically significant effect on whether those outcomes are considered important.

Households with more children are significantly more likely to

[5] A ninth model for the odor consideration could not be estimated due lack of variation (94% of respondents rated this consideration as important).

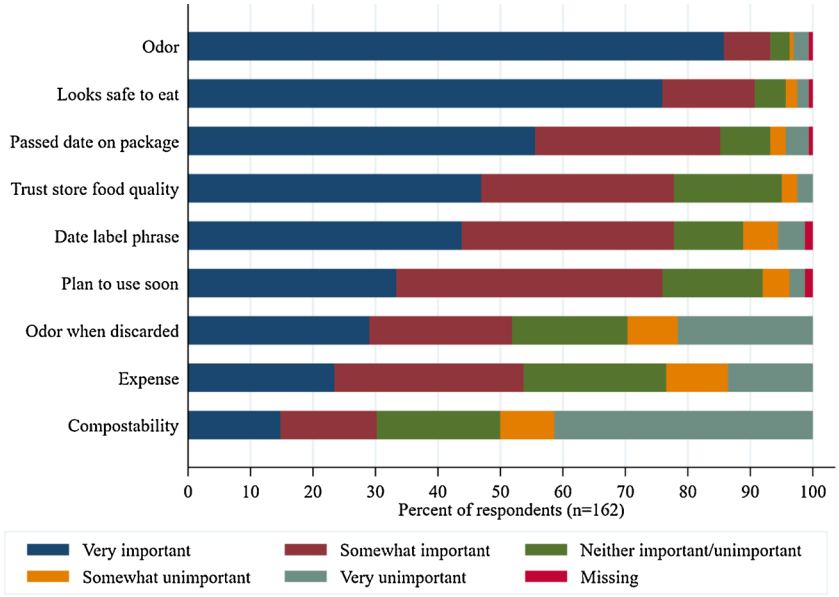

Fig. 1. Relative importance of various considerations in deciding to discard or keep food.

consider "trust store food quality", "odor when discarded", and "expense" as important factors in food-discarding decision making. Compared to full-time workers, students are less likely to consider "plan to use soon", "passed date on package", and "trust store food quality" as important factors, while retirees are statistically less likely to consider "plan to use soon" important, and part-time employees are less likely to consider both "plan to use soon" and "compostability" as important considerations but are more likely to consider expense as an important consideration. Being black, aged between 35–64 and 65 or older, being female, or having an annual household income above $100 000 is significantly associated with the outcome being considered important in at least one of the models in Table 3. Conversely, having an annual household income of $50 000 - $99 999 or above $100 000, household size, or having ten or more pieces of fruit and vegetables in the refrigerator at the time of the baseline survey significantly reduce the likelihood of outcomes being considered important in at least one of the models.

3.3. How household food-related routines and product characteristics relate to utilization of selected food items

3.3.1. Description of selected food items and their utilization

Selected food items were comprised of approximately 20% vegetables, 26% fruit, 32% dairy or eggs, and 22% meat, poultry or fish (n = 162). About 58% of these items were in their original package with a label at the time of the baseline survey, and 16% were bought on sale, while 44% were fully utilized by the time of the follow-up survey.

Figs. 2 and 3 show respectively the expected and actual utilization of selected items by product category. Specifically, Fig. 2 shows respondents' consumption expectations of selected food items during the baseline survey, as measured by the question "Do you think you will consume the rest of the selected item? If no, why not? Select all that apply". Most responses were positive about food utilization expectations, regardless of product category.

In Fig. 3, we report whether the selected item was still present in the respondents' refrigerator approximately one week after the baseline survey. Only half of the selected meat items were fully utilized, and less than half of the selected vegetable (44%, n = 32), fruit (40%, n = 42), and dairy (42%, n = 52) items were entirely eaten by the time of the follow-up survey. In aggregate, about 44% of respondents (n = 162) fully utilized the selected product, while a further 52% partially utilized the selected product.

3.3.2. Regression results

Table 4 shows the relationship between product characteristics, as well as household food-related routines, and whether selected food items were fully utilized by the follow-up survey. The model has overall significance at the 2% level, and all regression coefficients are expressed in terms of log odds.

Beginning with product characteristics, we see that consumption expectations are significantly predictive of full utilization, *cet. par.* Selected items bought on sale is are also significantly more likely to be fully utilized. However, product type has no statistically significant effect on whether the selected item is fully utilized. Date label phrasing is jointly significant in explaining full utilization and, compared to items with no label or for which a date label phrase is not applicable, items displaying "best by", "use by" or just a date without an associated phrase ("date only") significantly decrease the odds of the item being fully utilized. Packages displaying "date only" also has the largest effect of any of the date label regressors: compared to the base category, items with a date only decrease the odds of full utilization by about 99%, *cet. par.* ($p < 0.01$).

Several food-related routines also have a notable effect on whether the selected item is fully utilized. Although refrigerator cleaning frequency is not jointly significant, compared to those who rarely/never clean their refrigerator, those who clean their refrigerator occasionally or frequently are significantly less likely to utilize the selected item. Compared to shorter typical shopping trips, grocery shopping for 30 min or more has a significant and positive influence on utilization. Frequency of checking nutrition labels is not jointly significant in explaining full utilization, though frequent checking is associated with significantly higher odds of full utilization than rarely or not checking nutrition labels.

Holding all other factors constant, those who identify as belonging to racial groups other than white or black are associated with a higher full utilization rate of the selected food item than those who identified as white. Age has joint significance in explaining utilization, with respondents older than 35 significantly more likely than younger respondents to fully utilize the selected item. Food insecurity also has a significant and positive influence on the likelihood that the selected item is fully utilized.

Lastly, we see that relative refrigerator fullness during the baseline survey is jointly significant in explaining selected item utilization. In particular, households with unusually empty or unusually full refrigerators are significantly less likely to utilize the selected item

Table 3
Binary logistic regressions explaining whether various considerations are important in deciding whether to discard refrigerated food.

