Smart Mobility for Seniors: Challenges and Solutions in El Paso, TX, and New York, NY

Matthew Vechione[1]
mmvechione@miners.utep.edu

Corina Marrufo[2]
cjmarrufo@miners.utep.edu

Raul Alejandro Vargas-Acosta[3]
ravargasaco@miners.utep.edu

Maria Guadalupe Jimenez-Velasco[3]
mgjimenezvelasco@miners.utep.edu

Okan Gurbuz[1]
ogurbuz@miners.utep.edu

Assel Dmitriyeva[4]
assel@nyu.edu

Ruey Long Cheu[1]
rcheu@utep.edu

Natalia Villanueva-Rosales[3]
nvillanuevarosales@utep.edu

Guillermina Gina Nunez-Mchiri[2]
ggnunez@utep.edu

Joseph Y. J. Chow[4]
joseph.chow@nyu.edu

[1]Department of Civil Engineering, The University of Texas at El Paso, El Paso, TX, United States of America

[2]Department of Anthropology and Sociology, The University of Texas at El Paso, El Paso, TX, United States of America

[3]Department of Computer Science, The University of Texas at El Paso, El Paso, TX, United States of America

[4]Department of Civil and Urban Engineering, New York University, New York, NY, United States of America

***Abstract*— Many older adults or seniors face mobility issues as they age, for example, switching from driving to using carpool, taxi, or staying on fixed routes. Seniors require responsive transportation services to attend activities. Unfortunately, there are limited tools to assist seniors to find the most appropriate transportation options given their mobility needs (e.g., inability to walk long distances, use of a cane). Mobile devices (e.g. smartphones, tablets, etc.) have demonstrated to be a useful tool to provide real-time information that has the potential to assist seniors with mobility challenges. This paper focuses on investigating senior citizens' mobility needs in El Paso, Texas and New York City, New York in order to define the requirements and recommendations for an ad-hoc solution on smart mobility for seniors, using state-of-the-art mobile technologies. In order to identify the main concerns and requirements to assist in mobility of seniors, a survey was conducted at various senior recreation centers across El Paso and New York City with a total of 458 and 61 responses, respectively. Survey results indicate that: (i) the most required assistance for seniors is the avoidance of traffic congestion; (ii) the majority of seniors who own mobile devices are not using the available applications or functions to meet their mobility needs; and (iii) seniors indicated that they prefer mobile applications that are easy and intuitive to use. These findings provide additional insights to those from previous surveys. We provide recommendations for researchers and developers interested in creating solutions for mobility of seniors based on these findings and the interactions with seniors when the survey was performed.**

Keywords—smart cities, smart mobility, seniors, mobile application

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I. INTRODUCTION

A. Motivation

Many seniors face mobility issues and changes in their lifestyle as they age; for example, switching from driving to using public transportation, carpooling, or relying on taxis. Seniors require the use of transportation services to participate in quotidian activities. However, a survey on current tools to support the mobility of seniors found that there are few solutions for the mobility of seniors. Although mobile devices, such as tablets and smartphones, have demonstrated to be a useful tool to provide real-time information that can assist seniors with mobility challenges, there are a few mobile applications that cater to the mobility needs of seniors in particular (e.g., information on Americans with Disabilities Act (ADA)-compliant infrastructure), and the few that exist have limited functions. Several national surveys have been conducted on senior mobility needs over the years (e.g. [1]). This study provides new insights to current literature by relating senior sociodemographic attributes with the use of technology (i.e., mobile devices) and emerging mobility services, from the perspective of two distinctly different cities.

B. Objective

The objective of this research is to better understand the mobility needs of seniors based on their lifestyle, in order to inform the development of technology-driven solutions and personalized mobility services. The information about the seniors' mobility challenges, needs, and preferences was acquired through a survey carried out in El Paso, Texas and New York City, New York in 2017 and 2018, respectively.

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C. Outline

This paper is outlined as follows. The next section reviews literature about challenges faced by seniors and existing mobile applications for seniors. Next, the survey instrument and the survey process are described. Then, we summarize the general findings, followed by the requirements for an ad-hoc mobile application that aims to increase senior mobility, specifically in El Paso, Texas and New York City, New York.

