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National Surface Transportation Safety Center for Excellence

Improving Mobility for Rural Older Adults: A Program Review

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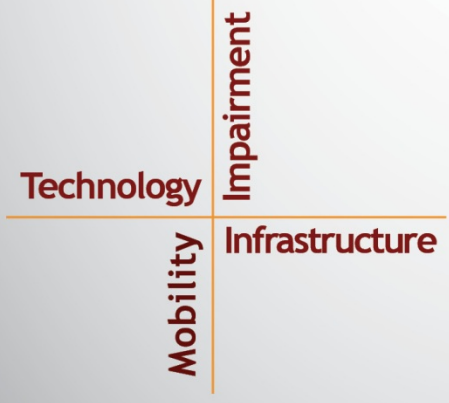

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ABSTRACT

The population of older adults is increasing and is expected to represent a larger proportion of the population over the next several decades. Those who live in rural areas face many transportation challenges, including a reliance on personal vehicles, reduced availability of public transportation, fewer friends and family to rely on for rides, and longer travel distances. This research effort entailed expert interviews and a search to determine what types of programs currently exist in rural or urban environments that might enable rural seniors to retain mobility. The results illustrate a wide variety of programs, many of which offer multiple types of services. Among these, there are also minute but important differences.

Several gaps between users requiring rides and available mobility options for seniors are noted. Suggestions for an implementation to bridge the gap are explored. Researchers discovered that many law enforcement training programs appear to no longer be functional. Additionally, gaps related to the use of GPS technologies as well as expansions of current implementations are discussed.

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LIST OF ABBREVIATIONS AND SYMBOLS

AI	artificial intelligence
DMV	Department of Motor Vehicles
MaaS	Mobility as a Service
MSHP	Missouri State Highway Patrol
N4A	National Association of Area Agencies on Aging
TDIS	Tallahassee Driver Information System
RV	recreational vehicle
V2V	vehicle-to-vehicle
VMT	vehicle miles traveled

CHAPTER 1. INTRODUCTION

RURAL MOBILITY CHALLENGE

Many rural areas suffer from a lack of transportation options simply *because* they are rural. Options such as public transit, ride-sharing, or local shuttle services do not exist at satisfactory levels in rural communities because they lack the needed population to support them. Further complicating matters, a small population base means fewer taxpayers, resulting in less funding, leaving rural localities at a clear disadvantage with respect to receiving infrastructural improvements to facilitate mobility. Taken together, this means that rural communities face a challenge in finding or developing transportation options that are both feasible and sustainable. If the goal is to expand ride-sharing modalities into rural areas, it must be done without the expectation of being fully supported and may need to be subsidized by the higher number of riders in urban locations or through some other incentive(s).

ECONOMIC AND SOCIAL BENEFITS OF MOBILITY

Economic

Communities benefit socially and economically when older adults maintain mobility. At the most fundamental level, mobile seniors help to sustain local businesses. Further, respondents in focus groups have noted that the availability of a local public bus system allows exploration of unknown parts of a city, or even a break from a normal routine, thus affording additional economic opportunities (Loukaitou-Sideris & Wachs, 2018). Travel to grocery stores, work, volunteer opportunities, and to see loved ones contributes to the local economy, as well as promoting social interactions that guard against social isolation (Kabiri et al., 2018; Perissinotto et al., 2019).

Research has found that improved health and mobility resulting from osteoarthritis treatment reduces nursing home utilization, increases employment and earnings, and improves overall quality of life (Kabiri et al., 2018). Other research has shown that improved physical functioning from arthritis treatment resulted in an estimated fewer days of missed work, higher household income, and a higher likelihood of employment (Dall et al., 2013).

Social Isolation

Rural residents often have to travel longer distances than urban residents (13.8 miles vs. 10.1 miles) or drive for longer periods of time (24.1 minutes vs. 21.8 minutes) to reach their destination or access needed amenities such as hospitals (Lam et al., 2018; Federal Highway Administration, 2017), other medical/dental care (Probst et al., 2006), and supermarkets (Ploeg et al., 2012). For example, in rural areas, the median distance to supermarkets was found to be 3.5 miles compared to 0.68 miles for urban areas (Ploeg et al., 2012). Adding to the problem is the increasing rate of hospital closures in rural areas. Between 2013 and 2017, 64 rural hospitals closed, compared to 31 in the previous 5-year period. Compared with 42 closures between 2014 and 2016, only three hospitals were opened during the same period (Government Accountability Office, 2018).

As people age, living alone becomes more common, magnifying mobility issues. In 2019, 44.3% of women over 75 lived alone. Overall, 25.8% of those aged 65–74 and 11.8% of those between 35 and 65 lived alone (U.S. Census Bureau, 2019). A reduction in social isolation may have impressive benefits on a variety of health outcomes commonly present in older adults, such as frailty, cardiac diseases, dementia, diabetes, and early death (Perissinotto et al., 2019). In Japan, interactions with friends, family, and neighbors were found to be significant predictors for the 5-year survival rate of seniors (Morita et al., 2009). Other research has demonstrated that even *perceived* social isolation can impair sleep, executive function, and both mental and physical well-being, leading to an increase in disease or death (Cacioppo and Cacioppo, 2014). Rural seniors face increased isolation, which impacts several health outcomes. Increased mobility may help prevent social isolation and have a positive impact on health.

URBAN AND RURAL LOCALES

Definition

An urban area includes both urbanized areas and urban clusters. Urbanized areas are those with 50,000 or more individuals, while urban clusters contain between 2,500 and 50,000 residents. It is worth noting that regardless of subclassification, to be considered urban an area must have a population density of at least 1,000 people per square mile. Areas defined as *rural* are simply those that are not *urban* (Ratcliffe et al., 2016). Between 2012 and 2016, it was estimated that 18.9% of Americans (60 million individuals) lived in rural areas, which have a higher proportion of individuals over the age of 65 (17.5%) compared to urban locations (13.8%; Smith & Trevelyan, 2019).

Personal Vehicle Use

In 2017, the average annual vehicle miles traveled (VMT) for drivers in rural communities across all ages was 14,177, whereas the average annual VMT for those in urban locations was 11,011 (Federal Highway Administration, 2017). Specifically, seniors who live in rural communities drive a greater number of miles and take more trips than urban residents (Payyanadan, Lee, & Grepo, 2018). However, another study using data from 1983 to 1995 illustrated that both rural and urban seniors rely on personal vehicles at a high, but not reliably different, rate: rural residents use a personal vehicle for 95% of trips and urban residents for 90% of trips (Glasgow, 2000). It is conceivable that data from the period used in Glasgow (2000) resulted in a higher overall use of personal vehicles due to the increase of public transportation use over the last 20 years after the publication of their study (Hughes-Cromwick and Dickens, 2020). Higher VMT in personal vehicles, as well as a greater number of trips by rural seniors, taken with poorer pedestrian access in rural communities (Wilcox et al., 2000) and less frequent use and availability of public transportation (Douthit et al., 2015; Fan et al., 2017; Mattson, 2017) suggests that rural individuals of all ages rely on a personal vehicle for transportation more than urban residents.

VULNERABLE GROUP

Aging Population

The proportion of adults aged 65 and older is projected to rise from 17% in 2020 to 21% in 2030 (U.S. Census Bureau, 2017). Additionally, the proportion of older adults is projected to continue to increase even as the overall population of the Unites States grows (Vespa et al., 2018). This growth may lead to greater strain on mobility systems already in place. Aging brings about a loss of family and friends, decreasing the pool of available drivers who may be able to provide some level of support for a senior's transportation needs (Wrzus et al., 2013). Unfortunately, as 71% of seniors note a preference for riding with family or friends as an alternative to driving, this creates a unique disadvantage as seniors age (National Aging and Disability Transportation Center & KRC Research, 2018).

