

# **From the Shelf to the Landfill: The Effect of Socio-Demographic Factors on Wasting Behavior and the Impact of Survey Methods on Food Waste Reporting**

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## **Abstract**

Food waste is a global concern with significant economic, environmental, and ethical implications. Household food waste behavior has been studied extensively using techniques such as self-reported surveys, focus groups, food waste diaries, image applications, and waste audits. However, there remains a lack of clarity on the accuracy of measurement methods. For example, self-reporting methods are commonly associated with underreporting biases due to guilt, shame, and a lack of self-awareness surrounding food waste. The uncertainty associated with each method can lead to misallocation of resources and misinformed policy decisions. To address this, the uncertainties associated with each method must be quantified. These uncertainty values can then be applied to statistical models of food waste behavior to improve predictions affected by various stages of state development. Food waste causes, behaviors, and solutions differ based on factors such as socioeconomic status, culture, social pressure, and intention to reduce waste. For instance, forgetting about perishable food, purchasing or cooking excess food, and misunderstanding best-by dates largely contribute to food waste in developed countries. In contrast, upgrades to storage and transportation infrastructure are most effective at reducing food waste in developing countries. This literature review delves

into the various drivers of food waste, ranging from individual behavior to sociocultural influences. It examines how demographic and psychographic factors play a crucial role in shaping individuals' food waste behaviors. Additionally, this literature review describes previous data on underreporting biases associated with different data collection methods. Understanding how specific demographics impact these drivers and factors is vital to designing effective strategies to reduce food waste such as targeted composting programs.

## **I. Introduction**

Although about 2.5 billion tons of food are wasted each year worldwide, the United States is the largest contributor to food waste. Almost 40% of food in the United States is discarded, equating to 60 million tons of food per year or 325 pounds of waste annually per person (U.S.D.A., 2023). This includes waste at the retail (commercial) and consumer (household) levels. About 30% of Americans claim that they do not produce food waste (Neff et al., 2015). However, this is extremely unlikely, indicating a general lack of Americans' self-awareness of their role in food wastage. Food is currently the single largest contributor to municipal solid waste making up 22% of the space in US landfills. Land, water, capital, and energy are used to produce, process, transport, store, and dispose of food waste valued at \$218 billion.

Household food waste (HFW) accounts for 39% of total food waste in the U.S. (Feeding America, 2023). Household food waste (HFW) refers specifically to food discarded by consumers at their residences. HFW consists of leftovers, expired or stale food, blemished produce, inedible portions of food like peels and rinds, and excess food. Recent studies of Italian, Dutch, Serbian, and Polish families found that the most commonly discarded foods are bread, fresh fruit, vegetables, non-alcoholic drinks, milk, yogurt, and meat (Aureli et al., 2021; Janssens et al., 2019; Djekic et al., 2015; Bilska et al., 2019). Bread is particularly wasted by younger consumers (Bilska et al., 2019). These wasted products are perishable and often go bad before use or after only partial use (van Geffen et al., 2017). Food quality markers, such as cosmetic flaws, bruises, scratches, texture changes, deterioration, odor, and off-colors play a role in consumers' decision to discard food regardless of whether the food is unsafe to eat (Dusoruth & Peterson, 2020). As a result, improving the quality and shelf-life of perishable foods with postharvest treatments reduces the likelihood that consumers will waste food. When

quality attributes of produce remain acceptable to consumers, they are more likely to consume the product than waste it (Neff et al., 2015).

Over time, people have paid increased attention to food waste reduction for economic, environmental, and ethical reasons. Despite the increasing attention given to household food waste, there remains a lack of clarity on the accuracy of measurement methods. The uncertainty associated with each method can lead to misallocation of resources and misinformed policy decisions. To address this, the uncertainties associated with each method must be quantified. These uncertainty values can then be applied to improve predictive models of food waste behaviors. In addition, the impact of demographics and psychographics explains 7-13% of the variance in intention to reduce waste and perceived control of HFW (Visschers et al., 2016; Werf et al., 2019). Analyzing specific interactions between these factors will allow for more accurate agents in the model. Amounts of HFW determined in several studies are summarized below (Table 1).

**Table 1.** *Breakdown of amounts of household food waste (Ai & Zheng, 2019).*

Waste Generator Type	Generator Rate	Amount of Recoverable Waste
Single-Family Household	212-215 kg (Jones, 2004; U.S. EPA, 2009)	41-93 kg, 2-5% to 36-46% (KCI, 2012)
Multi-Family Household	143 kg (CDM, 2010a)	---
Individual	52-59 kg (Griffin et al., 2008; U.S. EPA, 2014) 109 kg (Jones, 2004)	2.4% (Griffin et al., 2008)

## II. Factors Impacting Food Waste

The basic drivers of food waste are self-explanatory: either too much food is prepared, or food is not consumed before its expiration date (de Bruin et al., 2019). However, these studies have also demonstrated that a wide variety of factors can impact food waste, including gender, age, household attitudes, diet, socioeconomic status, and seasonality.