II. Literature Review

A. Definition of Seniors

Seniors are legally distinguished from the rest of the population by their age, although a person's seniority may depend more on the mental state, medical and physical health. Even if one uses age as the criterion, different age ranges have been found in Federal departments and agencies. These are summarized in Table I.

TABLE I. AGENCIES' DEFINING AGES FOR SENIORS

Agency	Defining Age
The U.S. Census Bureau [2]	65
The U.S. Department of Labor [3]	55
The U.S. Congress [4]	65-67
The U.S. Department of Health & Human Services [5]	65
Sun Metro (El Paso, TX bus service) [6]	65

The range of ages regarding what constitutes one being a senior varies from 55 to 67; however, there is a clear consensus of describing a senior as a person with at least 65 years of age. For this paper, a senior is considered a person age 65 or older.

B. Mobility Challenges Faced by Seniors

Accessibility to transportation options is a challenge for seniors [7]. Approximately 12 percent of all trips and 10 percent of all miles traveled in the United States in 2009 were taken by persons age 65 and older [8]. The share of transit users age 65 and older had increased by 40 percent between 2001 and 2009. In 2009, seniors accounted for more than 1 billion trips on public transportation (a 55 percent increase from what was reported in 2001).

As the share of trips made by seniors increases, providing senior-friendly transportation services will become a challenging problem for transportation agencies - seniors are challenged by the accessibility of transportation systems that are inadequately designed to meet their needs. Alsnih and Hensher [9] suggested conventional and specialized public transport as solutions to address mobility needs for seniors.

The changes that occur with aging can lead to problems with a person's ability to move around. Muscle weakness, joint problems, pain, disease, and neurological difficulties in older people contribute to mobility problems, as does falling [10], rheumatism (arthritis) [11], cognitive decline and dementia [12], and, subsequently, disorientation [13]. Therefore, a mobile application designed specifically for seniors must consider not only their physical challenges, but also their challenges in using technology (e.g., speech-to-text technology may be useful to mitigate typing constraints). Short message service (SMS) or texts, and email reminders would be welcomed by some patients, and extensive patient training would not be needed before implementation [14].

C. Existing Mobile Applications

This work focused on the use of mobile applications (simply known as Apps) that can be used in mobile devices to assist seniors with mobility challenges. Smartphones, when used with applications, are the primary solution to the mobility challenges faced by seniors. Mobile applications can assist with planning tasks that require the estimation of time periods to travel from point A to point B under specific circumstances, scheduling for transportation services, appointment reminders, and other functions that assist the seniors with mobility challenges.

Forbes [15] and Keystone Technologies [16] each released an article regarding the top-six mobile applications for seniors. Medical Alert [17] determined the top apps for seniors related to medical needs. These are summarized in Table II.

TABLE II. TOP MOBILE APPLICATIONS ACCORDING TO FORBES, KEYSTONE TECHNOLOGIES, AND MEDICAL ALERT

Forbes [15]	Keystone Tech [16]	Medical Alert [17]
Magnifying Glass with Light	Lumosity	Fade
Skype	Prismatic	iPB Blood Pressure
Pill Boxie	Medisafe	Pill Boxie
MedCoach	Mint Bills & Money	Viz Wiz
Games	WebMD	Motion Doctor
Red Panic Button	Audible	

The options listed in Table II show that the focus of mobile applications for seniors has not been on facilitating mobility for seniors, despite the presence of a few mobile applications in the market for various mobility needs. For example, AccessMap [18] enables safe, accessible trip planning on pedestrian ways for people with limited mobility. AXS Map [19] helps to find, rate, and share wheelchair accessible facilities. Although Google Maps is not designed specifically for seniors, the application is voice responsive [20] with navigation alerts, providing real-time route suggestions, and finding parking [21]. While it does not show ADA-compliant transport mode choices, from March 15, 2018, it supports "wheelchair accessible" route suggestions in London, New York, Tokyo, Mexico City, Boston, and Sydney [22]. The emergence of these mobile applications, along with their lack of acknowledgment from the senior community, illustrates the gap in this research area.