Decrements and Self-Restriction

Along with an aging population comes a decrease in mobility. On average, by the time older adults reach the ages of 60–70, physical mobility begins to rapidly decline (Ferrucci et al., 2016). The decline is likely driven by changes in body composition, levels of strength, and nervous system function (Kasper et al., 2015). Cognitive declines may also become more prevalent, which can result in increased crash risk in scenarios such as

- intersections (Stamatiadis et al., 2003; Zhang et al., 2000);
- merging and speed estimations (Eby et al., 1998; Scialfa, Lyman, Kline, & Kosnik, 1987); and
- inclement weather and night driving (Charlton et al., 2001; Stutts et al., 2009).

Research has also demonstrated evidence of cognitive decline as it relates to

- processing speed for memory and spatial ability (Bashore et al., 1997; Finkel et al., 2007; Matas et al., 2014); and
- decreases in visual sensory functioning (Clay et al., 2009; Edwards et al., 2006)

As a result of increased crash risk, potentially due to decreased sensory and perceptual skill, seniors have been known to self-restrict driving in challenging situations, such as at night, in inclement weather, or in high-traffic areas (Charlton et al., 2001; Evans, 1999). Even if seniors reduce exposure to high-risk scenarios, a crash may still occur. With increased fragility, seniors remain an at-risk group (Regev et al., 2018). In situations where rural residents have no or minimal additional transportation options, self-restriction in an attempt to reduce crash risk, by definition, is likely to have a negative impact on accessibility. Conversely, if mobility is maintained in such a scenario, safety may be compromised. Given that mobility is related to health and independence in a rural community, a decrease in mobility may result in decreased quality of life and psychological well-being (Bacsu et al., 2012; Musselwhite & Haddad, 2010; Smith & Sylvestre, 2001).

POTENTIAL SOLUTIONS

The challenges rural seniors face in maintaining mobility are undeniable. However, the ideal method to address them is not known. Looking to the future, fully autonomous vehicles (AVs) may be a promising mobility solution. Transportation mobility could be maintained for those with perceptual, physical, or cognitive deficits. Additionally, a 24-hour taxi service could be created without the need to pay for a driver. However, AV implementation is not currently a viable option. A number of situations still present hurdles: inclement weather, such as snow or ice, may limit the scenarios in which AVs are useful; an attendant may be required to monitor the vehicle for some time (at a cost); and market saturation, especially in rural areas, is likely many years away. Additionally, operating an AV safely, even in controlled circumstances, without unintended consequences (such as emergency stops) presents several safety issues to occupants, especially those who are older (O'Kane, 2020). Even the lateral and longitudinal control features in SAE level 2 AVs may not support mobility due to potential performance issues in rural localities compared to higher population areas, such as the lack of detailed lane markings required for lane-keeping systems (Ort et al., 2018). Given that available, reliable, and safe autonomous transportation does not currently exist, older adults must either rely on friends and family or mobility solutions that are market-based or publicly funded. Some market solutions currently in place in more-populated areas include ride-hailing, shuttle services, and driver refresher courses, among others. Public solutions include expanded public transportation routes and police outreach and training.

OBJECTIVES

The objectives of this report were as follows:

- Investigate the current mobility opportunities available
- Create a database of mobility options
- Discuss the benefits and pitfalls of each modality
- Discuss gaps and opportunities available

CHAPTER 2. METHODOLGY

To acquire information on solutions to the mobility challenges faced by rural seniors, we conducted interviews with three experts in the field and supplemented that with research on existing programs that address senior mobility.

INTERVIEWS

The first expert interviewed is the director of a national organization who currently leads a program designed to support mobility needs for underserved communities in several states. The second expert is employed at a major federal outreach and advocacy organization. The final expert is a program manager employed by a nationwide organization dedicated to advocating for transportation mobility.

The interview was designed to elicit opinions and suggestions based on the experts' real-world experience. The questions asked included the following:

- From your experience, what are the main mobility challenges faced by rural seniors?
- What approaches or modalities represent the best way to overcome these challenges to facilitate mobility for rural seniors?
- Is public transit integral to addressing rural mobility?
- What are the biggest barriers to implementing successful solutions?
- How do you envision emerging technological advancements (e.g., automated/autonomous vehicle related systems) reshaping the rural mobility landscape?
- What role should the federal or state government play in supporting mobility?
- What other important information would you like to share?

PROGRAM REVIEW

Additionally, we conducted an internet search for mobility programs and options using several key words and phrases in the Google search engine related to senior mobility. As relevant programs were found, some led to additional source material that was explored, including links and sources from programs reviewed.

Four general categories were researched: Ride Services, Training and Evaluation, GPS and Navigation, and Outreach and Care. Example search keywords from each category are listed in Figure 1.

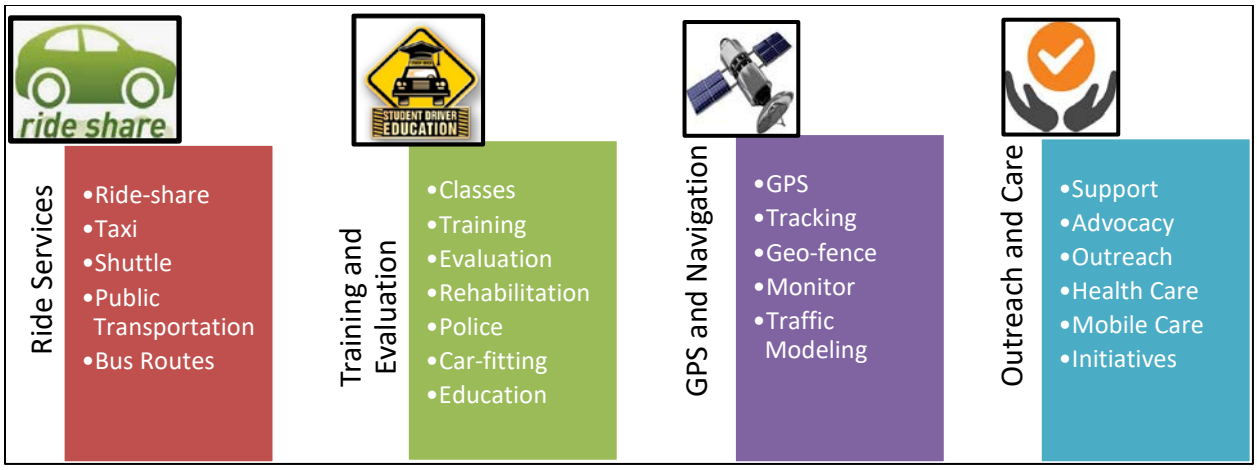

Figure 1. Diagram. Example keywords utilized in a search for mobility options.

CHAPTER 3. RESULTS AND DISCUSSION

STRUCTURED INTERVIEWS

The results from the structured interviews were coded for common themes. The discussion below provides a summary of statements made by the experts for each of the questions. Themes and dissenting opinions (where expressed) are discussed as well.

1. From your experience, what are the main mobility challenges faced by rural seniors?

- Requires more planning and travel covers greater distances – sometimes involving multiple modalities
- Seniors have the same challenges as other groups, but magnified due to age and decrements
- Greater reliance on personal vehicle – greater hindrance when unable to drive anymore
- Lack of other travel options (modality, time of day, day of week)
- Lack of on-demand options (shuttles, ride-hail services)
- Other travel options perceived as harder or less safe than personal vehicle

Results from the first question revealed that older drivers in rural locations face the same challenges as riders of all ages, but greatly magnified. A younger individual who relies on a personal vehicle to travel may be inconvenienced when needing alternative transportation, but older individuals face additional challenges due to physical and cognitive limitations. A strong reliance on personal vehicles by those living in rural areas likely hinders the development of alternative transportation options in the area by reducing demand. With fewer alternatives, riders can find that limited availability affects planning and usefulness, especially if the available options do not cover all hours of the day or days of the week.