	(1) Expense		(2) Plan to use soon		(3) Passed date on package		(4) Date label phrase		(5) Compostability		(6) Odor when discarded		(7) Trust store food quality		(8) Looks safe to eat	
	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)
Food-related routines																
Refrigerator cleaning frequency (Base: Never/rarely)	*Joint p = 0.013*		*Joint p = 0.628*		*Joint p = 0.014*		*Joint p = 0.176*		*Joint p = 0.180*		*Joint p = 0.987*		*Joint p = 0.005*		*Joint p = 0.358*	
- Sometimes	−1.803**	(0.853)	0.147	(0.978)	−0.019	(1.128)	−1.507	(1.044)	−2.237*	(1.242)	0.098	(0.942)	0.636	(0.958)	8.735	(6.845)
- Often/very often	−0.571	(0.832)	0.640	(1.001)	2.421*	(1.236)	−0.664	(1.062)	−1.389	(1.106)	0.029	(0.934)	2.640**	(1.037)	8.004	(5.601)
Grocery shop frequency (Base: Once a month or less)	*Joint p =0.195*		*Joint p = 0.479*		*Joint p = 0.285*		*Joint p = 0.448*		*Joint p = 0.541*		*Joint p = 0.158*		*Joint p = 0.021*		*Joint p = 0.425*	
- 2 to 3 times a month	0.172	(0.861)	1.160	(0.958)	0.948	(0.887)	0.473	(0.623)	0.282	(1.070)	0.963	(0.844)	−1.459	(1.375)	−2.493	(3.126)
- Once a week or more	0.943	(0.900)	1.039	(0.989)	0.000	(.)	0.000	(.)	0.926	(1.142)	1.556*	(0.872)	0.350	(1.451)	0.000	(.)
Grocery shop typically 30 mins or more? (Y = 1)	−0.204	(0.386)	−0.317	(0.504)	−0.826	(0.887)	−0.418	(0.529)	−1.426***	(0.543)	−0.034	(0.410)	−1.642***	(0.616)	−1.748	(4.570)
Check nutrition labels (Base: Never/rarely)	*Joint p = 0.989*		*Joint p = 0.792*		*Joint p = 0.265*		*Joint p = 0.561*		*Joint p = 0.011*		*Joint p = 0.256*		*Joint p = 0.315*		*Joint p = 0.173*	
- Sometimes	0.092	(0.622)	−0.431	(0.762)	1.643	(1.120)	0.645	(0.752)	2.590**	(1.182)	0.483	(0.642)	0.917	(0.843)	−2.773	(3.410)
- Often/always	0.041	(0.570)	−0.458	(0.714)	0.082	(0.951)	0.758	(0.737)	3.262***	(1.104)	−0.425	(0.599)	1.056	(0.740)	5.907	(6.903)
Check expiry date (Base: Never/rarely)	*Joint p = 0.083*		*Joint p = 0.485*		*Joint p = 0.062*		*Joint p = 0.025*		*Joint p = 0.459*		*Joint p = 0.113*		*Joint p = 0.265*		*Joint p = 0.274*	
- Sometimes	1.414*	(0.788)	−0.774	(0.870)	−1.146	(1.233)	−1.134	(0.923)	−0.657	(1.258)	0.025	(0.805)	−1.215	(0.985)	−11.387	(7.394)
- Often/always	1.511**	(0.693)	0.078	(0.783)	1.631	(1.125)	1.014	(0.863)	0.487	(0.996)	1.163*	(0.685)	0.162	(0.919)	−7.352	(6.319)
Other shopping & food disposal characteristics																
Use own car to do shopping? (Y = 1)	−0.004	(0.660)	−1.123	(0.996)	−2.886*	(1.747)	−0.130	(0.953)	1.203	(0.911)	−0.223	(0.734)	−1.177	(1.002)	−11.142*	(6.577)
Compost/food waste disposal service? (Y = 1)	−0.078	(0.628)	0.348	(0.873)	−0.187	(1.252)	−0.180	(0.871)	3.060***	(0.852)	0.094	(0.629)	−2.109**	(0.956)	−7.426*	(3.923)
Pets/animals that eat unwanted food? (Y = 1)	0.495	(0.588)	0.492	(0.801)	2.374	(1.495)	1.980*	(1.038)	0.326	(0.783)	1.341**	(0.634)	1.111	(0.866)	0.000	(.)
Respondent characteristics																
Race (Base: White)	*Joint p = 0.911*		*Joint p = 0.673*		*Joint p = 0.550*		*Joint p = 0.255*		*Joint p = 0.222*		*Joint p = 0.058*		*Joint p = 0.414*		*Joint p = 0.581*	
- Black/African American	0.018	(0.665)	−0.279	(0.904)	−1.341	(1.380)	−1.312	(0.895)	1.443*	(0.848)	1.864**	(0.784)	−1.169	(0.946)	−5.327	(6.500)
- Other	−0.219	(0.534)	−0.620	(0.703)	−0.696	(0.928)	−0.768	(0.685)	0.527	(0.689)	0.439	(0.556)	0.029	(0.818)	3.477	(4.824)
Age (Base: Under 35)	*Joint p = 0.376*		*Joint p = 0.978*		*Joint p = 0.410*		*Joint p = 0.703*		*Joint p = 0.922*		*Joint p = 0.057*		*Joint p = 0.246*		*Joint p = 0.684*	
−35 to 64	−0.763	(0.666)	−0.223	(1.191)	−2.132	(1.606)	−0.752	(0.906)	−0.220	(0.853)	1.702**	(0.729)	−1.507	(1.057)	0.831	(5.820)
−65 and older	−1.114	(0.813)	−0.144	(1.276)	−1.782	(1.776)	−0.549	(1.071)	0.064	(1.079)	1.801**	(0.865)	−0.532	(1.139)	−4.225	(9.712)
Female (Y = 1)	0.036	(0.473)	0.653	(0.588)	0.960	(0.967)	1.871***	(0.665)	−0.618	(0.649)	0.537	(0.484)	−0.028	(0.690)	−2.882	(4.515)
Highest level of education (Base: High school diploma or less)	*Joint p = 0.094*		*Joint p = 0.065*		*Joint p = 0.050*		*Joint p = 0.082*		*Joint p = 0.010*		*Joint p = 0.036*		*Joint p = 0.063*		*Joint p = 0.139*	
- Some college or Associate`s degree	1.056*	(0.555)	1.765**	(0.727)	1.872*	(1.135)	1.214	(0.750)	−2.438***	(0.788)	−0.182	(0.561)	0.531	(0.705)	7.220**	(3.260)
- Bachelor`s degree	0.455	(0.589)	1.577**	(0.732)	1.507	(1.050)	0.830	(0.722)	−2.398***	(0.924)	−1.392**	(0.611)	−1.220	(0.753)	7.580	(4.895)
- Graduate or professional degree	1.621**	(0.769)	1.336	(0.922)	5.049***	(1.871)	2.874**	(1.146)	−3.060***	(1.110)	0.385	(0.755)	0.000	(.)	8.828**	(4.365)
Employment status (Base: Full-time)	*Joint p = 0.247*		*Joint p = 0.028*		*Joint p = 0.326*		*Joint p = 0.339*		*Joint p = 0.092*		*Joint p = 0.632*		*Joint p = 0.306*		*Joint p = 0.452*	
- Part-time	1.786*	(0.961)	−1.877*	(1.087)	0.586	(1.824)	1.448	(1.441)	−3.342**	(1.614)	−0.264	(0.883)	−0.729	(1.195)	0.000	(.)
- Retired	0.534	(0.652)	−2.419***	(0.927)	0.371	(1.132)	−0.358	(0.828)	−0.990	(0.802)	−0.991	(0.684)	−0.751	(0.912)	1.370	(2.825)