D. Previous Surveys of Seniors Mobility

Previous surveys have investigated the mobility needs of seniors in the United States. AARP Inc. commissioned the Understanding Senior Transportation Survey in 1998 [23].

The Independent Transportation Network (ITN) [24], founded as part of the Transit IDEA program, has sample data ($n = 2{,}094$) across the U.S. relating senior demographics to travel mode preferences [1]. Various cities and counties have conducted their own surveys (e.g. Sarasota County, CA [25]). Silvis and Niemeier [26] noted that ridesharing tends to be the second most common transport mode for seniors, behind driving. They then conducted a survey in California retirement homes and conducted behavioral analysis, which concluded that seniors with more active social networks used rideshare more regularly. Berenguer et al. [27] surveyed seniors on smartphone adoption but did not focus on mobility. These surveys provide useful information. Our work provides additional information with a focus on a resource that was not available before: mobile applications from a diverse set of population segments.

III. Surveys

A. Background and Purpose

Two identical surveys were conducted concurrently and analyzed—one in El Paso, Texas, and the other in New York (NYC), New York—to better understand the mobility needs of seniors and to identify common challenges, so that a mobile application can be developed to better meet their mobility needs. El Paso is a border city between the U.S. and Mexico, while NYC is the largest megacity in the U.S., which provides an additional understanding of features needed by the mobile application to be transferable from one city to another. In addition, the surveys targeted members of underrepresented groups. Both surveys had the approval of the Institutional Review Board (IRB) of the respective universities. Furthermore, all surveyors had proper IRB certification via the CITI program on research ethics and compliance training to survey human subjects.

B. El Paso, Texas Survey

Since the University of Texas at El Paso (UTEP) has an interagency agreement to collaborate with the City of El Paso Parks and Recreation Department, the research team coordinated with their representatives to gather information about the eleven senior centers in El Paso, which are strategically located across the city. The research team determined that the seniors from these centers were representative of the potential users of the mobile application, as they were still mobile and actively participated in the events held at the centers. Discussions regarding survey logistics, incentives, and survey instruments occurred during subsequent meetings.

1) Instrumentation

A survey instrument was created, which incorporated questions about the subject's demographics, physical limitations, activities, and open-ended questions. Once the survey instrument was drafted, it was translated to Spanish, as many seniors in El Paso are native Spanish speakers. The draft version of the survey instrument was shared with the City of El Paso Parks and Recreation Department staff and administrators for input and collaboration in administering the survey. The research team was advised to reduce the number of questions to 15 and to limit the survey duration to seven minutes, as seniors tend to have less patience and attention span. The research team was also advised to provide tangible incentives as tools to promote the survey and the future mobile application. Tote bags and water bottles with the application's logo, as well as snacks were given as incentives to survey participants in El Paso (no incentives were provided to participants in NYC, which might have contributed to a lower participation rate).

The survey was then tested with a small, yet representative, group of seniors. For this, undergraduate student researchers in the Department of Anthropology and Sociology at the University of Texas at El Paso tested the survey on senior family members. The final version of the survey instruments consisted of 17 questions, organized into four sections:

- Section 1: Participant's demographic characteristics
- Section 2: Three questions on participant's lifestyle
- Section 3: Five questions on participant's mobility needs
- Section 4: Three questions on smartphones and mobile applications

2) Survey Implementation

The eleven senior centers in El Paso are operated and managed by the City of El Paso Parks and Recreation Department. They are geographically located throughout various geographic areas of El Paso. We obtained permission from the City of El Paso Parks and Recreation Department to conduct the survey, and then coordinated with the directors and staff in each center regarding the dates and times to conduct the survey. The surveys took place mostly in the mornings, before lunch, between November 6, 2017 and December 1, 2017.

In addition to the senior centers, we coordinated with the El Paso Community College (EPCC), who has a senior living channel and computer classes offered to seniors. The survey was distributed to seniors in those classes and advertised on the senior living channel.

Both versions of the survey (i.e. English and Spanish) were created in Qualtrics as well as in an editable document. Hard copies were brought to the senior centers to have the seniors fill-out. The Qualtrics links (in English and Spanish) were shared with EPCC for their senior living channel and senior classes. Every hard copy of a completed survey was manually uploaded to Qualtrics at the end of each survey day.