### **a. Gender and Ages in Household**

In certain cases, gender and age have significant impacts on the amount of food waste one produces. Research from Romania used questionnaires to gather data about food waste behavior based on various age groups (Cantaragiu, 2019). The data suggested that for people aged 30 and younger, men were likely to adjust their consumption to avoid throwing away aging or excess food. On the other hand, women between the ages of 20-30 tended to cook more food than the household could consume and suffered from feelings of guilt related to food waste. In the 30 to 40-year-old group, women were more proficient at cooking and ate at home more than men. The women in this age category were also more concerned about the financial impact of their food waste (Cantaragiu, 2019). This data provides insight into the behavior of these groups and how they perceive themselves, which has the potential to be used in targeted program design surrounding food waste. It is also important to note that both genders reported that having a supportive partner and the attitudes of their family members were pivotal in their food waste habits (de Bruin et al., 2019). Other studies have shown similar trends: in general, women report higher awareness of the consequences of HFW and more negative feelings towards food waste than men (van Geffen et al., 2017). Women and older individuals also report more confidence in their abilities to assess food safety, cook creatively, plan accurately, and assess shelf-life compared to men and younger respondents. These differences in attitudes and awareness impact decisions to waste food or employ reduction strategies (van Geffen et al., 2017).

Household size and mean age are associated with varied HFW as well. A waste analysis study conducted in Chicago found that the HFW of a single-family household was almost double that of a multifamily household (CDMb, 2010). However, another study found that HFW increases with household size (van Geffen et al., 2017). Households composed of younger generations or including children under 18 have been found to sometimes waste more. Younger people in general tend to waste more food than older individuals. This is due to a difference in lifestyle. Young individuals tend to eat out more frequently and have less experience in meal planning and food management (Neff et al., 2015). Retired individuals also have more time for food waste reduction practices compared to working adults (van Geffen et al., 2017).

### **b. Diet**

Diet is an element of food-wasting behavior that is heavily impacted by several factors. It is relatively well-known that diet and socioeconomic status are linked—people with high socioeconomic status (SES) tend to have

diets that are more consistent with national nutritional recommendations (Ala'a Alkerwi, 2015). A study in Iran found that an unhealthy diet increased the amount of bread waste but illustrated several discrepancies with other countries' findings: research in the US suggested that a higher diet quality was associated with higher household food waste using linear regression models, and research in Canada found that only daily fruit and vegetable waste was positively associated with diet quality. One theory presents that healthier diets may be more perishable, and thus result in more waste. Households with at least one member who follows a specialty diet may also pay increased attention to their waste production (Ghaziani et al., 2022). In addition, environmentally conscious individuals with pro-environmental attitudes and a high level of awareness about the impacts of food waste are more likely to engage in behaviors that reduce food waste. Thus, diet is a factor whose impacts on food waste are not fully understood, and more research is required in this area.

### **c. Social Pressure and Culture**

The culture one is raised in dictates tightly-held values that a person carries throughout their life. As a result, culture has a significant impact on food waste behaviors, as revealed in a review published in the *Journal of Ethnic Foods*. For instance, in South Africa, cultural and social events often involve preparing large quantities of food, leading to wastage when not all the food is consumed (Phasha et al., 2020). In contrast, Chinese culture promotes thrift and "clean plate campaigns" to reduce waste. As a result, those raised in Chinese culture may feel a larger burden to minimize their HFW (Wang et al., 2022). Studies have also found that Hispanic households have lower rates than non-Hispanics (Jones, 2004). The culture in which someone lives and participates in as an adult also plays a role in food waste behaviors. The actions of neighbors put social pressure on individuals to conform to local expectations (Van Herpen et al. 2019). Guilt and social pressure were found to be some of the most impactful drivers of food waste reduction and underreporting in food waste studies (de Bruin et al., 2019; Qi & Roe, 2016). This phenomenon has been termed "social desirability."

Parental status also impacts food waste behaviors. Parents with young children feel a unique type of social pressure to model good behavior to their children to encourage desirable habits (Neff et al., 2015). They may also engage in food waste reduction strategies like meal planning and creating a grocery list as they are cooking for a larger number of people (de Bruin et al., 2019). Approximately 57% of people report engaging in these preparatory activities regardless of parental status (Janssens et al., 2019).

