

# Chapter 7

## Improving Equity in Robot Deployment: A Study of Food Pantry Patrons

### 7.1 Introduction

Recent developments in robotics have enabled impressive capabilities in locomotion [174], manipulation [175], and socially-aware navigation [176]. As a result of this progress, it seems that large-scale robot deployment is only a short time away, with applications of manufacturing [177], warehouse management [178], and healthcare [179] receiving significant attention. One robotic technology that has already been deployed for several years is the autonomous delivery robot (ADR). Companies have been deploying ADRs in cities across the world, focusing on delivering food and groceries directly to customers. These companies promote their technologies as improving the convenience, sustainability, and affordability of food shopping [180–182]. Additionally, cities like Boston, U.S.A., have launched initiatives in collaboration with private partners to expand the deployment of ADRs [183].

Despite demonstrated interest and commercial viability, there are social, technical, and regulatory challenges surrounding ADRs that are still not resolved. For instance, researchers found that about 40% of YouTube comments relating to ADRs were negative [184]. Another study dis-

covered that public acceptance of ADRs is stratified among different groups [185] and publicized cases of harms caused by AI and robotics [138,143,145] may amplify certain groups' anxiety toward ADRs. Furthermore, ADRs are more reliable traversing wide, well-maintained sidewalks, which are more commonly found in affluent neighborhoods [186] and might exclude underserved communities that lack such resources. Meanwhile, cities and states have started enacting regulations for ADRs, but their approaches have varied significantly. The state of Pennsylvania, U.S.A. has a generous policy that limits ADRs to 550 lb and enforces a speed limit of 12 mph [187]. On the other end of the spectrum is the city of Toronto, which in 2021 voted to ban ADRs from operating due to safety concerns for people with disabilities [188]. Social, structural, technical, and policy factors all influence whether people from diverse backgrounds can benefit from ADRs, and there is still no consensus on the strategies needed to achieve this goal.

A relevant population for ADRs that has so far been overlooked is food pantry patrons. Boston has a significant population facing food insecurity, primarily concentrated in its most diverse neighborhoods of Dorchester, Mattapan, and East Boston. In these neighborhoods, over a quarter of residents face food insecurity [189], a rate twice the national average [190]. Food pantries can be a vital resource for these individuals, offering free distributions of food funded partially by the city. However, data from the City of Boston reveals that there are no food pantries in Dorchester or Mattapan, forcing residents to travel considerable distances to access this essential service [189]. ADRs could potentially address this issue, but it is unknown whether current ADR services align with the needs of food pantry patrons. Given Boston's public investment in both ADRs and food pantries, we explore whether these programs can be integrated to deploy ADRs for delivering free food to those in need. This concept is already being tested by the city of Arlington, U.S.A., which has launched a pilot program utilizing robots and drones to make food pantry deliveries [191]. However, as of this writing, the program has not yet publicized any findings on the specific needs of the food pantry community.

To evaluate the potential for ADRs to serve food pantry patrons, we approach the following research question: **How can ADR services be designed and deployed to benefit the food**

**pantry community?** This question is pertinent because while there is a body of work chronicling food insecurity in the United States, little attention has been given to how technological solutions could address this issue. Conversely, while significant effort has been invested in developing ADR technologies, there has been minimal investigation into their impact on underserved communities like food pantry patrons. Addressing this question will improve equity in robot deployment, meaning that people from all backgrounds can access and benefit from these technologies, regardless of their status.

To this end, we conducted semi-structured interviews with 21 food pantry patrons in the Boston area to gain insight into their food shopping experiences, related technology adoption practices, and perspectives on ADRs. Our data suggests that despite challenges, robot delivery would empower patrons to make food shopping decisions according to their evolving personal needs and preferences. This work offers the following novel contributions:

- an extension of prior literature investigating habits of those experiencing food insecurity by explicitly connecting to a potential technical solution
- identification of patron needs that current ADR services are unable to address and recommendations to tailor ADRs to these needs
- a guide for developers to study how technologies can be deployed equitably, ensuring that benefits are accessible to underrepresented populations.

These contributions will help governments synthesize insights from social science and technical innovations to deploy services that benefit marginalized communities.

The rest of the chapter is organized as follows. Section 7.2 provides an overview of food insecurity in the United States and the role of food pantries in addressing these needs, reviews the development of robots and other digital tools to support food pantry operations, and discusses research on the social, economic, and policy factors that influence ADR deployment. Section 7.3 details the design, execution, and analysis process of the qualitative study. Section 7.4 presents four themes that tell a nuanced story about the experiences and perspectives of food pantry

patrons. Section 7.5 connects these themes to the research question and provides takeaways for decision-makers. Section 7.6 discusses limitations of the study and Section 7.7 concludes the work.