3) Results

The survey was conducted in English and Spanish to be as inclusive as possible of the senior demographics in El Paso, TX. A total of 458 responses were received. The results obtained from the English and Spanish versions were analyzed separately and then combined.

The first part of the survey recorded the standard demographic profiles of the participants. The results for both Spanish- and English-speaking respondents (combined) are highlighted below:

- 73% of participants were over the age of 65.
- 69% of participants were female.
- 72% of participants were retired, followed by 12% who work full-time.

- 80% of participants were Hispanic/Latino, followed by 11% White.
- 77% speak Spanish with confidence, followed by 53% who speak English.
- Zip code results show that residents of all areas of El Paso were well represented (east, west, northeast, central, lower valley).

Most of the participants (80%) reported that they lived in their own house, which indicates that a majority of the participants were relatively independent, as they do not live in an assisted living facility (i.e. a nursing home). Slightly more than one-third (37%) of the participants reported that they did not have any impairments and/or disabilities. Of the remaining 63% who reported having impairments and/or disabilities, the three frequently reported issues were difficulty with walking, followed by visual and hearing impairments. A majority of participants (63%) reported that they did not require any assistance, followed by those who require only a cane to facilitate their mobility and balance.

The frequency of destinations traveled (per week) are tabulated in Table III, with the most frequented places being senior centers, libraries, parks, and gyms, with 64% of respondents reporting that they visit these types of places between three to six times per week.

TABLE III. EL PASO SURVEY TRIP FREQUENCIES [COMBINED].

Destination	Frequency
Work Place	Never (79%)
Volunteering Place	Never (59%)
Family Member, Relative, or Friend	1 to 3 times per week (44%)
Grocery, Market, or Retail Shop	1 to 3 times per week (55%)
Healthcare Facility, or Pharmacy	Less than once per week (64%)
Senior Center, Library, Park, or Gym	3 to 6 times per week (41%)
Civic or Religious Center	1 to 3 times per week (48%)
Restaurant, Coffee Shop, Diner	1 to 3 times per week (43%)
Bank, ATM, or offices	Less than once per week (54%)

The frequency of use of transportation means are tabulated in Table IV.

One of the last questions asked the participants to list the factor that would motivate them the most to use a mobile application, specifically designed for their mobility needs. A majority of the participants, who did not own a smartphone, as expected, did not provide an answer. For those who did own a smartphone, the most popular answers were getting to a destination efficiently while avoiding traffic congestion, followed by the simplicity and low cost of the application. Approximately 10% of the participants reported that they would be interested to use the application if there were educational classes offered to teach them how to use it, and even how to use a smartphone in general. Lastly, over three-quarters (78%) of participants reported that they would be willing to anonymously share their data collected via the application (e.g. their origins, destinations, travel time, departure time, etc.), which are all very valuable to transportation researchers.

TABLE IV. EL PASO SURVEY MODES OF TRANSPORTATION [COMBINED].

Mode of Transportation	Frequency
Walking More Than ¼ Mile	Never (41%)
Bicycle	Never (91%)
Motorcycle/Scooter	Never (97%)
Car (as Driver)	7 times per week or more (45%)
Car (as Passenger)	Never (42%)
Carpool (as Driver or Passenger)	Never (79%)
Public Bus	Never (71%)
Special Bus (e.g. Lift)	Never (90%)
Taxi	Never (95%)
Rideshare (e.g. Uber)	Never (95%)

C. New York City, New York Survey

Concurrent to the El Paso survey, an identical survey was conducted in New York City. The purpose of this survey was for quality control and quality assurance, as well as providing requirements from a different city for the design of a solution that can be transferred across cities.

1) Instrumentation

To conduct the survey in New York City, two students from New York University conducted the survey at various senior centers.

2) Survey Implementation

Based on NYCHA Facilities and Service Centers source data from December 2012 [28], there are 116 occupied senior centers in New York City. Facilities are sponsored by different agencies and geographically located in Bronx, Brooklyn, Manhattan, Queens, and Staten Island boroughs. It was decided to focus on urban areas and conduct surveys in Manhattan's senior centers.