One of the experts relayed a story in which an older individual wanted to visit a family member unexpectedly taken to a local hospital. She found transportation planning was nearly impossible. She was unable to make an appointment for the same day and was required to schedule 1 to 3 days in advance—and only between certain limited hours when the local organization was open. In addition, her location did not have on-demand options available, so she walked to the hospital. Her path took her alongside roadways without sidewalks or designated walkways during winter with snow present. Not only was the path unsafe to begin with, but with the presence of snow and cold weather, the opportunity for injury was greatly increased. This example highlights limitations that may be encountered by an older person without access to easily available and accessible transportation options.

2. What approaches or modalities represent the best way to overcome these challenges to facilitate mobility for rural seniors?

- All modality options should be utilized (on-demand, public, etc.), but locality affects what will work
- One stop/call locations with multiple mobility options
- Volunteer drivers from multiple organizations (under umbrella organization)
- Mobility as a Service (MaaS) implementation combined with artificial intelligence (AI) and AVs in the future

- State or federal subsidies for mobility options in rural areas
- Communities should invest in local infrastructure (sidewalks, bus routes, etc.)
- Alter regulations to allow sedans for rural transport in addition to vans
- More training for public transit drivers to aid in all areas of senior's life if needed (nutrition, socialization, handyman, etc.)

The experts provided several suggestions to improve mobility in rural areas. Two individuals responded that all modality options should be utilized, while all three agreed that a coordinated effort involving multiple solutions was needed, highlighting the need for a multifaceted approach. All mobility options from fixed bus routes to on-demand transportation and ride-hailing services to infrastructure development and subsidies should be employed, as they all play a specific role. The experts viewed the mobility challenge as one where multiple organizations should engage in a coordinated effort rather than focusing on individual elements. Interviewees all noted that flexible thinking needs to be used to solve the transportation problem. One comment mentioned using vehicles such as sedans rather than busses for rural transportation. Sedans are available at a lower initial purchase price, require less maintenance, have lower fuel costs, and are more maneuverable and easier to drive than larger vans or busses, though all of these types of vehicles should be deployed in underfunded rural areas.

The experts also agreed that some form of a one-stop/one-call/MaaS implementation would be beneficial. By folding all local transportation information into one facility, a personalized approach could be applied to each transportation request. The service could even add counseling or training. For example, FlexDanmark, a Danish company, offers an implementation similar to one expert's suggestion. FlexDanmark integrates mobility from several private transportation companies into a single piece of software controlled by an algorithm. When the user requests a ride, the algorithm selects an appropriate driver by location, amenities, and user assistance required, irrespective of the driver's employer.

3. Is public transit integral to addressing rural mobility?

- Not just integral, but essential
- Local organization should act as transportation coordinator and resource center for options

Public transportation was viewed, across the board, as integral and essential to rural mobility. All experts agreed that access to a fixed-route bus service was an important component (though not the sole component) of full mobility. Public transportation was viewed as a piece of the solution. It is important to note that one individual sees public transportation as a mobility provider, which also includes for-profit companies and is not limited to publicly funded organizations. One expert stated that the local transportation centers should act as a one-stop/one-call/MaaS organization similar to FlexDanmark. Responses strongly suggest that public transportation services should be viewed as a backbone of transportation to be augmented rather than as an outdated service to be replaced.

4. What are the biggest barriers to implementing successful solutions?

- Funding – both state and federal level
- Every community is unique and has its own challenges

- Providers get tunnel vision – mobility providers need to look for creative ways to serve the population and raise funds
- Crossing political boundaries may require multiple services and modalities
- Providers need to work together for solutions
- Lack of population density and infrastructure lead to a lack of options

Funding issues were noted as a main barrier to implementing solutions. One individual noted that transportation providers often became fixated on typical funding avenues (federal grants) or forms of service (providing just only a shuttle) and should instead strive to become more creative. This may mean local fundraising or combining services with another local organization to take advantage of unique opportunities (providing help carrying groceries or other door-through-door services). A number of potential avenues to increase funding were mentioned: increased gas tax, congestion charges for urban areas funneled back to rural localities, or even funding through gambling similar to the lottery. One expert mentioned creating a legislative requirement that, for an urban company to service a city, that company must also provide some form of rural service.

5. How do you envision emerging technological advancements (e.g., automated/autonomous vehicle related systems) reshaping the rural mobility landscape?

- AVs, level 3, and level 4 automation – high automation will provide rides while lower levels will help keep drivers mobile longer
- Alternative fuels will affect how fleets are maintained/purchased
- Better routing/scheduling for demand-response services
- Better communication between drivers and providers to increase efficiency and to provide more personalized service when needed
- More operations without a local command center, such as Uber, Lyft, etc.
- MaaS apps – universal mobility for all riders and more modalities
- AI to optimize mobility for multiple riders/routes/times

The two main technological advancements noted were AVs and communication improvements. The experts all saw advancements in automation as playing a key role in mobility improvements, whether that comes from level 3 and 4 partial automation or full automation. The experts discussed the need for inclusive design, a process that accounts for a diverse group of users who may have a variety of restrictions, for automated and partially automated vehicles. If the usability of such systems is too complicated or too technical, it will likely fail as a major provider of mobility for seniors; inclusive design is integral for widespread adoption and safe use.

Communication was another theme that emerged from the interviews. Communication has the potential to drastically change the shape of mobility, especially as AI improves. Algorithms could be designed to optimize route selection based on available modalities and riders requesting rides, even working with mobile apps designed to better relay information to the rider. FlexDanmark employs such an algorithm to optimize routing and drivers based on the rider's needs (as discussed above). Continued development of the algorithm can lead to ongoing efficiency improvements and may even allow for implementation of more-personalized service. AI also has a potentially large impact on the optimal use of AVs if implemented as a mobile taxi

fleet. A combination of vehicle-to-vehicle (V2V) communication, AVs, and AI functioning together as a mobility fleet could power an essentially stand-alone service.

6. What role should the federal or state government play in supporting mobility?

- Government should play a big role – industry will not go where profit cannot be made, government needs to supplement
- Government should take the lead – build/maintain/provide technical assistance for infrastructure
- Government should stay out of the way – policy can inhibit innovation
- Policy changes – if a company wants to service a given locality, that company should be required to service the rural area nearby; charge fees, such as congestion fees, by locality
- Funding – mobility should be treated like healthcare and education – an equal right with equal access
- Provide oversight of transit to ensure responsible use and management
- Subsidize rides

The experts interviewed held contrasting views on the role of the federal and state government. Two individuals felt strongly that the federal government needed to play a leading role. These two experts imagined the government taking a leading role to invest in infrastructure or taking a supporting role for upkeep and technical assistance. The other individual saw the federal government as an entity that primarily hinders innovation that needed to be removed from the equation for businesses to thrive. One expert believed the federal government could focus on policy changes to effect change. One suggestion was to create legislation that required urban providers to also service the surrounding rural areas in exchange for access to the urban center.