(*continued on next page*)

Table 3 (*continued*)

	(1) Expense		(2) Plan to use soon		(3) Passed date on package		(4) Date label phrase		(5) Compostability		(6) Odor when discarded		(7) Trust store food quality		(8) Looks safe to eat	
	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)	Log odds	(SE)
- Student	−1.459	(1.452)	−4.431**	(2.029)	−5.014*	(2.709)	−0.597	(2.247)	1.509	(1.758)	−1.115	(1.569)	−3.700*	(1.945)	−19.259	(12.398)
- Other	−0.131	(0.600)	−0.576	(1.006)	−0.770	(1.221)	−1.270	(0.813)	0.886	(0.747)	−0.637	(0.634)	0.179	(0.929)	1.315	(3.570)
Household characteristics																
Annual HH income (Base: Less than $50 000)	*Joint p = 0.594*		*Joint p = 0.210*		*Joint p = 0.827*		*Joint p = 0.129*		*Joint p = 0.081*		*Joint p = 0.562*		*Joint p = 0.064*		*Joint p = 0.987*	
- $50 000 to $99 999	−0.505	(0.512)	−1.130*	(0.642)	0.179	(0.900)	0.167	(0.692)	0.649	(0.676)	−0.070	(0.535)	−1.784**	(0.763)	0.015	(3.294)
- $100 000 or more	−0.024	(0.720)	−0.485	(0.975)	−0.681	(1.306)	−1.672*	(0.899)	2.139**	(0.957)	−0.779	(0.741)	−0.464	(1.285)	−0.619	(3.994)
Household size	−0.182	(0.249)	0.680	(0.478)	−0.226	(0.578)	−0.036	(0.334)	−0.175	(0.295)	−0.237	(0.256)	−1.076**	(0.473)	1.564	(1.880)
Nr children in household	0.868**	(0.428)	−0.596	(0.702)	0.156	(0.787)	−0.314	(0.502)	0.409	(0.442)	1.345***	(0.477)	2.175**	(0.878)	−0.895	(3.959)
10 or more pieces of fruit/veg? (Y = 1)	−0.185	(0.512)	0.467	(0.681)	−1.147	(0.912)	−1.389**	(0.676)	0.111	(0.642)	−0.857*	(0.518)	0.860	(0.804)	−0.107	(2.881)
Constant	−0.764	(1.530)	1.046	(2.155)	3.433	(2.818)	1.137	(1.657)	−1.931	(2.157)	−2.620	(1.641)	5.320**	(2.485)	11.970	(11.314)
Observations	162		160		149		148		162		162		140		98	
McFadden's Pseudo R^2	0.188		0.266		0.411		0.264		0.393		0.236		0.349		0.648	
Model df	32		32		31		31		32		32		31		27	
$LR_{\chi 2}$(df)	42.056		45.988		52.630		42.060		77.965		52.854		55.774		52.124	
Prob > χ^2	0.110		0.052		0.009		0.089		0.000		0.012		0.004		0.003	

Notes: Standard errors in parentheses. The following explanatory variables are included but feature no statistical significance and are not reported to streamline results: Participation in government nutrition programs, food insecurity proxy, and whether a majority of shopping is conducted at a supermarket. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

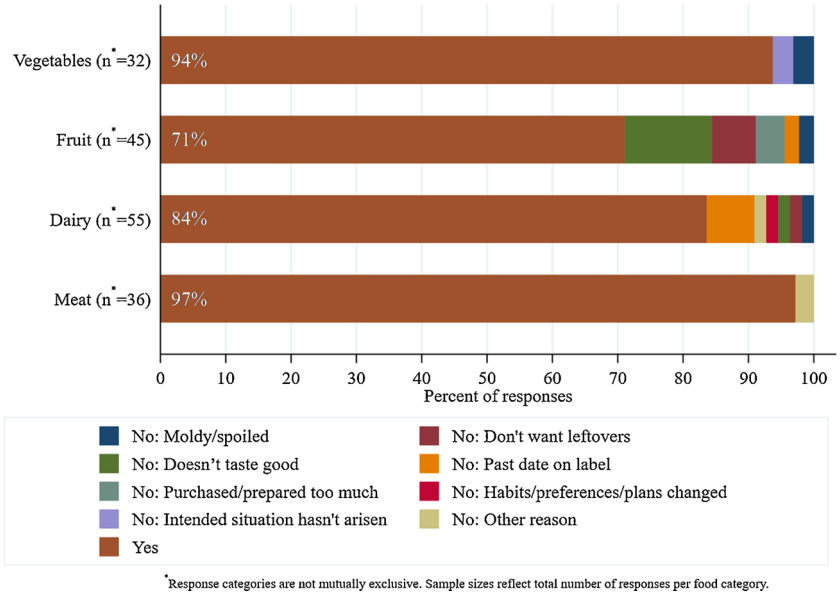

Fig. 2. Expected consumption of selected item by food type ("Do you think you will consume the rest of the selected item? If no, why not? Select all that apply"). Labeled bars indicate percentage of "Yes" responses per selected item category.