Further discussions took place with the staff at each center regarding logistics (i.e. best days and times to conduct the survey). The surveys took place at five different senior centers from February 5 to February 16, 2018.

Although the survey was created in Qualtrics, the same questions were copied in a word editor. Then, hard copies were brought to the senior centers to have the seniors fill-out. Each hard copy completed survey form was manually uploaded to Qualtrics at the end of each survey day.

3) Results

The survey in New York City was conducted only in English. A total of 61 responses were received. The first part of the survey recorded the standard demographic profiles of the participants. The results are highlighted below:

- 76% of participants were over the age of 65.
- 79% of participants were female.
- 93% of participants were retired.

- 60% of participants were African American, followed by 35% Hispanic or Latino.
- 75% speak English with confidence, followed by 43% who speak Spanish.
- Zip code breakdown results show that East Harlem, Harlem, Hamilton Heights, and Washington Heights neighborhoods were represented.

In contrast to the El Paso survey, a majority of the participants (97%) reported that they lived in an apartment, which makes sense, as there are more apartments in New York City [29]. Almost half (46%) of the participants reported that they did not have any impairments and/or disabilities. Of the remaining 54% who reported having impairments and/or disabilities, the three frequently reported issues were difficulty with walking, followed by visual and muscle control impairments. Approximately one third of participants (34%) reported that they did not require any assistance, followed by those who require only a cane (31%).

The frequency of destinations traveled (per week) are tabulated in Table V. The most visited places are senior centers, libraries, parks, and gyms. The frequency of use of transportation modes are tabulated in Table VI. We observed that 80% never use paratransit service, and only 13% use ridesharing services.

One of the last questions asked the participants to list the factor that would motivate them the most to use a mobile application specifically designed for their mobility needs. Among those who owned a smartphone, the most popular answers were getting to a destination efficiently, followed by the simplicity of the application.

TABLE V. NEW YORK SURVEY TRIP FREQUENCIES.

Destination	Frequency
Volunteering Place	Never (69%)
Family Member, Relative, or Friend	Never (41%)
Grocery, Market, or Retail Shop	1 to 3 times per week (38%)
Healthcare Facility, or Pharmacy	Never (33%)
Senior Center, Library, Park, or Gym	3 to 6 times per week (44%)
Civic or Religious Center	Never (43%)
Restaurant, Coffee Shop, Diner	Never (48%)
Bank, ATM, or offices	Less than once per week (36%)

Lastly, and in contrast to the El Paso survey, over half (56%) of the participants reported that they would not be willing to anonymously share their data collected via the application.

TABLE VI. NEW YORK SURVEY MODES OF TRANSPORTATION.

Mode of Transportation	Frequency
Walking More Than ¼ Mile	7 times per week or more (30%)
Bicycle	Never (93%)
Motorcycle/Scooter	Never (100%)
Car (as Driver)	Never (90%)
Car (as Passenger)	Never (54%)
Carpool (as Driver or Passenger)	Never (87%)
Public Bus	Less than once per week (26%)
Special Bus (e.g. Lift)	Never (80%)
Taxi	Never (56%)
Rideshare (e.g. Uber, Lyft)	Never (87%)

D. Key Findings from Both Surveys

1) Electronic Device Usage

For both surveys conducted, the smartphone was reported as the most frequently used electronic device at 49% and 62% for El Paso and New York City, respectively. Both are higher than the national average in the U.S., which is pegged at the mid-30s range [27], likely due to the correlation with city residents compared to rural residents. The basic home phone was the second most-frequently used electronic device for both surveys conducted at 39% and 56% for El Paso and New York City, respectively. The results for all electronic devices used from both surveys are presented in Fig. 1. The follow-up question asked the participants if they require any assistance to use such devices. Almost three-quarters (74% and 70% for El Paso and New York City, respectively) of respondents reported that they did not require assistance; however, an informal discussion with the respondents provided insights that they use their smartphone exclusively to call or text relatives, while expressing limited knowledge of the full functions and applications associated with smartphones.