## **7.2 Background and Related Works**

This section summarizes key research on food insecurity, the role of food pantries, the current state of ADR deployment, and the development of digital technologies for food pantries. It underscores the social issue of food insecurity, the limitations of current solutions such as food pantries in fully addressing this issue, and the lack of attention paid to how technologies like ADRs could serve these needs.

### **7.2.1 Food Insecurity and Shopping Patterns**

In 2022, 17 million U.S. households faced food insecurity, unable to provide enough food to meet their needs [190]. Confronted with these challenges, this underserved population is compelled to find unique ways to meet their food requirements. A large body of research has examined the food shopping patterns of low-income and food-insecure individuals. Studies reveal that factors such as price, accessibility, food quality, and selection significantly influence their shopping habits. [192,193]. These factors manifest in nuanced ways, such as shoppers evaluating food prices not only based on the sticker price but also considering potential food waste and how quickly the food will be consumed [194]. Additional research highlights that to navigate tight food budgets, low-income shoppers often display resourcefulness by shopping at multiple stores and seeking out sales [195–197]. This means they do not always shop at stores that are closest to them, and may travel farther for better prices rather than shopping at nearby stores [198,199]. However, this is not feasible for many shoppers who do not have a car and live in less affluent areas where public transportation is unreliable [200]. Addressing food insecurity is a complex challenge that demands further investigation.

When considering potential solutions, merely increasing the number of grocery stores may not effectively address food insecurity, as shoppers often travel farther for better prices. This has led to the appearance of food mirages— areas with a seemingly adequate number of food providers that remain inaccessible to those facing strict constraints [199]. Researchers have proposed expanding nutrition assistance programs like SNAP and encouraging more stores to accept these benefits [201], promoting urban agriculture [202], and enhancing access to affordable food through local food cooperatives and delivery [203]. This final piece is the focus of this study, as we investigate how ADR technologies could improve food access while reducing the need for extensive travel.

### **7.2.2 Food Pantries**

Given that up to 89% of food pantry<sup>1</sup> patrons experience food insecurity, food pantries are a crucial resource for many low-income households [205]. Research has shown that they positively impact food security, though they are often constrained by limited resources [206]. Food pantries tend to be independently run organizations connected to food banks and other organizations through partnerships like Feeding America [207]. Many are affiliated with schools, churches, or other community organizations. The frequency at which patrons can receive food varies depending on supply and demand, usually ranging from once a month to once a week. Some pantries also enforce residency requirements, such as neighborhood or zip code restrictions. In summary, food pantries are dynamic and diverse establishments that play a crucial role in their communities.

Research on food pantries and their patrons has involved soliciting direct feedback to enhance the food pantry experience. These studies have identified specific needs of patrons, including a desire for increased food quantity, improved food quality, healthier food options, and the ability to select their own food. [208,209]. Other studies have examined the characteristics

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<sup>1</sup>A food pantry is a location that distributes food at no cost. In contrast, a food bank is a warehouse that stores large amounts of food that is delivered to food pantries, but usually does not directly interact with patrons [204].

of food pantry patrons, revealing that long-term users often face prolonged unemployment and are likely to depend on government programs such as food stamps (now known as SNAP) [210]. A study conducted in the Pittsburgh, U.S.A. area found that ownership of a car was highly correlated with food pantry patronage, indicating patrons may have similar difficulties accessing food pantries as they do with traditional grocery stores [211]. Researchers have offered suggestions to improve food pantry services including formalizing food procurement and distribution operations and partnering with health organizations to promote healthy eating [206,212]. This study seeks to enhance the existing literature by exploring the potential of ADRs to address identified needs like food quantity and transportation, as well as the challenges that must be overcome to make this solution viable.

### **7.2.3 Autonomous Delivery Robot Deployment**

Research on ADRs is plentiful, particularly concerning deployment considerations like financial, regulatory, and social factors [213,214]. ADRs aim to solve the last-mile delivery problem, where traditional delivery vans are becoming increasingly costly as demand is increasing, workforce numbers are declining, and sustainability is becoming a more critical component of city planning [215]. ADRs attempt to address each of those challenges, promising financial savings for companies that deploy them [216]. In turn, companies assure customers will reap benefits of cheaper delivery fees and quicker deliveries [180,182].

As ADRs are being deployed in progressively greater numbers, regulation has become a priority for many municipalities. As referenced in the Introduction, states in the U.S.A. have begun limiting the size and speed of robots that can travel on public sidewalks [187,217]. Additionally, there is still uncertainty with how ADRs interact with existing laws and regulations such as data privacy, tort liability, and self-defense law [8,216]. These questions have so far gone unanswered in the legal realm and remain an obstacle to widespread ADR adoption. Although this work does not address specific laws and regulations, it documents the experiences of a marginalized community to better equip policymakers in protecting vulnerable populations. In particular, Sec. 7.5 dis-

cusses policy considerations for engineers and governments as they work toward public robotics initiatives.