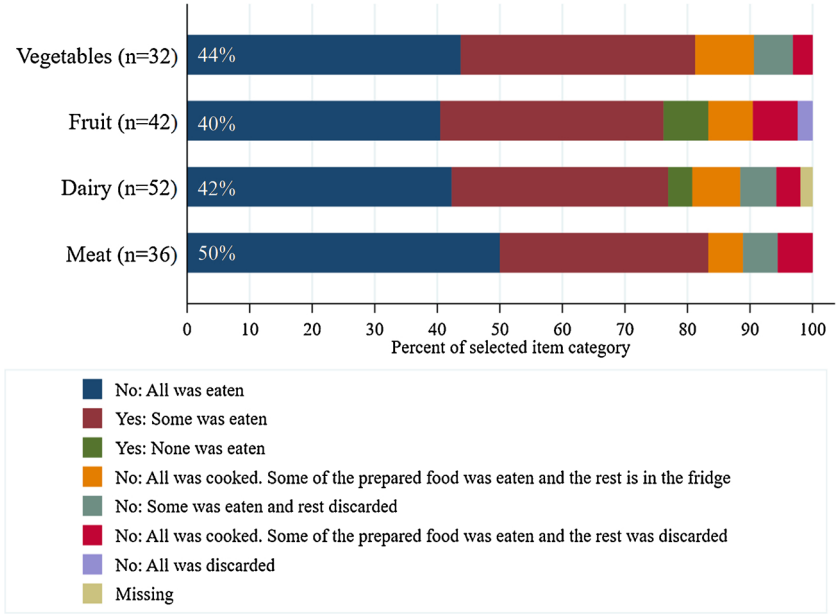

Fig. 3. Actual consumption of selected food item by food type ("Do you still have the selected item in your refrigerator?"). Labeled bars indicate percentage of "No: All was eaten" responses per selected item category.

compared to households with normally full refrigerators.

4. Discussion

4.1. Food safety and food quality as preeminent considerations in household decision making about discarding food

The results in section 3.2.1 reveal that considerations relating to food safety and food quality are among the most important to respondents when deciding to keep or discard food. The top two most important considerations (related to the odor and appearance of food items) are physical signals of food safety; the third and fifth most important considerations are label signals of food safety and quality (depending on the date phrase used and respondents' individual interpretation of the meaning of such a date phrase); while the fourth most important consideration (whether the consumer trusts the quality of food sold at the store where that food was purchased) is a reputational signal of food quality. These results suggest that clarifying and strengthening the meaning of these signals should be among the suite of strategies used to address household-level food waste. Such strategies include education campaigns specifically targeting consumers' understanding about physical signs food safety and quality, while institutional signals of food safety and quality need to be consolidated and standardized, as is advocated by those calling for a unified and understandable consumer-facing labeling system in the U.S. (e.g. Leib et al., 2013).

An obvious explanation for the preeminent importance of physical and institutional signals of food safety/quality is the human health concerns associated with eating food of diminished quality, and perhaps especially, diminished safety. Another potential explanation is

Table 4
Logistic regression explaining full utilization of selected item.

	Full utilization	
	Log odds (SE)	
Product characteristics		
Consumption expected at baseline? (Y = 1)	2.185** (0.883)	
Selected item bought on sale? (Y = 1)	1.124*	(0.671)
Selected product (Base: Vegetable)	*Joint p = 0.460*	
- Fruit	0.324	(0.707)
- Dairy	1.294	(0.792)
- Meat	0.811	(0.766)
Date phrase on package (Base: Not applicable/ unsure)	*Joint p = 0.100*	
- Best if used by	−0.704	(0.724)
- Best by	−3.032*	(1.578)
- Best before	0.729	(1.381)
- Use by	−2.141**	(1.080)
- Sell by	−1.239	(0.936)
- Other phrase	0.514	(1.970)
- Date only	−4.877***	(1.826)
Food-related routines		
Refrigerator cleaning frequency (Base: Never/ rarely)	*Joint p = 0.177*	
- Sometimes	−2.479*	(1.293)
- Often/very often	−2.230*	(1.276)
Grocery shop frequency (Base: Once a month or less)	*Joint p = 0.726*	
−2 to 3 times a month	1.001	(1.021)
- Once a week or more	0.627	(1.068)
Grocery shop typically 30 min. or more? (Y = 1)	0.997**	(0.483)
Check nutrition labels (Base: Never/rarely)	*Joint p = 0.140*	
- Sometimes	1.070	(0.789)
- Often/always	1.586**	(0.737)
Check expiry date (Base: Never/rarely)	*Joint p = 0.460*	
- Sometimes	0.854	(0.938)
- Often/always	0.875	(0.784)
Other shopping & food disposal characteristics		
Did a grocery shop since baseline survey? (Y = 1)	0.869	(0.581)
Majority grocery shopping done at supermarket only? (Y = 1)	−0.237	(0.512)
Use own car to do shopping? (Y = 1)	1.363	(0.910)
Compost/food waste disposal service? (Y = 1)	0.664	(0.763)
Pets/animals that eat unwanted food? (Y = 1)	−0.940	(0.723)
Respondent characteristics		
Race (Base: White)	*Joint p = 0.145*	
- Black/African American	−0.140	(0.903)
- Other	1.150*	(0.627)
Age (Base: Under 35)	*Joint p = 0.104*	
−35 to 64	1.728**	(0.872)
−65 and older	2.340**	(1.039)
Female (Y = 1)	−0.764	(0.602)
Highest level of education (Base: High school diploma or less)	*Joint p = 0.125*	
- Some college or Associate`s degree	0.066	(0.608)
- Bachelor`s degree	0.729	(0.714)
- Graduate or professional degree	−1.321	(0.955)
Employment status (Base: Full-time)	*Joint p = 0.700*	
- Part-time	0.060	(0.992)
- Retired	0.099	(0.811)
- Student	0.894	(2.030)
- Other	1.146	(0.747)
Household characteristics		
Annual HH income (Base: Less than$50k)	*Joint p = 0.288*	
- $50k to $100k	−0.612	(0.604)
- More than $100k	0.622	(0.840)
Household size	−0.012	(0.299)
Number of children in household	0.408	(0.459)
Participate in govt assistance nutrition programs? (Y = 1)	−1.079	(0.846)
Food insecurity proxy	1.699*	(0.890)
10 or more pieces of fruit/veg? (Y = 1)	−0.787	(0.615)
Other		
Refrigerator relative fullness at baseline (Base: About normal)	*Joint p = 0.017*	
- More empty than usual	−1.079*	(0.551)
- More full than usual	−1.736**	(0.746)
Constant	−6.092**	(2.490)
Observations	162	
McFadden's Pseudo R^2	0.307	
Model df	47	
$LR_{\chi 2}$(df)	68.294	
Prob > χ^2	0.023	