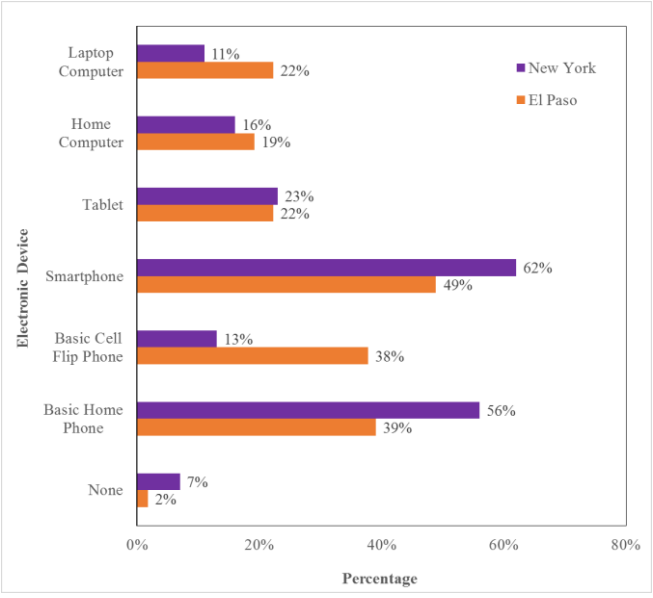

Fig. 1. Electronic device usage.

2) Concerns When Planning a Trip

In the El Paso survey, the most frequently selected concerns while making a trip within the city were on-time departure, followed by protection from extreme weather, and cost. In the New York City survey, the most frequently selected concerns while making a trip within the city were cost, followed by the protection from extreme weather, and on-time departure. The top three-concerns from both surveys were the same, in different orders. The results for all types of concerns when planning a trip are presented in Fig. 2.

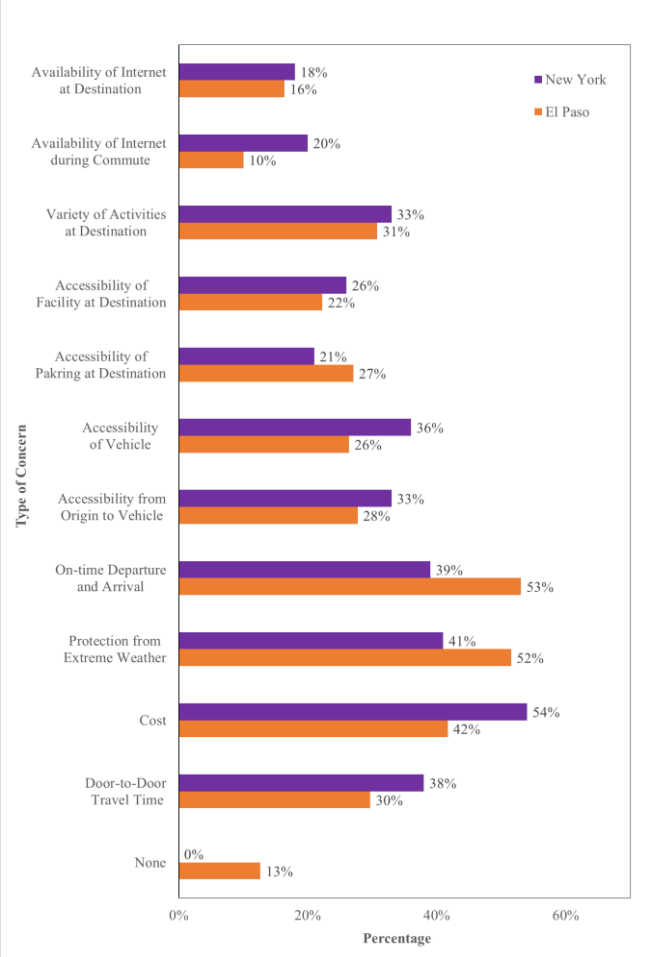

Fig. 2. Concerns when planning a trip.