Recently, increased attention has been paid to public reception of ADRs. As noted earlier, research has shown public support of ADR deployment is mixed [184,185]. However, much of this research has been done without participants actually interacting with a robot. Other studies examining real world human-delivery robot interactions have found mostly positive reactions to ADRs after observing cases of pedestrians greeting or assisting robots [218–220]. This tension suggests that interacting with a robot could alter how a person perceives ADRs, underscoring the importance of ensuring broad ADR access to prevent further stratification between privileged and underprivileged communities. Considering these studies drew from a convenience sample and did not consider underrepresented populations, this risk has so far been overlooked. We aim to address this gap by conducting a qualitative study with a diverse sample of potential ADR users who have not been involved in ADR development. This study did not involve direct interaction with robots, but future research could incorporate this element.

#### **7.2.4 Digital Technologies and Robots for Food Pantries**

In recent years, there has been some movement to incorporate digital technologies into food pantry services. Research has found that food pantry staff desire digital tools for staff and volunteer scheduling, inventory management, communicating with volunteers and staff, and more [221]. These technologies can help food pantry staff encourage patrons to consume more fresh vegetables [222]. On the other hand, in a review of 39 digital technologies that are currently being developed for food pantries, researchers found that most are lacking in user-centered design and have had limited real-world impact so far, indicating there is still much work to be done [223]. This work contributes to filling this gap by centering food pantry users in technology design.

Robots have been utilized in a few ways to support food pantries and food banks. One example is the “Picking with Purpose” program by warehouse automation company Berkshire Grey, where their pick-and-place robots packed meals for food banks to distribute [224]. Less directly,

robots have also been deployed to disinfect food bank warehouses [225]. Notably, these applications lacked any interaction with patrons.

In our review, we identified only two instances where ADRs have been used in conjunction with food pantry services. One example is at Arizona State University, U.S.A., where ADRs delivered food from a student-led food pantry to students on its Tempe campus [226]. The other case is a pilot program in Arlington, U.S.A., testing ADRs and drones for food bank deliveries [191]. Although the program is still in its early stages, the city has expressed plans to conduct community outreach to better serve the food pantry community. The use of ADRs for food pantries remains an underexplored possibility, and this study examines key considerations for practitioners to facilitate successful ADR deployments.

## **7.3 Methods**

While quantitative analysis is critical to test theories, qualitative analysis is equally necessary when building theories [227]. For a research problem that is poorly understood, like ADRs for food pantries, qualitative studies systematically reveal the holistic and emergent data that can then be evaluated with quantitative methods. In this section, we describe our methodology for this qualitative study, including participant recruitment, the authors' positionality regarding this study, the semi-structured interview procedure, and the data analysis process.

### **7.3.1 Participants**

In order to recruit participants for the study, we connected with two food pantries: the Margaret Fuller Neighborhood House [228] and the East End House [229]. While initial connection with the pantries in part consisted of email conversations, the first author also visited both pantries in person to volunteer, meet the staff, and assist patrons. These visits allowed the researchers to tailor the focus of the study based on this initial information finding. We then held conversations with the directors of these two food pantries to gauge how this study could be conducted to



maximize interest among patrons and minimize disturbance to food pantry operations.

Both partner food pantries have patrons representing a myriad of backgrounds, cultures, and demographics. In particular, there are many different languages spoken at the food pantry beyond English, including Cantonese, Haitian Creole, Spanish, Portuguese, Amharic, and more. Because Cantonese and Haitian Creole were the two most commonly spoken non-English languages, we hired interpreters to conduct interviews in these languages. Ultimately, we recruited 21 participants and conducted 8 interviews in English and 13 in Cantonese. We were not able to conduct any interviews in Haitian Creole as we had planned, which we discuss further in the following Sec. 7.3.2 and Sec. 7.6. In an attempt to preemptively address participant concerns around privacy and use of data, we did not collect any demographic or otherwise identifying data of the participants, including home location, age, race, gender, income, etc.

### **7.3.2 Positionality Statement**

None of the authors have been patrons of food pantries and approach the data with a level of privilege that influenced the project. The first author, who conducted all of the recruitment and interviews, is a mid-20 year old man of Chinese descent, and this may have had some impact on who was willing to participate in the study. It appeared that Cantonese speakers (which presumably were of Chinese descent, though this data was not collected) were significantly more eager to participate in the study compared to the Haitian Creole population that we also desired to recruit. Because of this, the majority of our participants were Cantonese speakers and we did not successfully recruit any Haitian Creole speakers.