7. What other important information would you like to share?

- A lack of broadband connectivity for business affects business startups in rural areas which may hinder mobility startups
- Inclusive planning is required to ensure all groups are represented
- Strive to find mobility options outside of typical mobility ideas
- We need to look at cutting-edge ideas – what is beyond fixed-route and demand-response services?
- Mobility issues will not go away – rural population ages while the young move to city centers
- Level 3/level 4/AVs need to be built to accommodate all riders
- Better/more communication between all industries

Accommodating all roadway riders was a common theme. Usability from the planning phase of physical infrastructure to the design of controls for partially and fully autonomous vehicles was mentioned. If the goal is to provide access for all riders, then the mobility system must be designed in such a way to facilitate that. Inclusive planning is already considered for wheelchair-bound individuals as well as those with other physical disabilities when it comes to buildings, and it also needs to be applied to complicated and advanced vehicle design for all riders. Additionally, one expert mentioned the need for broadband internet connectivity in rural areas to

reduce barriers for mobility start-ups. Without a reliable internet connection, local mobility services may be less willing to invest in a business in the local community.

PROGRAM REVIEW

While the primary focus of this effort was on rural mobility, the results presented are not limited to rural community programs. Rather, a wide variety of implementations were reviewed across all population densities. A categorization scheme was developed for organizational purposes. The scheme and the number of programs identified within each category are shown in Table 1. In all, 154 unique programs were identified. These are presented in the "Programs" Microsoft Excel notebook available for download from VTechWorks. It is worth noting that a large majority of the programs reviewed fit into more than one category. For each program, we sought to identify the following key pieces of information:

- Brief description
- Location of use
- Organization type
- Usage
- Cost to end rider
- Population served
- Reference to the source material

The results presented below the table describe the different approaches and provide an example program within each category. Superscripts in the column for estimated cost to the user correspond to each numbered program within the attached database. The benefits and limitations of each approach are also discussed.

Table 1. Program modality and number reviewed.

Type of Program	Number of Programs Fitting Each Category*	Door-Through-Door Service	Estimated Cost to User	Estimated Cost to Community	Ease of Expansion	Rural Suitability
Training and Evaluation						
Driving Schools, Training and Evaluation	30	No	Free[8,20,26] to High[13,58]	Moderate	Hard	Moderate
Transportation Training and Counseling	25	No	Free[5,53,77] to Moderate[100,142,152]	Low	Easy	Moderate
Law Enforcement	8	No	Free[7,42,114,120]	Moderate	Easy	Good
Adjustment	8	No	Free[30,45] to Moderate[9,12,30]	Moderate	Moderate	Moderate
Ride Services						
Shuttles	24	Yes[36]	Free[32,36,95] to Low[35,85,109]	Moderate	Hard	Moderate
Ride-hailing	22	Yes[36,121]	Free[31,36,131,133] to Moderate[48,74,121,152]	Free	Moderate	Good
GPS and Navigation						
Tracking	11	No	Moderate[64,79,128] to High[104,123]	Free	Easy	Good
Navigation	11	No	Free[60,68] to High[44,82]	Free	Easy	Good
Traffic Modeling	7	No	Free[1,2,49,60] to Low[127]	High	Hard	Moderate
Outreach and Care						
Outreach and Advocacy	38	No	Free[5,7,8,16,38]	Low	Moderate	Easy
Health and Mobile Care	19	No	Moderate to High	High	Hard	Moderate
Time Banks and Community Living	8	No	Free[31,36,72] to Low[96]	Low	Hard	Moderate
Emergency Response	7	No	Free[3,39,45,124] to Low[126]	Moderate	Hard	Moderate
Active Transportation	11	No	Free	Moderate	Moderate	Moderate

*Several of the 154 programs reviewed fit into two or more categories.

Training, Evaluation, and Counseling

Training and Counseling

Transportation training and counseling programs either advise riders about local transportation options, train them how to use the available options, or both. These programs can excel in terms of efficiency since a decentralized call center can be used, thus reducing the need for a physical presence in each city. Provided the call center employee has access to appropriate information for the caller's region, the employee can discuss the caller's needs and restrictions and present the available mobility options, such as a public bus route or shuttle service. In the case that the caller has a more complicated trip, the employee can provide a travel plan to help them coordinate among several different services.

In some cases, training is also available. Training is typically done in-person, where a rider may rehearse a local bus route, including how to pay, how to interpret relevant signs, and how to stay safe. This style of training can provide detailed information about specific local systems. Unfortunately, any form of in-person training requires the rider to be near the trainer and is thus more likely to only be available in areas with higher populations. While remote training (via video or website) does not have the same touch as person-to-person interaction, it succeeds in one major way: training can be provided to any person, at any location, and at any time of day. Even with the minimization of specific, local nuances, widespread remote training can reach a far greater number of people at far less cost. Once the training materials are developed, they can be readily shared with other organizations or posted to websites for wider dissemination. Generalized remote training can be augmented through guidance over the phone for a specific use case. However, in order to be useful, the trainer must be aware of any local nuances or requirements. Notably, the skills learned after receiving training are, in many cases, transferable to other transportation routes.

Training programs designed to improve personal safety on a bus are typically done in person. Some seniors may feel safer receiving training sessions in person where specific concerns can be voiced. Additionally, many may feel that information received from a person is more trustworthy. However, in-person training is not required for personal safety. These programs focus on staying safe in an unfamiliar environment, and suggestions are likely to be quite similar regardless of geographic location. Like generalized transportation training, materials could easily be developed for widespread use via a website or shared with other local entities for dissemination.

Training programs offer a major cost benefit for communities. Once a training protocol is developed, irrespective of modality, it can be easily disseminated to other locations. A program created in California is applicable (with some likely modifications) in Kansas and Mississippi. Lessons learned from one community can be easily passed on to another to improve training. From an end user perspective, costs are typically quite low or free, making these programs accessible to a large proportion of the population.

Example Program: Ride Connection. Ride Connection is a nonprofit program located in the Portland, Oregon, area that provides 2,000 public transportation training sessions per year. The program operates in an area with a population of around 648,000 individuals. In order to begin the transportation counseling process, the rider contacts the counselor, who gathers relevant information and works to explain the range of travel options available. These options can range from public transportation to a shuttle service or even ride-share options. Additionally, Ride Connection has an alternative that compensates individuals for the use of personal vehicles when available. The cost to the rider is free, but donations are accepted.

Ride Connection

Location: Portland, OR

Training Sessions Offered: 2,000

Population Served: 648,000

Cost: Free

Restrictions: None

Unique Traits: Training sessions can be done solo or in a group setting

Ride Connection also offers public transportation training. Individuals who sign up for this program are walked through the entire process of public bus use to build confidence and skills. They learn about bus schedules, understanding signage, route availability, and personal safety. Training sessions can take place either as a group or one-on-one, and are structured to create a comfortable setting. Personalized training provides a hands-on experience (Figure 2). All training is presented to riders at no charge and is available anywhere in Multnomah, Clackamas, or Washington counties.

Figure 2. Photo. Employee providing public transportation training to a rider; image from www.rideconnection.org.

Driving Schools and Evaluation

While many adults who have a license attended some version of a driving school, for older adults this was often decades ago. Many driver's education schools offer professional driving evaluations or refresher courses on the rules of the road and updates on relevant technological trends. Driving evaluations may result from a referral from a law enforcement officer or the Department of Motor Vehicles (DMV). Typically, they focus on evaluating a set of basic driving skills and techniques, such as turn signal use, speed maintenance, and safety behaviors, as well as perceptual testing. Driver refresher courses may highlight issues and concerns common to older drivers and tend to be open to any older adult. These courses focus on situations where older adults may struggle, including high-traffic areas, unprotected left turns across path, and night driving. Drivers are taught skills to help them better manage these scenarios or, if applicable, avoid them altogether.