3) Mobility Challenges

An open-ended question asked the participants to describe their biggest challenge when they commute in the city. In the El Paso survey, a majority of participants (62%) reported that traffic, parking, and construction was the greatest challenge when commuting in the city, followed by difficulty with walking (15%). In the New York City survey, one-third of participants (33%) reported that waiting time was the greatest challenge when commuting in the city, followed by traffic, parking, and construction (19%) and accessibility to vehicles and buildings (19%). These results confirm our hypothesis that seniors are in direct need of a mobile application that guides them before and during their trips within the city (e.g., avoiding traffic congestion, help finding parking, avoiding construction, etc.) The results for all recorded mobility challenges are presented in Fig. 3.

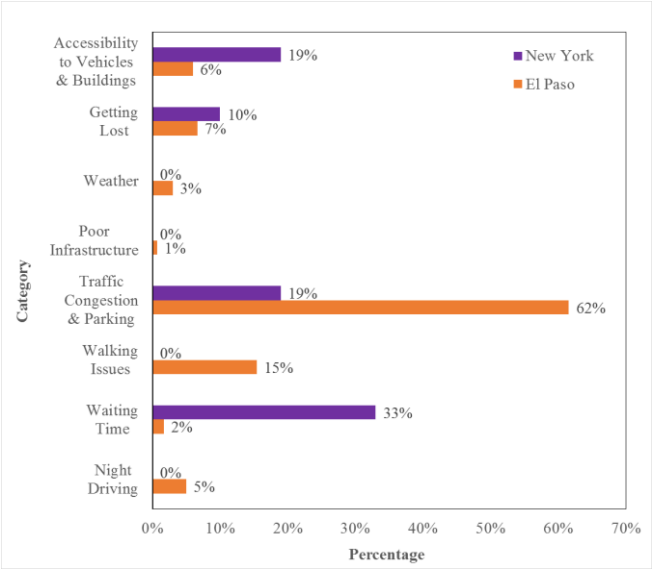

Fig. 3. Mobility challenges.

4) Desired Mobile Application Functions

Another open-ended question asked the participants to list one function they would like to see in a mobile application. In the El Paso survey, the most popular answer was navigation (53%), followed by the inclusion of bus routes (20%), and then the overall simplicity and intuitiveness of the application (13%). Fear of getting lost during navigation was a theme vocalized by survey participants. In the New York City survey, one answer choice that was not seen in the El Paso survey was the most popular answer: the features of the mobile application (60%). The next most popular answers were navigation (13%) and bus routes (13%). The results for all recorded desired functions are presented in Fig 4.

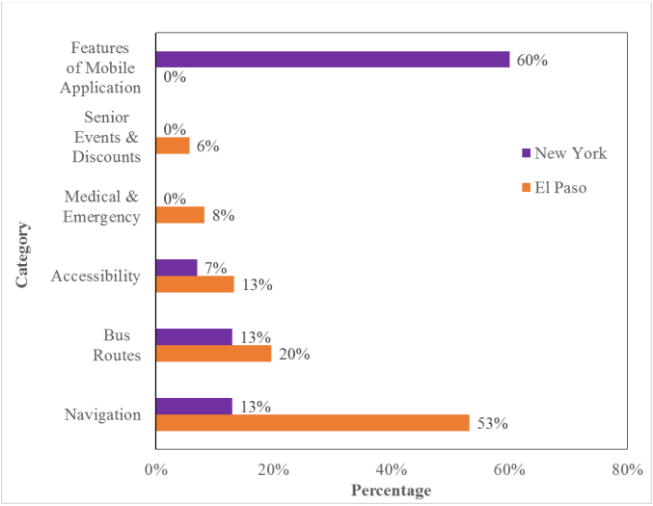

Fig. 4. Desired mobile application functions.

IV. Summary and Future Work

The surveys conducted for this study provided several insights focusing on the use of mobile applications to improve mobility for seniors that were not known from prior senior surveys in the literature:

- Public transit information and navigation are key features desired in mobile applications due to the desire to get to destinations efficiently;

- Smartphone penetration is positively correlated with city size and density (from a national average percent in the mid-30s to as high as 62% in NYC);
- Data privacy concerns, particularly tied to social security/retirement benefits, seem to range from 78% of El Paso surveyed seniors to 44% of NYC surveyed seniors who didn't mind sharing their data; and
- Among NYC surveyed seniors, 80% never use paratransit service, and only 13% use ridesharing; in El Paso, only 10% were willing to adopt a mobile application with some educational training.