### **7.3.3 Interview Design and Procedure**

We conducted a 30–60 minute long semi-structured interview with each participant that was live interpreted if requested. English interviews lasted 35 minutes on average, while interpreted interviews lasted close to an hour on average due to the additional time needed for live interpre-

tation. Interviews were held at a private room in one of the partner pantries and at public spaces like food halls when requested by participants. At the conclusion of the interview, participants received a grocery store gift card. All participants were completely anonymized. The study was approved by an external institutional review board (IRB).

While the semi-structured nature of the interviews meant that questions were not all predetermined or following a fixed order, the interviews generally consisted of three portions:

1. In the first portion of the interview, participants discussed their grocery shopping and food pantry experience. This consisted of information on where and how often participants shopped for groceries and their method of transportation to the grocery store. On the food pantry side, participants also shared their thoughts on the quality, convenience, and availability of foods along with how they felt the food pantry experience could be improved.

Example questions asked in this portion are:

- “What does your average week of grocery shopping look like?”
- “How did you first hear about the food pantry?”
- “What aspects of your food shopping experience would you change?”

2. Next, participants discussed any familiarity they had with grocery delivery services such as Instacart [230]. If the participant had utilized this type of service, they were asked to share why they chose to use the service and their perspective on the experience. If they had not used this service before, they were asked to discuss what changes might lead them to considering adopting the service. Questions in this portion include:

- “Are you familiar with existing food delivery services?”
- “What factors are preventing you from using these services?”
- “How would delivery services change your food shopping habits?”

3. Finally, we broached the subject of ADRs. For participants that were not familiar with these robot technologies, we showed images of different ADRs that have been deployed such as

Starship [180] and Serve [182]. Then, with this foundational understanding developed, the participants discussed their initial thoughts on using these robotic delivery services and the factors, both positive and negative, that differentiated the ADRs from human couriers. Types of questions in this portion are:

- “Do you believe a robot could successfully deliver groceries to your house?”
- “If you encountered a robot on the sidewalk, how would you react?”
- “Would you prefer having food delivered by a human or a robot?”

Each portion of the interview played a key role in answering our research question. The first portion allowed us to contextualize the needs, preferences, and practices of this sample in relation to prior studies on similar communities, laying the groundwork for discussions on how delivery services and robots could address these needs. The second portion was essential for evaluating participants’ current relationships with technology, which helped us assess the feasibility of ADRs for this group. For example, if participants were opposed to using digital tools, an ADR solution requiring a mobile app would likely be impractical. However, we found that while participants were not comfortable with navigating apps, they were willing to learn from friends or family members, suggesting potential for ADR adoption. The final portion built on the previous ones by providing insights into how robots might uniquely influence participant behaviors and decisions. This portion addressed the core objective of the study: identifying the design and deployment factors that would make ADRs valuable to patrons.

### **7.3.4 Data Analysis**

Each of the 21 interviews were audio recorded and then transcribed into English. For the Cantonese interviews, the spoken Cantonese was transcribed and then translated to English, giving us two versions of translation: one done by the live interpreter and one by the post-hoc translator. While this means that the translation was not strictly necessary, this was done to ensure the precise meaning of the participants’ words was captured. As will be discussed in Sec. 7.6,

there sometimes were minor discrepancies between the live-interpreted English and translated English. In cases of discrepancy, we deferred to the translated English for analysis due to the time constraints that make live interpretation difficult.

To analyze the transcripts, we followed the method of thematic analysis which “is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set” [231]. Thematic analysis ensures that takeaways from this study are backed by evidence from multiple participants. We also employed an inductive method of analysis, where codes and themes were not prepared ahead of time, but rather converged upon after several rounds of transcript review [232]. The purpose of this inductive method is to best allow the data to speak for itself, reducing the effect of researchers’ assumptions and biases into the analysis. Considering that this population has never been interviewed before about this topic, we found this approach most appropriate.

To conduct the analysis, two formal rounds of data review were conducted. First, an initial round of inductive, semantic coding was conducted. The first co-author coded all the transcripts, while the other five co-authors divided the transcripts among themselves, ensuring each was reviewed by two coders. Each coder was instructed to distill the core, “semantic” meaning of each participant’s words into a set of codes.

Next, the coders gathered to critically review the codes, focusing particularly on areas where discrepancies arose between coders. Since not every coder reviewed the data in its entirety, this meeting was also an opportunity to analyze whether the patterns that each coder observed in their portion of the data were representative of the data as a whole. From this, a set of initial proto-themes were generated that encapsulated the salient patterns the coders observed in the data.