Standard errors in parentheses
* p < .1 ** p < .05 *** p < .01

that respondents could be conflating the primary drivers of food-discarding decision making. For instance, in cases where poor planning and preparation routines result in refrigerated food perishing or exceeding label dates, respondents may be attributing the decision to discard food to food odor, appearance or date label phrases rather than the root cause of inadequate food inventory management. This conflation may stem from knowing or unknowing attempts to minimize feelings of guilt associated with food waste, a principal component of attitudes toward food waste (Qi and Roe, 2016). Such an explanation does not necessarily undermine the overall importance of signals of food safety/quality (since these signals are involved in a subsequent stage of the food-discarding decision-making process) but does potentially undermine the importance of other considerations.

By comparison, the relationships depicted in section 3.2.2 – intended to yield insights about the relationship between food-related routines and consumer decision making about discarding food, *cet. par.* – are less straightforward to interpret in a general manner. Part of the issue stems from the varied, potentially disparate, and likely incomplete set of considerations and food-related routines measured. For instance, the failure of food-related routines in predicting the importance of "plan to use soon" (model 2, Table 3) is potentially a result of a failure to account for indicators of planning routines (such as the making of meal plans and shopping lists, which were omitted from this survey to reduce respondent burden) measured in other studies (e.g. Stancu et al., 2016; Stefan et al., 2013). Also, routinized behavior does a poor job of explaining the importance of physical signals of food safety (i.e. "odor" and "looks safe to eat"), primarily because of their overriding importance in food-discarding decision making, regardless of household routines and sociodemographic characteristics.

Notwithstanding these challenges, evidence of relationships between measured food-related routines and important considerations about discarding food reveal interesting behavior on a variable-by-variable basis. Moreover, these results reiterate the preeminence of food safety and food quality in household decision making about discarding food. For instance, important considerations for which frequent refrigerator cleaning has explanatory significance are indicative of a principal concern with food safety and/or quality. That is, frequent refrigerator cleaners consider intuitional signals of food safety and/or quality ("passed dates on package" and "trust store food quality") to be important but consider expense less of a concern when food is perceived to be unsafe and/or of diminished quality. This finding is interesting in light of previous research conducted on so-called 'cabinet castaways' (purchased items left unused in pantries and eventually discarded) which suggests that frequent checking of cabinets reduces food waste by making the consumer aware of the existence of unused pantry items (Wansink et al., 2000). However, the results in this paper suggest that frequent checking and cleaning out of inventory with regards to perishable refrigerated items potentially *increase* food waste, since consumers are frequently removing and replacing inventory based on institutional signals which may be misleading indicators of food safety

and/or quality. Similar conclusions can be reached about frequently checking expiry dates. By contrast, longer typical shopping trips are either unrelated to, or negatively associated with institutional signals of quality being important considerations, suggesting that grocery shopping duration, which includes both travel and in-store time and represents a household's typical time commitment to sourcing groceries, is associated with a different strategy for the management of food quality and safety. A plausible explanation warranting future exploration is that these types of consumers 'insource' quality control by taking the time to pick the best items during shopping trips and relying primarily on physical signals of product safety and quality to determine when to discard food.

Lastly, the effects of other control variables warrant a brief explanation. The negative relationship between "uses own car to do shopping" and considerations related to both physical ("looks safe to eat") and institutional ("passed date on package") signals of food safety and/or quality as important considerations is an outstanding puzzle. A possible explanation is that the variable captures the effect of the consumer's location with respect to urban centers or grocery stores, or perhaps the variable captures the influence of grocery shopping frequency, which is constrained as an explanatory variable in these models due to cases of quasi-complete separation. "Odor when discarded" is an important concern to pet-owners, potentially because these consumers want to feed unwanted food to pets instead of discarding it and causing the home to smell.

4.2. Mismatch between expected and actual utilization

Results presented in section 3.3.1 suggest a mismatch between expected and actual utilization of selected food items. Expected consumption responses were generally inaccurate and overly optimistic. While respondents indicate widespread intentions to consume the remainder of the selected item (Fig. 2), less than half of the selected items were fully utilized by the follow-up survey (Table 5). Instances of pessimism, in which items not expected to be consumed actually were consumed, were relatively uncommon (4 of 19 items). Overall, only about half (49%, n = 162) of self-reported consumption expectations matched full utilization observed in the follow-up survey.

While many of the selected food items had at least been *partially* utilized by respondents in the follow-up survey, and the matching we observe is a lower bound of actual matching (respondents could still eat these items after the second survey), the perishability of selected food items suggests that quantities remaining uneaten after one week or more are likely to be wasted. As such, expected utilization over-estimates actual utilization and underestimates the rate of food waste. Consequently, although expected utilization is still significantly associated with actual utilization ($p = 0.013$), self-reported intentions of food consumption are, at best, an imperfect predictor of food consumption and waste that should be interpreted cautiously when the data about actual utilization are not available.

Table 5
Two-way frequency table illustrating a mismatch between expected and actual utilization.

		Selected item fully utilized by follow-up survey		
		Yes	Otherwise	Total
Consumption expected at baseline	**Yes**	67 (46.85%)	76 (53.15%)	143 (88.27%)
	Otherwise	4 (21.05%)	15 (78.95%)	19 (11.73%)
	Total	71 (43.83%)	91 (56.17%)	162 (100%)

Note: column percentages in parentheses, except for the final column, which features row percentages.