Considering the relatively high penetration rate of smartphones in everyday life activities, these new insights suggest that developing solutions that relate to smartphone mobility applications and ridesharing services need to consider specific senior mobility needs and privacy.

The following recommendations are provided for developers interested in creating mobile applications, targeting senior users, with a focus on mobility:

- Mobile applications should be intuitive, simple, and easy-to-use;
- Mobile applications should avoid overly invasive requests for information that impacts the privacy needs of seniors'
- Mobile applications should be inexpensive, or free of charge;
- Mobile applications should have large fonts for those with visual impairments;
- Mobile applications should provide speech-to-text features and text-to-speech recognition for those with hearing or typing impairments;
- The greatest mobility challenge faced by seniors was traffic, parking, and construction. Mobile applications should provide directions to the users based on real-time traffic. This will assist senior users in avoiding traffic congestion and long waits (which may also be caused by construction);
- Mobile application's core functionalities should be available off-line when there is no Internet connectivity [30].
- Mobile applications should have ADA-compliant alternate modes of transportation present (e.g. ADA-compliant buses, paved sidewalk, etc.) for those that have difficulty walking;
- Mobile applications should utilize an updated map of ADA-compliant sidewalks and ramps, e.g. National Elevation Dataset [31], wheelchair accessible places [32].
- Mobile applications should help the senior users find parking stalls at their destinations; and
- Mobile applications must ask the user if they are willing to anonymously share their data with the developers when they set-up their user profiles.

These key findings were taken into consideration in the design of the prototype of the "Urban Connector" mobile application, which is currently in the development and testing phase.

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Matthew Vechione is a doctoral student in the Department of Civil Engineering at UTEP, working with Dr. Cheu. His research interests include lane changing behavior and mobility for seniors.

Corina Marrufo is a master's student in the Social Work Department, working with Dr. Nunez-Mchiri in the Department of Sociology and Anthropology at UTEP. Her research interests include ethnographic issues and aging of the population in the border region.

Raul Alejandro Vargas-Acosta is a doctoral student in the Department of Computer Science at UTEP, working with Dr. Villanueva-Rosales. His research interest is about protecting privacy of public Linked Open Data, and its application to Smart Cities.

Maria Guadalupe Jimenez-Velasco is a doctoral student and member of the Vision and Learning Lab in the Department of Computer Science at UTEP, working with Dr. Villanueva-Rosales. Her research focuses on emotion detection using machine learning and computer vision.

Okan Gurbuz is a doctoral student in the Department of Civil Engineering at UTEP, working with Dr. Cheu. His research interests include parking management for universities and mobility for seniors.

Assel Dmitriyeva is a master's student in the Interactive Telecommunications Program at NYU. She currently works in the Behavioral Urban Informatics, Logistics and Transport (BUILT@NYU) Laboratory and C2SMART, both at NYU. Her research is focused on behavioral models of decision-making and data-driven statistical inference.

Ruey Long Cheu is a Professor in the Department of Civil Engineering at UTEP. He is well known for his research in the applications of AI in transportation, and ITS. His current research topics are related to university parking, autonomous vehicles, and mobility for seniors.

Natalia Villanueva-Rosales is an Assistant Professor in the Department of Computer Science at UTEP. Her long-term research goal is to improve the efficiency and effectiveness of the discovery, integration, and trust of scientific data and discoveries. Her current approaches link human and machine knowledge to address societally-relevant problems in areas that require interdisciplinary research such as sustainability of water resources and Smart Cities.

Guillermina Gina Nunez-Mchiri is the Director of Women and Gender Studies and an Associate Professor of Anthropology at UTEP. She specializes in ethnographic research, service learning, and community-university partnerships in the U.S.-Mexico border region.

Joseph Y. J. Chow is an Assistant Professor in the Department of Civil and Urban Engineering and Deputy Director of the C2SMART University Transportation Center at NYU. His research interests include multimodal transportation networks, behavioral urban logistics, smart cities, and transport economics.