In a second coding round, each coder revisited their data and revised, added, and removed codes with respect to the proto-themes that were generated. Then, the first author collected all of the codes to develop a conceptualization of the themes presented in Sec. 7.4, which were refined after further review of the data and codes. Quantitative data was compiled to summarize

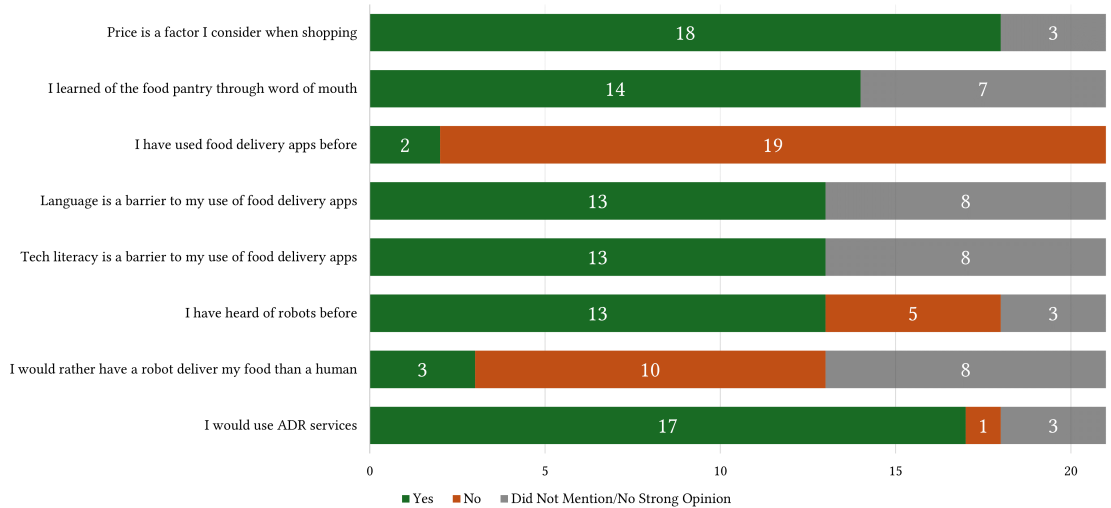


Figure 7.1: Summary of participant responses. Green shows the number of participants expressing agreement, orange shows disagreement, and grey indicates the topic was either not mentioned or no strong opinion was expressed.

key features of these themes, which are presented throughout this Sec. 7.4 and consolidated in Fig. 7.1.

## 7.4 Results

Based on the analysis of the data, we found four themes that are representative of participants' perspectives toward grocery shopping and ADRs. These themes highlight both challenges and opportunities for the successful adoption of ADRs within this community. By addressing these issues, technologists and decision-makers can enhance patrons' agency and quality of life, leading to more effective deployment of ADRs. The implications of these results are discussed further in Sec. 7.5.

### 7.4.1 Price dominates, but many factors are considered when patrons shop for food.

The first portion of the interviews shed light on how participants made decisions about food shopping and visiting the food pantry. Consistent with prior research, price was a primary consideration for most participants [192,193,201]. More specifically, we found the food pantry played a crucial role in providing flexibility and freedom, allowing participants to balance other important factors in their food shopping experience such as selecting foods they prefer and choosing their own fresh produce. This presents an opportunity for ADRs to further enhance this freedom by offering additional ways for patrons to access food.

### **Price as a driving force**

The most frequently mentioned factor participants considered when grocery shopping was price. This factor influenced where participants shopped and the types of foods they sought out. As P21 expressed: *"If I see an ad, like the ad and see something on sale that I want, then I'm like, okay, I'll go there."* Price also played a crucial role in participants' decisions to visit the food pantry. As P6 noted, *"Because now, ah, food prices are high. Food pantry is free, so we hope to get some food that will help reduce the food budget."* Overall, 85.7% (18/21) of participants cited price as a factor they considered. This suggests that in order for ADR services to be viable for this community, they will likely need to be offered free of charge, subsidized by external funds.

### **Prioritizing shopping factors based on preferences**

However, price was far from the only factor that participants considered when food shopping. They also weighed a variety of other factors, such as the freedom to select the types of foods they want and the ability to choose their own items to ensure freshness. As P8 and P17 expressed, respectively, *"I like that we can pick out stuffs that we don't need ... the food we like we will take, those we don't like we won't take. Then there won't be a waste."* and *"I go to the Chinese market to buy vegetables. They are so fresh. I want to choose the bag that I like the most."* As a result of having to carefully balance this complex set of factors, participants often faced inconveniences they were willing to tolerate, such as lengthy travel and long wait times at the food pantry. Some, like P5,

spent multiple hours on public transportation to reach the food pantry: *"I take the bus, I think one hour and a half or sometimes two hours [each way]."*

Despite these challenges, participants expressed appreciation for the food pantry's services. They did not view their food pantry experiences as acts of desperation, but rather as opportunities that provided them with agency in their food shopping. The food pantry allowed participants to prioritize essential factors like price, even if it meant sacrificing others, such as time.