Parents often feel pressure to be perceived as good role models and engaged citizens by other parents in their communities. With social pressure coming from multiple communities, parents may feel a larger responsibility to minimize their HFW. In addition, economic concerns drive HFW minimization as people believe it will save them money (Neff et al., 2015). Parents are often more conscious of food costs and tend to utilize leftovers.

Culture also plays a role in shopping behaviors which impact HFW. For example, those who make impulse purchases and buy more than they need tend to waste more. This type of shopping behavior is common in the United States (EPA, 2009). Impulse shopping can be influenced by the advertisements individuals see.



**Figure 1:** Posters for clean plate campaigns in the US (top) and China (bottom).

#### d. Socioeconomic Status

Demographic characteristics, as categorized by generation, income, rurality, and involvement in household food management, influence food waste behaviors as well (Neff et al., 2015; Ahmed et al., 2021; Melbye et al., 2016). Income level is associated with the quantity of food waste. Lower-income households waste less due to financial constraints and a focus on utilizing all available resources. Higher-income households tend to waste more, due to reduced price sensitivity and greater purchasing power. Food price plays a role in consumers' decision to waste food. If someone feels like the possibility of replacing a preferred food is low, they are likely to maximize the food they have (Ellison & Lusk, 2018). In addition, drivers of

food waste are different depending on the socioeconomic status of one's country of residence. In economically well-off countries such as the U.S., forgetting about perishable food, purchasing, or cooking excess food, and misunderstanding best-by dates largely contribute to food waste (de Bruin et al., 2019; Neff et al., 2015). One study highlights that nearly 70% of respondents agreed that throwing away food after the package date had passed reduced the odds of foodborne illness, demonstrating the influence of attitudes on food waste behaviors (Qi & Roe, 2016). In contrast, issues with proper storage and transportation infrastructure drive food waste in developing countries. With a lack of consistent access to refrigerated trucks, advanced processing techniques, and properly maintained food warehouses, food is more likely to spoil in these areas. The variance in food waste drivers in different countries is crucial to consider when developing effective mitigation strategies.

The effect of socioeconomic status on household food waste may vary internationally. In Iran, a study on the impact of dietary habits and socioeconomic status on household food waste was executed. The findings suggested a positive correlation between the volume of bread waste and income—in every season, the low-income group produced the least waste, and the high-income group produced the most waste (Ghaziani et al., 2022). However, other studies in Brazil suggested the opposite: that low-income groups were more likely to generate waste due to uninformed preparation management. In addition, people in rural areas may waste less food compared to their urban counterparts, possibly due to a greater connection to food production and a culture of waste reduction.

#### **e. Education and Knowledge**

Education level was found to have a moderate effect on individuals' attitudes toward food waste, as individuals with higher education were more likely to exhibit behaviors and attitudes associated with reducing food waste (Djekic et al., 2019). Individuals with higher levels of education are more likely to be conscious of food waste and its environmental and social implications, potentially leading to less waste. However, it is worth noting that other socio-demographic variables, such as age and income, had a more substantial impact on attitudes related to food waste (Karim Ghani et al., 2013). Self-awareness of food waste does play a role in HFW reduction (Ahmed et al., 2021; de Bruin et al., 2019; Roe et al., 2020; Hebrok & Boks, 2017). Specific knowledge of food handling, preparation, and storage techniques as well as food safety knowledge minimize waste (de Bruin et al.,

2019; Neff et al., 2015). With proper food handling techniques, individuals can maximize the shelf-life of their perishable foods. More advanced cooking knowledge contains techniques to utilize portions of food that are often discarded. For example, orange peels can be candied for dessert and animal bones can be used to add flavor to bone broth.

### **III. Survey Methods**

Survey methods are commonly used to study food waste behaviors. The IFIC survey revealed that consumers often underreport the quantity of food waste in their households in surveys. This underreporting could be attributed to the cognitive difficulty of estimating waste, social desirability bias, and the retrospective nature of reporting. Different survey approaches are associated with varying levels of uncertainty (Table 2). Diaries, for instance, are more accurate when using weighing methods, but they are susceptible to underreporting and behavior changes during recording; for example, diaries that ask participants to visually estimate waste have low accuracy. Participants also tend to stop recording their data over time due to the consistent work required to write in a diary multiple times a day. On the other hand, surveys with no specified recall time are quicker and have a higher response rate but suffer from the difficulty of recalling past behaviors. A study comparing survey methods, as reported in ScienceDirect, found that general survey questions about food waste over a non-specified period tend to lead to underestimation of food waste and low variance in reported food waste. The low variance between demographic groups makes determining useful relationships difficult. However, surveys about food waste in the past week proved to be useful for differentiating households based on the amount of food waste produced, despite still underestimating the total waste.