The driving schools evaluated covered two modalities: online and in-person. The online courses are available at any time of the day from any location with an internet connection, which makes the program quite accessible. Online training can be a valuable tool to present a wide variety of safety information, ranging from scenarios where older drivers may struggle to reinforcement of roadway rules and regulations. Many online courses are inexpensive to complete and may afford an insurance discount upon completion, depending on several factors. Additionally, a variety of courses are offered so drivers can select a course for specific needs. However, the older driver may still struggle to find an online program tailored to a specific need (if it is an uncommon issue for seniors), whereas in-person training may be more likely to offer customized solutions. For example, a senior may have difficulty backing down a long driveway, a topic that is not readily discussed in online training. In this example, the senior would be better served visiting an in-person training facility.

In-person training is likely of a higher quality given the interactive nature of the communication between student and teacher, but obviously requires the driver to be near the school or able to travel to one. Often, classes will be held at specific times or days of the week, requiring the driver to complete the training on someone else's schedule. Driving schools can be a valuable resource for older drivers to not only learn where skills may be declining, but also how to mitigate those decrements. Quality in-person training will be individualized, and potentially enlightening, if additional, unknown issues come to light.

Proper training requires a skilled professional and generally costs more than online coursework. However, it is worth noting that the some in-person driving schools also present the classroom information online, allowing easier access for some of the training. However, cost may still be an issue; for example, $200 for a class may be too expensive for those on a fixed income. Depending on what the driver desires, the trade-offs can guide them to one modality over the other.

Driver evaluations are conducted by a Certified Driver Rehabilitation Specialist and are primarily initiated in one of two ways: the senior chooses to engage with an evaluation specialist or is given a referral from a doctor or officer. Drivers undergo a series of assessments, including physical and cognitive screening, as well as an on-road evaluation. A report is then generated for

the referring authority. In some cases, a senior does not need to be referred, but simply can volunteer to undergo an evaluation, perhaps at the request of friends or family.

Driving evaluations and classes may prove quite beneficial for older drivers, but there may be cost hurdles for both users and the community. While the materials or protocols can be easily shared between locations, a brick-and-mortar site is required for an evaluation or in-person training. From an end-user perspective, the cost can be substantial, reaching hundreds of dollars per class, thereby excluding some individuals who require training.

Example Program: Barber's Driving School. Barber's is a for-profit driving school that caters to drivers of all ages. It is located in Columbus, Georgia (population 197,000), and offers two older- driver programs for $150 to $200 in addition to a driver evaluation course. The driver evaluation course provides a wide array of skill evaluations. Results from the evaluation can determine what augmentations are needed for the driver to continue to drive safely, if any (e.g., panoramic rear-view mirrors, convex mirrors, etc.). Barber's Driving School advertises customized recommendations to the older driver, such as using different routes or even changing the time of trips to reduce crash risk. Potential other restrictions, such as avoiding high-speed roadways or suggesting that the driver have a copilot, can be discussed as applicable.

Barber's Driving School

Location: Columbus, GA

Courses Offered: Driver evaluation, 2- and 6-hour driver refresher courses

Population Served: 197,000

Cost: $150-$200

Restrictions: None

Unique Traits: Customized recommendations to older driver including route/time of day avoidance

The driving refresher courses are either a 2-hour course or a longer 6-hour defensive driving course. These courses are designed to update the driver on any new or recently changed transportation laws. The defensive driving course focuses on a variety of techniques to reduce crash risk, such as increasing following distance or improving mirror use. The senior driver training program is designed for those who have not yet learned how to drive, those have given up driving, or those who are presented with a situation that requires them to start driving again, such as in cases where a recently deceased spouse was the primary driver. Figure 3 shows an older adult receiving driver training from Barber's Driving School.

Figure 3. Photo. An individual receiving driving training from Barber's Driving School; image from www.barbersdrivingschool.com.

Adjustments

Adjustment programs evaluate how well a driver's vehicle fits. Based on the evaluation, adjustments or adaptive equipment can be suggested to improve usability. The goal of the service is to adjust the driver's position so that all controls are easily accessible, there is maximum mirror coverage, and to accommodate any restrictions or impairments. Many vehicle adjustment programs rely on the methodology and implementation of the nationwide CarFit program.

The greatest benefit of vehicle fitting programs is the personal and one-on-one interaction between the expert and the driver. By helping to better fit the driver to a personal vehicle—whether that focuses on seat or mirror adjustments or even implementation of assistive devices—the expert offers the driver customized advice rather than generalized information that may or may not apply. The one-on-one attention allows drivers to interact with the expert to learn about specific alterations that may improve safety or even discover previously unknown new limitations. The process is tailored to the driver's specific needs or interests.

Widespread adoption of adjustment programs is hindered by the limited number of locations and experts. Adjustment programs are more often concentrated in areas with a larger population, limiting their availability for rural drivers. Moreover, while one-on-one interaction with an expert is a great benefit, it is also one of the largest hindrances to access because it prevents higher throughput.

Vehicle adjustment services can readily adopt protocols from other locations, which enables fast and easy transfer of information, helping to keep the cost down for the community. However, these programs require local organizations to have access to a location for evaluation and the required equipment for measurements. While not prohibitive, these costs can slow the spread of the program. However, because the program is free to users, it is inclusive to users of all income levels.

Example Program: CarFit. CarFit is a national nonprofit car-fitting program that provides training and expertise for community implementations. The stated goal is to help older drivers learn how to correctly fit a personal vehicle and to highlight actions to improve fit. Both safety and comfort can be increased by improving the fit of the driver to the vehicle. Some examples of improved fit may include proper adjustments to mirrors to minimize blind spots, proper foot positioning on pedals to decrease fatigue and increase reaction time, and adjustments to steering wheel distance from the driver (Figure 4). In the case that adaptive equipment is suggested, a visit to a separate driving rehabilitation specialist is required. A CarFit evaluation only takes 20 minutes to complete. A list of upcoming car-fitting events is displayed on the website. Currently, there are 208 clinics across the United States. Additional clinics are available in Australia and New Zealand. CarFit claims to have provided help to an estimated 50,000 drivers since inception. There is no cost for a driver to attend one of these clinics.

CarFit

Location: Multiple states, Australia, New Zealand

Fits Offered: 50,000

Population Served: 329,000,000

Cost: Free

Restrictions: None

Unique Traits: Structured course allows for easy dissemination and expansion of clinics

CARFIT
Helping Mature Drivers Find Their Safest Fit

Figure 4. Photo. CarFit employee checking steering wheel height for an unobstructed field of view. Image from www.car-fit.org.

Law Enforcement Approaches

Law enforcement agencies often have some form of public safety outreach between the police force and citizens. In addition, there are training programs directed toward law enforcement

officials to help them to better understand the needs of elderly drivers or how to recognize the signs of Alzheimer's disease or other forms of cognitive impairments. The primary goal behind these training programs is to enable law enforcement to respond appropriately to older drivers.

Law enforcement interventions to improve rural older driver mobility can be one of the most efficient means of disseminating information. Law enforcement agencies exist in nearly every town across the country, meaning that the infrastructure required for the dissemination of information is already in place. Once created, materials and protocols can be readily shared with other agencies across the country. One program, Safe Mobility for Life, has already created a well-rounded program with supporting materials that could easily be distributed to law enforcement agencies across the country. Additionally, as information coming from law enforcement benefits from a position of authority, some older drivers may be more likely to integrate that information and any lessons learned into their driving.

Law enforcement agencies are publicly funded entities, which is why they exist in nearly every town. This benefit is also the largest hindrance since budget constraints are likely a common issue. Outreach, training, and interaction by law enforcement require additional funding to pay for salaries, as well as the cost of printing and dissemination of safety materials. As such, the money for these programs may not easily be found and may come at the expense of cutting other programs. Sharing protocols and information between agencies can help to reduce costs, but a financial hurdle will likely still exist for agencies. For private citizens, however, these programs are free, which allows individuals of all income levels to benefit.