*P11 – "It's free. So I don't think we can request anything more in my heart. It's impossible. They give away things for free, how can you have too much expectation?"*

The results from this theme largely align with prior studies, which highlight price as a dominant shopping factor [192,193,201] and the challenge of traveling long distances [198,199]. Synthesizing these findings allows us to conclude that food pantries empower participants by offering them choices in their food shopping. Importantly, ADRs have the potential to further enhance this agency by providing patrons with additional options to access the food they need.

### **Evolving needs**

Many participants noted that while their current situations led them to a certain optimal balance of factors, they expect that their needs may change in the near future as they age. As a result, they saw ADRs as a way to maintain flexibility and preserve agency as they navigate the shifting priorities in their lives. Many participants, like P16, currently preferred shopping in person but recognized that delivery services might become necessary in the near future: *"Because I can buy it myself, and I don't need it for now. When I get older ... maybe I will need it."* For others, these changing circumstances were already a reality:

*P17 – "But since I am old, it is too heavy and too many things to carry, so I feel difficult ... But of course, if the delivery service is good, then it's good. We don't have to go there. If we go to there, we'll have to take the public transportation and transfer, and then we have to bring the food back. It is also hard."*

ADR deployment for food pantries should focus on increasing the agency of patrons to food shop in ways that align with their preferred balance of factors like price, selecting preferred food types, picking the freshest produce, convenience, etc., especially as their life situations change. While ADRs can only address some of these factors, such as convenience, time, and the ability to select food types, enabling patrons to make choices that best suit their needs makes ADRs worthwhile.

#### **7.4.2 Patrons' social connections are key to their food pantry experiences.**

Participants found great value in a network of like-minded individuals with shared cultural backgrounds. This network included friends and family who informed them about the food pantry, as well as connections made with other patrons at the food pantry. Understanding and leveraging this network will be important for ADR adoption since formal methods of advertising may not be as effective. It is also necessary to acknowledge that ADRs may not support the preservation of connections made at the food pantry.

##### **Reliance on social connections**

Participants depended on friends and family for various aspects of their lives, including navigating technology and managing schedules. Social connections also influenced their food shopping habits, such as learning about the food pantry through word of mouth:

*P13 – “I talked to my friend about my situation and they just told me that ‘Oh I can bring you somewhere you can get free food.’ That’s how I know.”*

While both partner food pantries run substantial awareness campaigns through social media, mailing flyers, and other methods, 66.7% of participants reported learning about the food pantry through word of mouth. Previous research indicates that social connections support SNAP recipients in managing their food needs, with shoppers favoring trustworthy acquaintances over



unfamiliar sources [233]. Similarly, food pantry patrons may rely on their social networks because of established trust. Therefore, fostering trust with this community will be essential for effectively promoting ADR adoption.

### **Forming social connections at the food pantry**

At the food pantry, participants had the chance to expand their social networks by interacting with others who spoke their native language and shared similar backgrounds. P4 enjoyed the social aspect of visiting the pantry, saying: *"That's the reason I go to pantry because many people to talk ... the supermarket, I cannot talk too much. So that's good."* Similarly, P6 mentioned offering help to those they met at the pantry: *"I will chat with some people. Oftentimes, they don't speak English, so I will help them a bit, the easy stuff. Sometimes when they need to sign up, they don't understand."*

Participants benefited from meeting people at the food pantry, gaining both social interaction and assistance that would otherwise be unavailable. While it may be challenging for ADR technologies to replicate the in-person community building that occurs at food pantries, it's crucial to consider this factor in ADR development. The ineffectiveness of existing digital tools that automate communication and interaction between patrons might be due to this oversight [223]. ADR development should consider how the preferences and needs of users can be best served by technology while allowing patrons to determine themselves what trade-offs they are willing to make.

### **7.4.3 Language barriers and gaps in technological literacy are major obstacles to patrons adopting food delivery services, but they are open to learning how to use technology.**

Only 9.5% of participants reported having used existing human food delivery services, with most having never considered trying them. The two main reasons cited were English language barriers (62%) and lack of technological literacy (62%). These factors pose challenges for adopting ADRs

within this community. However, participants saw these issues as addressable with solutions such as offering mobile apps in multiple languages and providing assistance in navigating these apps, with many expressing a willingness to learn if given proper guidance.

### **Language barriers**

Almost all participants were non-native English speakers, and most were uncomfortable with English in conversation and when operating mobile devices. They expressed a lack of confidence in their ability to navigate an app available only in English. This is consistent with previous findings on the prohibitive nature of language barriers at food pantries [234]. Although a straightforward solution to this problem is to offer the app in Chinese and other languages, identifying the most commonly spoken languages at the food pantry requires deliberate effort by technologists. Engaging with patrons to promote multi-language options will significantly impact the adoption of ADR services.