The FoodImage™ smartphone app, discussed in a study published in PMC, demonstrated advantages in reducing errors compared to traditional diary methods. It offers an efficient and accurate way to measure food waste by allowing users to transmit photos and tagged information about waste reasons and destinations. This method showed promise in overcoming the underreporting bias often observed in surveys. Food waste imaging apps often employ an artificial intelligence network to identify and quantify food waste. Artificial intelligence networks characteristically require large data sets to provide accurate analyses. There is currently a deficit in this type of data, requiring users to manually tag their images. This increases the burden on respondents and may reduce the response rate in longer studies. Winnow, a company that works on food waste solutions, has developed a



system that employs machine learning and cameras focused on trash cans to categorize food waste. This type of system may be useful in commercial kitchens but would be cost-prohibitive for the average American household. Food waste imaging holds promise to reduce the underreporting of food waste but requires further development to be a viable solution.

**Table 2.** *Summary of the benefits and drawbacks of different survey methods assessing food waste (van Herpen et al., 2019).*

Survey Method	Benefits	Drawbacks
Diary Method	More accurate than surveys if using a weighing scale method. More specific information can be gathered compared to a survey.	Approximately 45% underreporting of data. Behavior may change and confound variables during recording. Visual estimations have inaccuracies. Greater respondent burden.
Survey Without a Specified Recall Time	Quick, easy, higher response rate due to the survey being completed all at once. More participants can be recruited.	Participants have difficulty recalling past events. Associated with a large underreporting bias.
Pre-announced Survey with a Specified Recall Time	Less error than other survey methods. Quick, easy, and potential for more participants.	Prone to underreporting. Behavior may change when participants know their information will be collected.
Food Waste Imaging App	High accuracy when using a high-quality app. Much less respondent burden. Higher response rates. No underreporting bias so long as the app works as intended.	Technical difficulties. Researchers must teach users how to use the app. User error is possible. Lack of training data for accurate estimations.
Interviews	More specific details can be gathered regarding motivations and habits.	Time and logistic investment for researchers and participants. Lower number of participants possible with same amount of resources.

#### **IV. Food Waste Reduction Strategies**

To address the critical issue of food waste in the United States, various mitigation strategies can be employed. First, it is imperative to tackle the impulse-driven food purchasing behavior prevalent among Americans.

Promoting mindful and realistic assessment of food requirements and discouraging the habit of buying more food than needed can significantly reduce food waste. Additionally, fostering a cultural shift towards a more sustainable approach to food consumption is crucial. Encouraging people to utilize leftovers and creatively repurpose food scraps can help reduce waste. Specifically, Ai and Zheng found that of HFW from single-family households, 1.4% could have been viable donations (2019). Composting should be integrated into everyday food-preparation routines to divert organic waste from landfills, which contribute to greenhouse gas emissions. Moreover, improving product development, storage, shopping and ordering practices, marketing, labeling, and cooking methods can help minimize avoidable food waste. Inedible food can also be repurposed into various products, such as animal feed, compost, bioenergy, bioplastics, and clothing, further reducing its environmental impact.

Karim Ghani et al. used the theory of planned behavior to explain how individuals can be incentivized to reduce food waste (2013). Attitudes and setting an intention are key. Viewing food waste reduction strategies as a method to save money is also an effective strategy. Encouraging individuals to plan their meals and create shopping lists based on what they need can significantly reduce food waste (Neff et al., 2015). By framing this strategy in terms of saving money, people can realize the economic benefits of buying only what they will use, as it reduces the likelihood of impulsive purchases and food items going to waste. Educating individuals about the proper storage of perishable items can help extend their shelf life. Emphasizing the cost-saving aspect of this practice can motivate people to use airtight containers, resealable bags, and appropriate temperature settings in their refrigerators and freezers.

Leveraging social pressure can be a powerful tool to motivate individuals to reduce food waste. Community initiatives, challenges, or social media campaigns can be designed to encourage households to compete in waste reduction, creating a sense of responsibility and competition. Framing it as a community effort to reduce food waste can invoke a sense of social responsibility, adding a layer of motivation. Encouraging individuals to donate excess food to local food banks and shelters can be framed as both a way to save money (by not overbuying) and a socially responsible act that benefits the community. By framing food waste mitigation strategies in terms of saving money and utilizing social pressure, individuals can be motivated to make tangible changes in their daily lives. These approaches

not only help reduce food waste but also foster a culture of mindful consumption that benefits both individuals and their communities.