Example Program: Missouri State Highway Patrol. The publicly funded Missouri State Highway Patrol (MSHP) provides a variety of free programs to older drivers. In one such program, "Senior Drivers," troopers connect with local older adults to discuss issues related to occupant safety, child passenger safety, defensive driving, and winter driving. MSHP also provides a pamphlet for older drivers designed to detail what to do in the event of a crash. In addition to training for older drivers, the MSHP also provides training for troopers to recognize symptoms of Alzheimer's disease and cognitive decline. The goal is to help officers recognize safety issues related to cognitive decline and provide the necessary referrals or interventions. Unfortunately, the current MSHP website does not currently advertise the above programs, suggesting that they are no longer operational.

Missouri State Highway Patrol

Location: Missouri

Population Served: 6,013,000

Cost: Free

Restrictions: None

Unique Traits: Trains officers to recognize issues related to cognitive decline for earlier intervention

Example Program: Safe Mobility for Life. The publicly funded Safe Mobility for Life program, located in Florida, provides a wide variety of free training sessions for officers to improve safety for older drivers. The population of Florida is 21.3 million, which suggests this program could have a large impact. Safe Mobility for Life provides a training toolkit designed to teach officers to look for the root cause of a violation (Figure 5). For example, a driver may be slowly swerving as a result of feeling lost while searching for familiar landmarks. By engaging in a conversation with the driver, the officer may discover evidence for some form of cognitive decline (leading to being lost) that needs to be addressed. The officer can then refer the driver or contact a loved one to discuss options rather than passing the responsibility on to the next officer or hospital to catch. The other benefit of the program is that it encourages officers to discuss the violation with the driver to help them to better understand rules and regulations that may have been forgotten. If a referral or driving course may be warranted, the Safe Mobility for Life program trains officers on the local options available. The program also trains officers to encourage self-assessment by drivers.

Safe Mobility for Life

Location: Florida
Population Served: 21,300,000
Cost: Free
Restrictions: None
Unique Traits: Trains officers to look for the root of a driving violation—perhaps indicating a safety issue for older drivers

In cases where the officer may decide to speak to the older driver's family, Safe Mobility for Life provides training on discussions with the family about any programs or classes that may be warranted. Given that the information is coming from an authority figure, it may be received better by the older driver than if coming from family or friends. In addition to programs or classes, training is also provided for the officer about legal support in the case of driving restrictions.

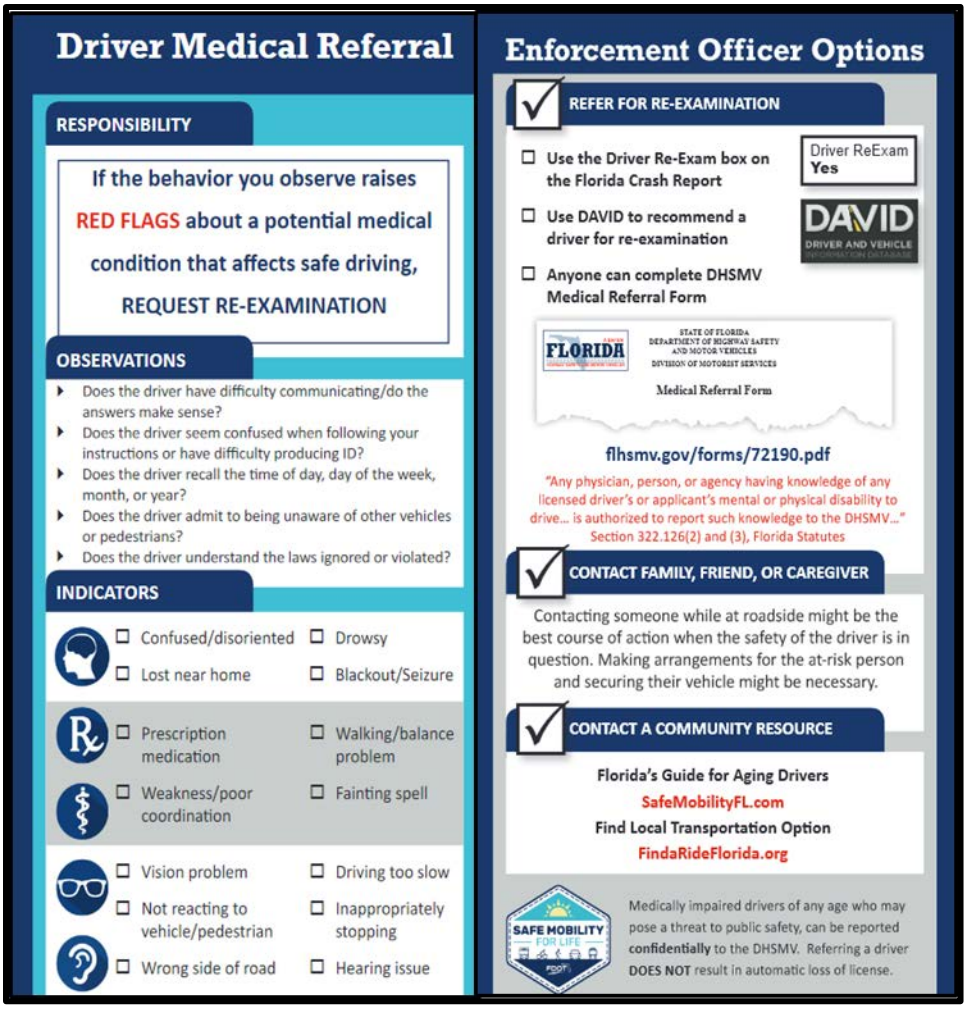

Figure 5. Screen capture. Example toolkit pamphlet for medical referral. Image from www.safemobilityfl.com.

In addition to training programs for officers, Safe Mobility for Life hosts a ride search for the state. Riders can select a starting location, destination, the purpose of the ride, and any additional services required (such as an escort or wheelchair accommodation) for the trip. The website then returns a list of suggested services that can accommodate the rider. This implementation also offers a variety of webpage color combinations for those with low vision to improve readability.

Ride Services

Ride-Hailing

A ride-hailing service functions similarly to a taxi, but the individuals offering the ride are private contractors operating a personal vehicle. In many cases, the driver and rider are connected via a mobile app or a phone call.

The primary benefit of a ride-hailing company is that the service is crowd-sourced. By having a large population as potential drivers, even those who want to only work a few hours a week, the

number of rides and hours of availability are not limited by time of day or by a fixed number of available vehicles in a fleet. Additionally, there is no need for a brick-and-mortar presence to support such services in each location where rides are offered. This may encourage an expansion of the network of drivers into other locales. The lack of a need for a local building allows an individual on the East Coast to provide rides while working for a company based on the West Coast. This modularity allows a fast expansion of the business model and thus provides more drivers in more locations. Another major benefit of ride-hailing services is that the riders do not need to be concerned about parking, as they are simply dropped off at the specified destination. This eliminates searching for a space, worrying about potential conflicts with other vehicles, and paying parking fees. Another benefit of ride-hailing services is that riders know the cost *before* the ride has taken place (in many circumstances). This gives the rider a choice of when use the service in order to be cost-efficient.

One major drawback of ride-hailing is that its usefulness is tied to the number of individuals in the area. People in San Francisco, for example, may be able to access a ride more easily due to the increased number of drivers in the area, while those in a small town located some distance from a large city may struggle to find a ride. Another advertised benefit of some ride-hailing services is that drivers are required to pass two separate background checks prior to driving (though others only require a single check). Some companies that offer a ride-share service as part of a more diverse undertaking to improve mobility require face-to-face interviews in addition to background checks.