### **Challenges with technology, but a willingness to learn**

Technological literacy also poses a challenge for using delivery services. Participants expressed low confidence in their ability to navigate apps. As P1 put it: *"But for me, no... Because you know, I don't know how to go to the app."* On the other hand, participants expressed a willingness to learn, with P9 stating, *"I would like to learn as long as someone can teach me."* While the Boston Public Library offers free computer and technology classes (even in languages like Chinese) [235], it did not appear that participants were familiar with these services. Instead, participants envisioned relying on children and younger family members for guidance. As P18 shared: *" I will ask my daughter to teach me. She teaches me, and I will know how to use."* This ties into the earlier theme of patrons' reliance on social connections, emphasizing the importance of understanding how to leverage these networks to promote ADR adoption.

Previous studies have provided recommendations for designers to make apps more accessible to older adults, who often struggle with smartphone interfaces [236,237] and these lessons

can also be incorporated into ADR app design. ADRs introduce the additional challenge of requiring human-robot interaction during drop-off, which participants also expressed anxiety about. As P16 noted: *"Because the real person delivering the goods will talk with you, but I don't know if the robot knows these things."* Although studies have explored how visual and auditory cues can enhance communication between robots and humans [238–240], the samples have lacked diversity and need further investigation to be applicable to this community.

#### **7.4.4 Despite mixed views on robot capabilities and risks, patrons are open to using robot delivery services.**

Participants had mixed perspectives toward robots in terms of both their capabilities and the risks they posed. Some believed that robots could perform almost any task, while others were concerned about their reliability in safely navigating around people. Participants also expressed concern about surveillance and job loss. These views tie into broader, ongoing discussions about assigning responsibility when robots fail and establishing regulations to prevent negative outcomes. It is crucial for governments to closely consider the perspectives of marginalized groups to ensure that communities most at risk are protected from potential harms caused by robots and other technologies.

Overall, participants had more confidence in humans making deliveries compared to robots. Despite this, an overwhelming majority expressed interest in using ADRs now or in the future. This apparent contradiction may stem from participants' belief that engineers will eventually resolve the current issues with robots. Consequently, roboticists have a responsibility to clearly communicate the capabilities and risks of robots and ensure they meet stakeholder expectations.

## Confidence and concern about robots

When asked about situations that ADRs may struggle with, some participants expressed full belief in robots. P12 stated, *"I feel like everything's so advanced now, that robots can pretty much do anything..."* Yet, others like P9 were concerned whether robots could safely navigate human environments: *"Yeah, I guess I'd be worried. Can they detect pedestrians? Yeah, I would be concerned about if they could sense a person. I don't want to see a crash or anything like that..."*

Participants also expressed concern about surveillance and job loss, though attitudes towards these issues varied widely. Regarding surveillance, some participants were uneasy about the possibility of a robot using a camera to record them, while others were indifferent.

*P12 - "I will feel that they are spying on me when I am walking."*

*P3 - "I doesn't matter to me. I am an old lady."*

Similarly, while some worried about job losses due to automation, others viewed the potential increase in efficiency favorably.

*P1 - "Maybe a lot of people, you know, lost jobs. Right?"*

*P14 - "The good part is that one robot can replace four or five persons; it will save costs that can be used on development."*

While the primary goal of this work is to improve equity in robot deployments by expanding access to the benefits of ADRs, these responses underscore the complementary need to equitably distribute the risks associated with ADRs. It is well-documented that certain groups, such as women and elderly adults, tend to have less positive attitudes toward robots [241,242] and face increased risks, including robot surveillance [145] and job displacement [243]. Regulatory agencies have a responsibility to protect vulnerable populations from harm, especially as interactions with robots will extend beyond the scope of current laws [244]. To effectively mitigate the risks posed to the food pantry community, it will be crucial to deepen our understanding of how robots will impact their lives and develop appropriate regulations.

## **Openness to using ADRs**

Despite mixed views toward robots overall, participants were overwhelmingly consistent in their answers to the following question: “Would you be interested in using a delivery robot for the food pantry?” 81% of participants stated they would be interested in utilizing ADRs at some point if they were available. This result suggests that ADRs for food pantries would address participants’ self-identified needs and would likely be readily adopted by food pantry patrons.

This comes despite most participants believing that robots would not outperform humans and might even perform worse in areas like speed and navigating obstacles such as stairs. Overall, only 14.3% of participants preferred robot delivery over human delivery, while 47.6% favored human delivery, and 38.1% had no strong preference. This apparent contradiction between participants’ preference for human delivery and their interest in using ADR services might be explained by the novelty of encountering a new technology. Based on our data, we also propose that participants had high confidence in engineers’ ability to resolve any lingering issues with ADRs.

*P3 – “If [roboticists] make this happen, you must have a good solution, right?”*

It is unclear why participants had such high trust in engineers’ ability to preempt any challenges that ADRs might face. This trust could stem from a lack of awareness about the negative impacts robots and AI have had on underrepresented groups [245–247] or from a belief that the potential benefits of ADRs outweigh their concerns. Regardless, ongoing engagement with this community will be essential to ensure that the technologies deployed align with their expectations.