Moreover, further analysis reveals that the mismatch between expected consumption and full utilization is not random. Logistic regression analysis (see Table A2 in the appendix) reveals that the mismatch is itself systematically related to food-related routines and other food-related habits and characteristics, date label phrasing, food insecurity, as well as relative refrigerator fullness. These findings support concerns expressed elsewhere (e.g. Neff et al., 2015; Qi and Roe, 2016) regarding the bias associated with self-reported perceptions about food waste outcomes in food-waste studies. Researchers should be cautious when interpreting utilization data based on self-reported expectations and should instead develop and use reliable measures of actual food consumption and food waste.

4.3. Labeling characteristics and food-related routines as determinants of household food utilization

Like the results in earlier sections, the analysis presented in section 3.3.2 highlights the influence of labeling characteristics, but in this case, on the full utilization of selected refrigerator items by the time of the follow-up survey. The specific date label phrases with statistical significance in explaining full utilization ("best by" and "use by" in Table 4) are often interpreted by consumers to indicate food quality and food safety respectively (Leib et al., 2016). In addition, these date label phrases are prevalent on food items nationwide and are also the basis of ongoing efforts to consolidate and standardize the U.S. date labeling system (Wilson et al., 2018). Furthermore, the negative effect of "best by" and "use by" labels on utilization reflects the disposal of food items based on (sometimes mistaken) concerns about food safety and quality, as signaled by such phrases (Leib et al., 2016; Rethink Food Waste Through Economics and Data (ReFED, 2016; Wilson et al., 2018). Moreover, the large and negative effect of the "date only" label potentially reflects the compounded influence of ambiguous date labeling on food waste outcomes.

The positive effect of "selected item bought on sale" on utilization is seemingly in conflict with a literature that suggests that routinely buying items on sale leads consumers to buy more than they need, ultimately resulting in food waste (Qi and Roe, 2016; Stefan et al., 2013). However, the results in this literature are typically based on consumer agreement with such statements as part of a survey, and not based on actually tracking the utilization of particular items purchased on sale as we are able to do. In contrast, one study of unutilized shelf-stable foods found few consumers attributed item non-use to impulse or sales-motivated purchases (Wansink et al., 2000). Hence, we suggest that the effect of sales on in-home food waste may remain an open question.

The analysis presented in section 3.3.2 also highlights the importance of a few food-related routines in explaining the utilization of selected items. In terms of refrigerator cleaning frequency, increased frequency of refrigerator cleaning is potentially associated with increased food waste due to efforts to ensure only products with viable date labels are stocked in the household. Earlier results also offer a possible explanation for why consumers who typically take more than 30 min to do their grocery shopping are more likely to utilize the selected item. In line with the 'insourced quality control' hypothesis (see section 4.1), such consumers potentially make use of food planning, acquisition, preparation, and leftover-use routines as part of a broader strategy of managing food inventory. In turn, because these types of routines are not controlled for in this paper, the grocery shopping duration variable in this model may capture the positive effect of such routines on food utilization (Stancu et al., 2016; Stefan et al., 2013). However, this mechanism needs to be confirmed by future research incorporating a broader set of food routine variables.

The positive influence of frequently reading nutrition labels on item utilization echoes Parizeau et al. (2015), who, in a Canadian study of the beliefs, attitudes and behavior of households with regards to food waste, find that people who demonstrate conscientiousness in their eating habits tend to effectively manage food waste in their households

and those who frequently read nutrition labels produce less organic waste overall and per capita.

The refrigerator fullness variable also reinforces the importance of food-related routines for improved food waste outcomes. The negative relationship between unusually over- or under-stocked refrigerators indicates that disruptions to usual shopping and meal planning routines, due to unusual circumstances in the household (e.g. increased food inventory due to upcoming holidays, or depleted food inventory due to an unusually busy period at work – perhaps associated with a temporary substitution of take-out for home-cooked food), negatively affect food utilization.

The finding that those who identify as belonging to racial groups other than white or black are significantly more likely than whites to fully utilize the selected item potentially reflects differences in underlying cultural attitudes towards food waste. Qi and Roe (2016) find a similar result in which those identifying as Asian or other racial groups scored highest on the principal component of food-waste attitudes representing guilt associated with food waste. With regards to other sociodemographic characteristics, the positive effect of age on full utilization aligns with previous literature showing that older people are more aware of and knowledgeable about wasted food (Neff et al., 2015; Qi and Roe, 2016). The positive effect of our food insecurity proxy on selected item utilization reflects the high opportunity cost of food waste for food-insecure households and supports a similar finding by Yu and Jaenicke (2018). However, our results did not replicate the other key findings in the Yu and Jaenicke (2018) paper (namely, healthful diets and higher incomes increase food waste and should therefore be associated with lower levels of utilization, while the opposite relationship should be true for participation in food assistance programs) possibly because our survey was only able to follow up on one selected item and measure utilization over a limited time frame, and also because of dissimilarities in the measurement of variables.

5. Limitations and recommendations for future research

To the best of the authors' knowledge, this is the first attempt to document U.S consumers' food-related behaviors with respect to refrigerated foods. However, we must recognize the following limitations of this pilot study. First, the study involves only 307 subjects and 169 follow-ups from the continental United States. Our sample is generally older and has more formal education but lower annual household incomes than the average U.S consumer. To ensure the quality of the data on refrigerated foods, which is the same across all household members because all members share the same refrigerator, we limit our sample to the people who are familiar with the food in their refrigerators, i.e., adults who identified as the primary or co-primary grocery shopper for their household and had access to the household's refrigerator. This criterion may lead to a sample with more female subjects (72%) than the national average US consumers (51%), which further limits the representativeness of our sample with respect to opinions about food discard behavior. Future research with multiple waves of data collection based on a larger and more representative sample will better reveal consumers' food related behaviors and attitudes about refrigerated food. Secondly, the primary shopper criteria limits our ability to reveal the non-shoppers' attitudes toward refrigerated food and its discard. For example, primary shoppers may be more or less likely to believe that date label phrases on packages are important when making discard decisions. Future studies could collect refrigerated food data and attitudinal surveys of all household members, which could better reveal the role of each household members on managing refrigerated food.

Also, in this study, a limited number of household food-related routines were measured in the survey. However, it is not clear that adopting a broader set of routines[6] used in prior literature (Neff et al., 2015; Stancu et al., 2016; Stefan et al., 2013) captures the full range of relevant food-related routines. In order to advance our understanding of how food-related routines drive decision making about discarding food, and food waste more generally, future research needs to make a comprehensive assessment of (i) what types of behavior specifically constitute food-related routines, (ii) which of these routines are associated with food waste behavior, and (iii) what measures, or combinations of measures, are appropriate for measuring such food-related routines in household-level surveys.