Some providers offer extended services to riders, such as door-through-door service, where an escort, either the driver or a secondary employee, will accompany the rider to an appointment and help once inside. Door-through-door services may work well in rural or suburban locations but prove difficult in urban localities. Densely populated areas are likely to have less parking available to leave the vehicle and assist the rider while inside. Additionally, door-through-door services will have a lower throughput of riders. While assistance is being provided, that driver is unavailable to other riders in the area, which may be a potential problem in areas with high demand.

Ride-hailing programs typically do not pose a direct cost to the community if they rely on private vehicles for the rides, but other drivers may indirectly feel the effects of increased congestion (Li et al., 2016) especially if more non-driving people are using the service than those who typically drive (Alexander & Gonzalez, 2015). Programs that operate a business vehicle for rides involve greater costs. At a minimum, a location to park the vehicle is required. The source of the vehicle for the program can make costs vary wildly for the local community. However, riders, are not as inconvenienced by the pricing of ride-hailing services. Costs can range from donation-based to a fare like a taxi service, neither of which is insurmountable for the majority of the population. However, some companies have dynamic pricing models, which can make the cost of a ride much more expensive if rides in the area are under high demand.

Drive a Senior

Location: Austin, TX

Rides Offered: 30,000

Population Served: 1,000,000

Cost: Free

Restrictions: Medical and health-related travel, aged 60+, non- or limited driving individuals

Unique Traits: Curb-to-curb, door-to-door, and door-through-door services

Example Program: Drive a Senior. This program is located in Austin, Texas. In 2016, Drive a Senior provided over 30,000 rides. The program is implemented among an estimated population of 1 million people. The nonprofit program is free to riders and relies on volunteers in the area to give three levels of ride-share services. For riders who are still mobile, a *curb-to-curb* service is offered to transport a rider from location to location. For riders who require assistance, a *door-to-door* service is offered, where the volunteer will greet the rider at the door and walk the rider to the door of the next location. Finally, for those who request it, a *door-through-door* service is offered. The *door-through-door* service is one in which the volunteer driver will accompany the rider at the destination, providing continued assistance. No details are given on the website regarding any limitations to the *door-through-door* service, so presumably riders could utilize the service for any medical need. The program states that Drive a Senior ride-hailing concentrates on medical and health-related travel.

In addition to the ride-hailing service, Drive a Senior offers a shuttle service for group trips to grocery stores, pharmacies, or banks. Drive a Senior also offers a variety of other support services to seniors such as yard work, care calls, and home maintenance.

The Drive a Senior website details eligibility requirements for services. Riders must be over the age of 60, have no or limited driving abilities, live in their own homes or with family members, be within the boundaries of services, and be able to walk with a walker or cane.

Example Program: Rides in Sight. This database provides riders with a list of available transportation options based on zip code. Upon searching a location, a rider is presented with mobility options in the area, links for more information, availability, eligibility, and contact information. The rider can also filter results by factors such as payment type, ride reason, and services for disabled individuals or veterans. This database is privately funded by Regeneron Pharmaceuticals, and service to the user is free to all riders. Rides in Sight can be accessed anywhere an Internet connection is available. Figure 6 shows an example of the output when searching for Blacksburg, Virginia.

Rides in Sight

Location: United States

Rides Offered: N/A

Population Served: 329,000,000

Cost: Free

Restrictions: None

Unique Traits: Accessible anywhere the Internet is available

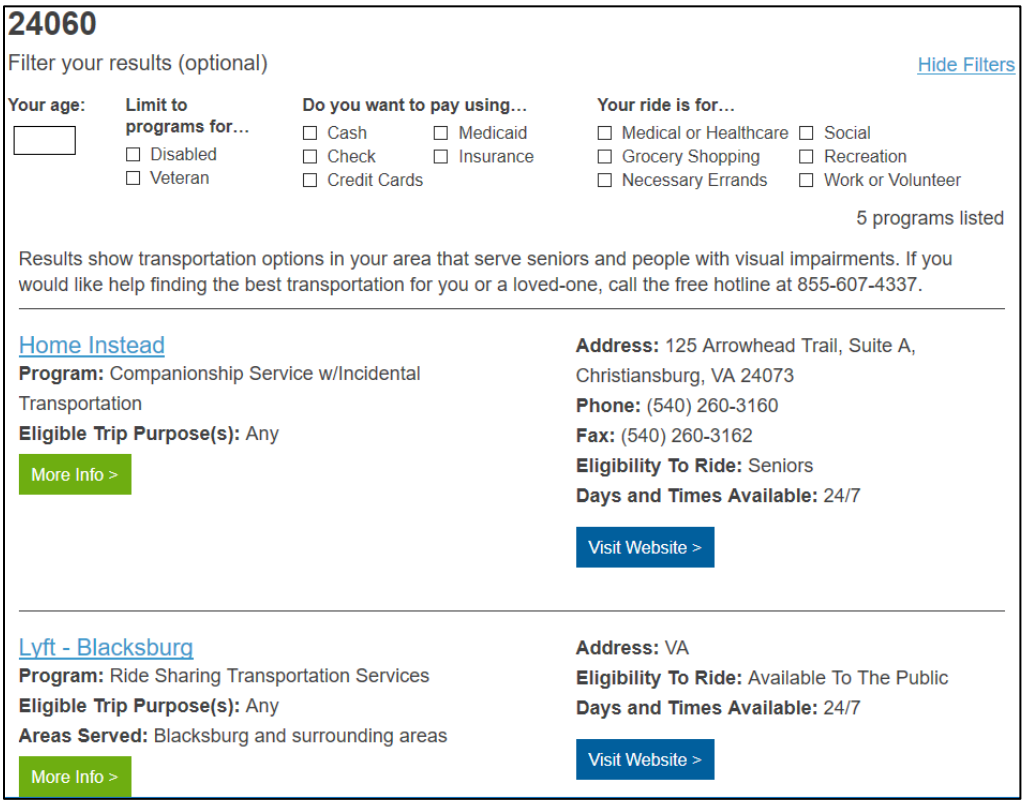

Figure 6. Screen capture. Example search result for zip code for Blacksburg, VA (24060). Image from www.ridesinsight.org.

Shuttle Services

Shuttles provide travel to locations such as a doctor's office or grocery store and are typically owned and operated by an organization. Some shuttle providers restrict how riders can use the service, while other providers allow transportation for any purpose.

Shuttle services have three major benefits: a personalized ride experience; employees who are vetted and hired by the organization; and elimination of the difficulty and expense of parking, as well as the need to walk or otherwise move between the parking space and the intended destination. There is also the benefit of having access to a consistently maintained fleet of vehicles with potentially higher safety standards for the driver and vehicle. Shuttle services may also be able to transport wheelchairs or walkers for users. Additionally, as with ride-hailing services, shuttle drivers or attendants may escort the rider to the door of the destination, or in some cases, through the door.

Shuttle services tend to serve a single area rather than be spread through several towns and cities. This requires a rider to be close enough to the organization to be picked up (or to travel there), a similar problem encountered with ride-hailing services, which are often located in areas with high fare potential. Shuttle services tend to have predetermined hours of operation in which rides are only available during certain hours.

The major drawback of shuttle services is that they can be expensive to implement. Travel is typically by bus or van, both of which have a higher initial investment than smaller vehicles and also cost more to maintain. In addition, some form of brick-and mortar location must exist for the shuttle and coordination of rides. Conversely, riders typically enjoy free or reduced-cost transportation, making these services ideal for all incomes.