## **7.5 Discussion**

### **7.5.1 Shaping the Future of ADRs**

This work builds on existing literature about food insecurity and food pantry patrons by exploring a potential technological solution. ADRs can offer significant value to food pantry patrons by providing them with additional flexibility to manage the complex food shopping needs in their lives. However, both our findings and previous research indicate that price is a major constraint for this community. To ensure that patrons can fully access ADR services, offering these services at no cost will likely be essential. Current ADR deployments are focused on profit-driven businesses, so implementing this solution will require government intervention and a redefinition of design requirements. But what incentives do governments have to invest in a food pantry ADR program? One motivation is the desire for cities to be at the forefront of technology deployment [248]. Many cities have already made significant investments in drones, robots, and AI chatbots for applications in policing and education [249–252]. Another incentive is the interest in promoting environmentally friendly alternatives to automobile travel. This was the motivation behind the U.S. Department of Energy funding the Arlington food pantry ADR pilot [191]. We encourage cities to explore whether deploying ADRs for food pantries could simultaneously achieve their goals of becoming technology leaders, promoting environmental sustainability, and serving marginalized communities.

Engineers will also play a crucial role in bringing ADRs to underrepresented communities. Much of the existing human-robot interaction research has focused on privileged populations, potentially alienating those with different needs and preferences [253]. Developers can address this by identifying communities that could benefit from their technologies and forming lasting partnerships to involve diverse groups in the technology development process.

### **7.5.2 Robots in Public Spaces**

This work closely ties into ongoing discussions about governing robots in public spaces. Scholars have argued that aspects of existing law can apply to robot interactions, like tort liability [254], privacy rights [128,244], and self-defense [8]. However, legal precedents for these issues have not yet been established, leaving these questions unresolved in the courts. If technologies do

not tightly adhere to regulations, they could face consequences like Cruise, whose autonomous vehicles were banned indefinitely after multiple accidents and traffic violations [255].

However, adhering to existing laws does not necessarily mean technologies are guaranteed to be accepted. Concerns of safety led Toronto, Canada to ban ADRs from operating in the city [188]. Developers must engage closely with the public and be sensitive to expressed concerns. This work contributes to a better understanding of community perspectives on robots. We found concerns regarding privacy and job security, though they were not pressing. As previously mentioned, this may be a consequence of participants not yet interacting with a robot and these perspectives may shift in the future. Continued effort to monitor public opinion of robots will be essential for robots to live up to their potential.

## **7.6 Limitations**

A particularly challenging aspect of this work was navigating the language barrier between the interviewer and participants. As mentioned, this was handled by providing live interpretation services along with translating all the spoken Cantonese into English during transcription. We chose to translate each Cantonese speaker into English twice (once during the interview and once afterwards from the recordings) in order to ensure we reported participants' words as faithfully as possible. We believed that the post-hoc translation would be more accurate because of the time constraints associated with live interpretation. There were occasions where there was minor discrepancy in the transcripts between the interpreted English and translated English, and in all of these cases we deferred to the translated English for coding and reporting. However, because none of the researchers spoke Cantonese, there was no reasonable way to prove which version was more faithful in these cases.

While this study successfully captured the perspectives of a previously unrepresented community toward robot deployment, there are potential sources of sample bias that may have made it difficult for certain groups to participate in the study. First is the fact that by recruiting partic-

ipants at the food pantry, people who have either chosen to not go to the food pantry or who are unable to were not recruited. This population deserves future attention, as enabling more people to access food pantry services should be a key goal. Additionally, as discussed in Sec 7.3.2, only English and Cantonese speakers participated in this study, excluding speakers of many other languages that may have diverse perspectives toward ADRs. For this study, forming further connections with the food pantry community and related community groups may have informed us of how to better recruit Haitian Creole speakers. These sample limitations are also opportunities for future research to further engage groups that were not fully captured in this work.

## **7.7 Conclusion**

Despite the growing presence of ADRs, research on their impact on underrepresented communities remains minimal. This study extends prior work on food insecurity and automated food delivery systems and explores how engineers and policymakers can effectively deploy ADRs for food pantry patrons. We interviewed 21 patrons from the Boston area, who shared their food shopping experiences and perspectives on delivery services and ADRs. Participants emphasized that ADRs could enhance their ability to navigate various food shopping factors. Although challenges such as language barriers, technological literacy, and privacy concerns exist, participants showed strong interest in using ADR services if available. Amid ongoing public discussions about regulating robotics technologies like ADRs, this research provides valuable insights into the potential risks and benefits for food pantry patrons and contributes to improving technology accessibility for underrepresented communities.

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