The analysis presented in this paper could also be enhanced with several improvements to the survey. Added survey items related to respondents' expertise and confidence around certain food-related routines (e.g. cooking), which have been shown elsewhere to influence how and why some household's adopt certain food-related routines (Stancu et al., 2016; Stefan et al., 2013), may provide insight about possible intervention points for reducing consumer food waste. Although the survey is limited in terms of the number of food items that can feasibly be tracked, following up on items from aggregated food groups (e.g. plant-based versus animal-derived foods) may yield further insights regarding the influence of product type on utilization patterns within the same household. Furthermore, while the survey did measure refrigerator characteristics, unit-of-measurement errors in refrigerator dimensions meant that such characteristics could not reliably be included in our analysis. Improving the acquisition of this information from respondents will enable future studies to control for potentially important refrigerator characteristics. Another issue with the analysis presented in this paper is that it does not account for the effect of seasonality; repeated rounds would enable researchers to understand the effect of periodic changes in food-related routines as well as consumption and waste patterns while controlling for household-level fixed effects.

Lastly, based on the preliminary evidence presented in this study, an interesting avenue for future research is to test the 'household quality-control strategy' hypothesis put forward in section 4.1. That is, consumers adopt distinctive strategies for managing the safety and/or quality of household food inventory; some consumers 'outsource' quality control to institutions and monitor the safety/quality status of food items through both physical (e.g. appearance and odor) and institutional (e.g. date labels and grocery store reputation) signals, while others 'insource' quality control by selectively choosing high-quality produce and managing post-retail safety/quality through storage and preparation routines, monitoring the safety/quality of household food inventory primarily via physical signals. Such an investigation may yield a deeper understanding of the mechanisms through which food-related routines and product characteristics impact food waste outcomes.

6. Conclusion and policy recommendations

Using a national web-based survey to assess respondents' household refrigerator inventories, this pilot study assessed the relationship between food-related routines and important considerations in food-discarding decision making, as well as the influence of food-related routines and product characteristics on the utilization of refrigerated foods. The results indicate that consumers are primarily concerned with physical, followed by institutional, signals of food safety and quality when deciding whether to discard food. We also find evidence of systematic bias in self-reported expectations of food consumption, supporting the use of actual utilization as an indicator of food waste

[6] By comparison, structural models evaluated in Europe measure planning routines (meal planning, making of shopping lists, checking inventory) (Stancu et al., 2016; Stefan et al., 2013), shopping routines (whether consumers regularly buy too much) (Stancu et al., 2016; Stefan et al., 2013), and leftover use routines (methods of storage and reuse) (Stancu et al., 2016).

outcomes in this study. Additionally, despite using a limited set of food-routine indicators, this paper found evidence that food-related routines influence the utilization of refrigerated food items, supporting research findings from Europe showing that food-related routines are a primary driver of household-level food waste. Furthermore, this paper finds that specific date label phrases reduce the likelihood of food utilization, with ambiguous date labeling having the strongest negative effect. Consequently, clarifying and strengthening the meaning of physical and institutional signals of food safety and quality should be among the suite of strategies used to address household-level food waste in the United States. Such strategies include education campaigns specifically targeting consumers' understanding about physical signs of food safety and quality, while the system of date labels needs to be consolidated and standardized.

Declaration of Competing Interest

None.

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Appendix A

Table A1
List of original and modified coding for all variables used.

	Original coding		Modified coding	
Product characteristics				
Consumption expected at baseline?		NA [a]	0	Otherwise
			1	Yes
Selected item bought on sale?	1	Yes	0	Otherwise
	2	No	1	Yes
	3	Don't remember		
	4	Not applicable		
Selected product		NA	1	Vegetable
			2	Fruit
			3	Dairy
			4	Meat
In original package with a label?	0	No	0	Otherwise
	1	Yes	1	Yes
Date phrase on package	1	Best if used by	1	Best if used by
	2	Best by	2	Best by
	3	Best before	3	Best before
	4	Use by	4	Use by
	5	Sell by"	5	Sell by
	6	Packed on"	6	Other Phrase
	7	Other phrase	7	Date only
	8	No words, but there is a date	8	Not applicable/unsure
	9	I don't have the original package/I can't see the date clearly/I don't know the date		
	10	Not applicable		
Food-related routines				
Refrigerator cleaning frequency	1	Very Often	1	Never/rarely
	2	Often	2	Sometimes
	3	Sometimes	3	Often/very often
	4	Rarely		
	5	Never		
Grocery shop frequency	1	Less than once a month	1	Once a month or less
	2	Once a month	2	2 to 3 times a month
	3	2-3 times a month	3	Once a week or more
	4	4 Once a week		
	5	Twice a week or more		
Grocery shop typically 30 min. or more? (Y = 1)	1	Less than 15 minutes	0	Less than 29 minutes
	2	15-29 minutes	1	30 minutes or more
	3	30–44 minutes		
	4	45 – 49 minutes		
	5	60 – 90 minutes		
	6	More than 90 minutes		
Check nutrition labels	1	Always	1	Never/rarely
	2	Often	2	Sometimes
	3	Sometimes	3	Often/always
	4	Rarely		
	5	Never		

(*continued on next page*)

Table A1 (*continued*)