## **V. Citizen Science**

### **Overview**

Citizen science refers to a relatively new phenomenon in which community residents are engaged in research projects to help further scientists' understanding of subjects and formulate reliable conclusions (Bonney et. al, 2015). Citizen science projects differ from other types of research in that they require data collection and submission by members of the public (Bonney et. al, 2015). In this sense, people are given an opportunity through citizen science to contribute to research through a structured environment set forth by the leaders of the study. The term citizen science comes from a 1995 study at the Cornell Lab of Ornithology that used the public's participation to collect data on bird species (Bonney et.). al, 2015). Since then, citizen science projects have become incredibly widespread. As time has gone on, new technology has made it easier than ever to conduct successful citizen science research and make breakthrough policy recommendations as a result.

There are several ways to approach and structure citizen science projects depending on the research objectives and abstract (Pateman et. al, 2020). One group of researchers deduced that there could be four categories of citizen science research: Data Collection, Data Processing, Curriculum-Based, and Community Science (Bonney et. al, 2015). In the case of food waste research, data collection is by far the most common type of citizen science that is utilized. In recent years, many studies across the world have begun to use citizen science to collect information regarding food waste as well as make recommendations on how it can be reduced or eliminated (Pateman et. al, 2020). The hope is that citizen science can help researchers understand the root causes of food waste and its prevalence while also engaging people in an important issue that they can help to directly mitigate.

### **b. Benefits**

There are several benefits of the use of citizen science to research food waste. One such benefit is that citizen science helps to increase accountability in individuals and families for the food they consume versus waste (Pateman et. al, 2020). Additionally, researchers have found that citizen science is linked to the empowerment of people to get involved in important political issues and interact with local government institutions

(Bonney et. al, 2015). For food waste research, this means that people who participate in citizen science projects will be compelled to go further than simply collecting their data and potentially making a positive difference in their respective communities. Moreover, the use of citizen science in food waste research can help create a deeper understanding of the specific causes of food waste as well as any variables that may be involved (Pateman et. al, 2020). One study reinforced these findings through their recommendation for the use of citizen science to research food waste as a method of meeting the United Nations Sustainable Development Goals (SDGs) (Fritz et. al, 2019). Researchers point out that citizen science could be extremely helpful in monitoring how much food is wasted over several decades to encourage analysis and further study (Fritz et. al, 2019). Furthermore, emerging technology has made it a lot easier to advance citizen science in food waste to track more complicated statistics such as food expiration dates and weights (Fritz et. al, 2019).

### **c. Potential Drawbacks**

Although there are many benefits of using citizen science to study food waste, there are also some shortcomings that should be considered when deciding how to approach research in this area. For example, researchers note that to capture full legitimacy, citizen science projects must be extremely careful to follow all standards, regulations, and protocols in both the design and production of the study (Pateman et. al, 2020). This is no easy feat and can make it a lot more difficult to apply citizen science to food waste research. Another potential obstacle in using citizen science for food waste research is that there are not enough established methods of analyzing the data that is gathered which can lead to inferior conclusions in certain arenas (Bonney et. al, 2015). Along with these drawbacks, there are issues in citizen science research involving the recruitment of a diverse range of people to participate (Bonney et. al, 2015). This means that citizen science projects do not always have the reach they are intended for and end up attracting the same group of people who are already interested in a certain subject. Despite the drawbacks summarized here, citizen science is a unique and nonconforming approach to studying food waste that should be explored through further research and community participation (Fritz et. al, 2019). In doing so, researchers as well as policy makers will be better equipped to address food waste issues and explain the leading factors that drive it.

## **VI. Future Research**

Overall, quantitative data on the uncertainties associated with different survey methods to collect food waste data is still lacking. Future research should be conducted comparing specific survey methods to actual food waste data in the form of audits. These studies should be a minimum of two weeks long as food waste behavior changes during travel, holidays, and other seasonal events. Holidays are typically associated with higher HFW due to excess food cooked when estimating meals for a larger than normal group of people. However, the implications of seasonality on food waste is yet to be studied in quantitative detail. Demographic information such as income, age, education level, attitudes on food waste and sustainability, knowledge of food waste impacts, household composition, and role in cooking and purchasing decisions should be collected as well. Continued improvements of food waste imaging applications have the potential to open the possibility of recruiting a much larger participant population for food waste studies. An open-source collection of tagged food waste data allowing entries as citizen science could help fill the gaps in food waste data needed to improve the accuracy of these applications.

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