		Original coding		Modified coding
Check expiry date	1	Always	1	Never/rarely
	2	Often	2	Sometimes
	3	Sometimes	3	Often/always
	4	Rarely		
	5	Never		
Other shopping & food disposal characteristics				
Majority grocery shopping done at supermarket only?	0	No	0	Otherwise
	1	Yes	1	Yes
Use own car to do shopping? (Original question: transportation used)	1	Own car	0	Otherwise
	2	Someone else's car	1	Yes
	3	Rented car/ car sharing		
	4	Public transport		
	5	Taxi, Uber, Lyft or similar service		
	6	Bike		
	7	Walk		
	8	Other		
Compost/food waste disposal service?	1	No, discarded food goes in the trash or disposal	0	Otherwise
	2	Yes, discarded food is picked up separately and is composted by others	1	Yes
	3	Yes, I transport discarded food to community compost bin		
	4	Yes, I compost discarded food myself		
Pets/animals that eat unwanted food?	0	No	0	Otherwise
	1	Yes	1	Yes
Respondent characteristics				
Race	1	White	1	White
	2	Black/ African American	2	Black/African American
	3	Asian	3	Other
	4	Native Hawaiian or other Pacific Islander		
	5	American Indian or Alaska Native		
	6	Other		
	7	Prefer not to answer		
Age	1	Under 18	1	Under 35
	2	18 to 24	2	35 to 64
	3	25 to 34	3	65 and older
	4	35 to 44		
	5	45 to 54		
	6	55 to 64		
	7	65 and older		
Female	0	Male	0	Male
	1	Female	1	Female
Highest level of education	1	Less than 12th grade, no diploma	1	High school diploma or les
	2	High school graduate, diploma or GED	2	Some college or Associate`s degree
	3	Some college or associate degree	3	Bachelor`s degree
	4	Bachelor's degree	4	Graduate or professional degree
	5	Graduate or professional degree		
Employment status	1	Full-time	1	Full-time
	2	Part-time	2	Part-time
	3	Retired	3	Retired
	4	Student	4	Student
	5	Other	5	Other
Household characteristics				
Annual HH income	1	Less than $24,999 per year	1	Less than $50,000
	2	$25,000 - $49,999 per year	2	$50,000 to $99,999
	3	$50,000 - $74,999 per year	3	$100,000 or more
	4	$75,000 - $99,999 per year		
	5	$100,000 - $150,000 per year		
	6	$150,000 and above per year		
Household size		NA		NA
Nr children in household		NA		NA
Participate in govt assistance nutrition programs? (Y = 1)	1	Yes	0	Otherwise
	2	No	1	Yes
	3	Don't know		
Food insecurity proxy		NA		NA
10 or more pieces of fruit/veg? (Y = 1)		NA	0	Otherwise
			1	Yes

(*continued on next page*)

Table A1 (*continued*)

	Original coding		Modified coding	
Other				
Refrigerator relative fullness at baseline	1	More empty than usual	1	More empty than usual
	2	About normal	2	About normal
	3	More full than usual	3	More full than usual

[a] Original categories comprised of non-mutually exclusive binary variables.

Table A2
Logit regression results for the mismatch between expected and actual utilization.

	Mismatch between expected and actual utilization	
	Log odds	(SE)
Product characteristics		
Selected item bought on sale? (Y = 1)	−0.663	(0.637)
Selected product (Base: Vegetable)	*Joint p = 0.746*	
- Fruit	−0.358	(0.696)
- Dairy	−0.826	(0.750)
- Meat	−0.535	(0.714)
Date phrase on package (Base: Not applicable/unsure)	*Joint p = 0.050*	
- Best if used by	−0.125	(0.665)
- Best by	3.052**	(1.374)
- Best before	−0.091	(1.271)
- Use by	0.898	(0.889)
- Sell by	1.678*	(0.934)
- Other Phrase	−0.573	(1.819)
- Date only	3.837**	(1.491)
Food-related routines		
Refrigerator cleaning frequency (Base: Never/rarely)	*Joint p = 0.075*	
- Sometimes	2.913**	(1.293)
- Often/very often	2.828**	(1.283)
Grocery shop frequency (Base: Once a month or less)	*Joint p = 0.642*	
−2 to 3 times a month	−0.645	(0.969)
- Once a week or more	−0.262	(1.025)
Grocery shop typically 30 min. or more? (Y = 1)	−0.775*	(0.437)
Check nutrition labels (Base: Never/rarely)	*Joint p = 0.048*	
- Sometimes	−1.776**	(0.748)
- Often/always	−1.430**	(0.710)
Check expiry date (Base: Never/rarely)	*Joint p = 0.643*	
- Sometimes	−0.782	(0.947)
- Often/always	−0.692	(0.798)
Other shopping & food disposal characteristics		
Did a grocery shop since baseline survey? (Y = 1)	−0.125	(0.496)
Majority grocery shopping done at supermarket only? (Y = 1)	0.613	(0.499)
Use own car to do shopping? (Y = 1)	−1.517*	(0.871)
Compost/food waste disposal service? (Y = 1)	−1.468**	(0.749)
Pets/animals that eat unwanted food? (Y = 1)	1.527**	(0.702)
Respondent characteristics		
Race (Base: White)	*Joint p = 0.441*	
- Black/African American	−0.787	(0.765)
- Other	−0.575	(0.600)
Age (Base: Under 35)	*Joint p = 0.306*	
−35 to 64	−1.235	(0.808)
−65 and older	−1.156	(0.941)
Female (Y = 1)	0.464	(0.572)
Highest level of education (Base: High school diploma or less)	*Joint p = 0.547*	
- Some college or Associate`s degree	−0.103	(0.580)
- Bachelor`s degree	−0.585	(0.664)
- Graduate or professional degree	0.555	(0.849)
Employment status (Base: Full-time)	*Joint p = 0.645*	

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Table A2 (*continued*)

	Mismatch between expected and actual utilization	
	Log odds	(SE)
- Part-time	0.164	(0.996)
- Retired	−0.108	(0.771)
- Student	−1.438	(1.907)
- Other	−0.922	(0.690)
Household characteristics		
Annual HH income (Base: Less than $50k)	*Joint p = 0.388*	
- $50k to $100k	−0.130	(0.575)
- More than $100k	−1.133	(0.832)
Household size	0.156	(0.283)
Number of children in household	−0.441	(0.440)
Participate in govt assistance nutrition programs? (Y = 1)	0.377	(0.774)
Food insecurity proxy	−2.846***	(0.930)
10 or more pieces of fruit/veg? (Y = 1)	0.112	(0.580)
Other		
Refrigerator relative fullness at baseline (Base: About normal)	*Joint p = 0.097*	
- More empty than usual	0.939*	(0.534)
- More full than usual	1.244*	(0.712)
Constant	2.165	(1.987)
Observations	162	
McFadden's Pseudo R^2	0.278	
Model df	46.000	
$LR_{\chi 2}$(df)	62.495	
Prob > χ^2	0.053	

Standard errors in parentheses
* p < .1 ** p < .05 *** p < .01

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resconrec.2019.104440.

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