Example Program: Mountain Empire Older Citizens Inc. Mountain Empire is a nonprofit organization that operates in the southwestern Virginia counties of Lee, Wise, and Scott (estimated population, 85,000). The organization offers many services for older adults, ranging from adult day health care and elder abuse information to transportation services. The shuttle service functions as an on-demand system with 24-hour notice required. Rides are provided for any trip and can accommodate those with canes, walkers, and wheelchairs. Riders over 60 are charged 75¢ per ride.

The drivers provide a curb-to-curb service; the driver picks up the rider from any location and drops them off at any location. Drivers do not provide additional services beyond loading and unloading assistive equipment. Typical hours range from 7:00 a.m. until 5:00 p.m., but special hours can be accommodated. Mountain Empire provides 145,000 rides annually. Figure 7 shows Mountain Empire Older Citizens Inc.'s facilities.

Mountain Empire Older Citizens Inc.

Location: Southwest Virginia

Rides Offered: 145,000

Population Served: 85,000

Cost: 75¢

Restrictions: None

Unique Traits: Offer a wide variety of additional services to support the older adult

Figure 7. Photo. Mountain Empire Older Citizens, Inc., located in Southwest Virginia. Image from www.meoc.org.

GPS Technologies

Vehicle Tracking

GPS tracking devices enable a caregiver to locate an older adult in the event they require help. GPS trackers transmit location information back to a designated recipient, allowing vehicle speed, location, and potential crash/near-crash events to be monitored. Users can also create waypoints or geofences to signal when the older adult has entered a location and how long they have been there.

Car-based GPS devices are ubiquitous and relatively inexpensive; many come as standard equipment on vehicles. Aftermarket devices tend to be small and unobtrusive. In addition, applications exist that allow vehicle-based tracking solutions to communicate with a caregiver's smartphone. One major benefit is that this allows a caregiver to track the senior's location from anywhere in the country without requiring close proximity.

Vehicle-based GPS tracking devices suffer from a few impediments that could hinder widespread adoption. Once an older driver leaves the vehicle, tracking information becomes significantly less helpful. An individual may exit the vehicle and wander away, making the tracking information from the vehicle useful, but only somewhat as the individual's exact location is no longer being tracked. Additionally, the caregiver must have a smartphone readily available, and the senior driver must not interact with or disconnect the tracking device in the vehicle (something which may happen accidentally or purposefully).

Vehicle tracking devices cost nothing to the local community; rather, the owner bears the full expense. The cost for a vehicle-based GPS is low, with many devices under $35. However, many devices also require a subscription service, which can be an additional $20 per month. While not

substantial in the short term, these costs can accumulate over the course of years and be detrimental to those on a fixed income.

Example Program: MotoSafety. MotoSafety is a privately owned company that created a car-based device designed to transmit data from a vehicle's On-Board Diagnostics port to a caregiver's cell phone. This product is intended to work anywhere within the United States. The hardware costs $40 plus a $20/month subscription service. In addition to location data, kinematic data from the vehicle network are used to generate a safety report for the caregiver. The report can be used as a starting point for discussions with the older driver regarding safe driving and skill retraining. In addition to kinematic data, the device offers real-time tracking and waypoints. The real-time tracking shows the vehicle location, direction, and speed. Waypoints can be used to alert the caregiver when programmed locations are reached (Figure 8).

MotoSafety

Location: United States

Rides Offered: N/A

Population Served: 329,000,000

Cost: $40 + $20/month

Restrictions: None

Unique Traits: Generates safety report for caregiver based on vehicle kinematic data

Figure 8. Screen capture. MotoSafety displays showing location, waypoints, and a safety report from a driving trip. Image from www.motosafety.com.

Individual Tracking

Some tracking products are designed to track individuals themselves. These products can be especially useful in situations where a vehicle-based GPS tracker stops providing useful information when the user is on foot. An older adult may be starting to experience cognitive decline but still driving and exploring. After leaving a vehicle, the senior may become lost or disoriented in unfamiliar situations. In these cases, individual trackers can provide precise location information for the caregiver. Some devices clip onto clothing or belt loops, while others are implantable in a shoe. The objective of the shoe application is to decrease the prevalence of the senior leaving the house without the tracker.

Individual GPS tracking devices improve on one of the major weaknesses of vehicle-based technologies: tracking can continue whether the individual is in the vehicle or not. One device also comes with an emergency button. In the case of an emergency, the user can press the button and alert a 24-hour response center, providing an extra layer of safety and security.

Any GPS device that tracks an individual rather than a vehicle requires a battery, which means that the device must be charged (or the battery changed when it is expended). Battery concerns prevent the device from being "set and forget," such as a vehicle GPS would be. Additionally, on-person devices must be remembered when leaving home. Some devices also require the purchase of a subscription service for the use of the emergency button function. Such a subscription may be a cost barrier to those on a fixed income.

Like vehicle-based GPS technologies, those that track individuals are free to the community because the user bears the cost. Devices that require both an initial purchase as well as a subscription service make the cost for the user higher. Over the course of years, the pricing could become a barrier for lower-income individuals.

Example Program: Mind Me. The for-profit company, Mind Me, invented a small, wearable product for older adults. The device costs $100 plus $20–$25 per month for a subscription. The tracker clips onto a key chain or can be placed in a pocket. Mind Me is intended to work in any location across the United States. It has two main purposes: a personal alarm for a user who may be lost or confused, and a tracking device for the caregiver. The caregiver can track the location from any internet access point with an accuracy of 10 meters. Should the user require help, an emergency button located on the device will signal a 24-hour response center. Mind Me also allows riders to set up predefined geofences that can alert the caregiver if the device leaves the preset location. An example device showing the emergency button is shown in Figure 9.

Mind Me

Location: United States

Rides Offered: N/A

Population Served: 329,000,000

Cost: $100 + $20-$25/month

Restrictions: None

Unique Traits: Has an emergency button that contacts

Figure 9. Photo. Mind Me device with emergency button. Image from www.mindme.care.

GPS Geofence

GPS technology can also utilize precise location information to limit the locations where an individual can drive—this is known as geofencing. This technology could be applied in legal cases where drivers with decrements or limitations may be restricted to certain roadways or locations. In a different application, one company combines GPS data with the known limitations of recreational vehicles (RVs) to create RV-specific navigation. For example, based on the size of the RV or the carry load, the system can calculate a route that avoids features such as low bridges or tight roads. Similarly, commercial motor vehicle operators use software to track and limit where drivers travel during delivery trips; when a driver moves outside a predetermined boundary, an alert is issued.

Utilizing a geofence to control or monitor the location of a driver does not place a cost on the community, but rather on the user. A system of this type may pose a substantial pricing hurdle. CarrierWeb, for instance, is designed for fleet services to monitor drivers. Alternatively, RV-specific navigation could be augmented with a geofence data structure and be redesigned for an individual user rather than a fleet, but that technology was not found during the program review.

Example Program: CarrierWeb. CarrierWeb (now owned by ID Systems) is a for-profit corporate-level GPS tracking program that uses tracking information to keep drivers on a given route. Once a route geofence is created, any deviation from those roads is recorded and an alert is created (Figure 10). A similar program could be used in any location within the United States and would be applicable to any individual with the GPS module. Although a price is not currently listed, CarrierWeb is likely expensive, as it appears to be designed for fleet-level or carrier-level organizations.

CarrierWeb

Location: United States

Rides Offered: N/A

Population Served: 329,000,000

Cost: N/A

Restrictions: None

Unique Traits: Uses GPS waypoints to track vehicle travel and ensure that the driver stays on the prescribed route

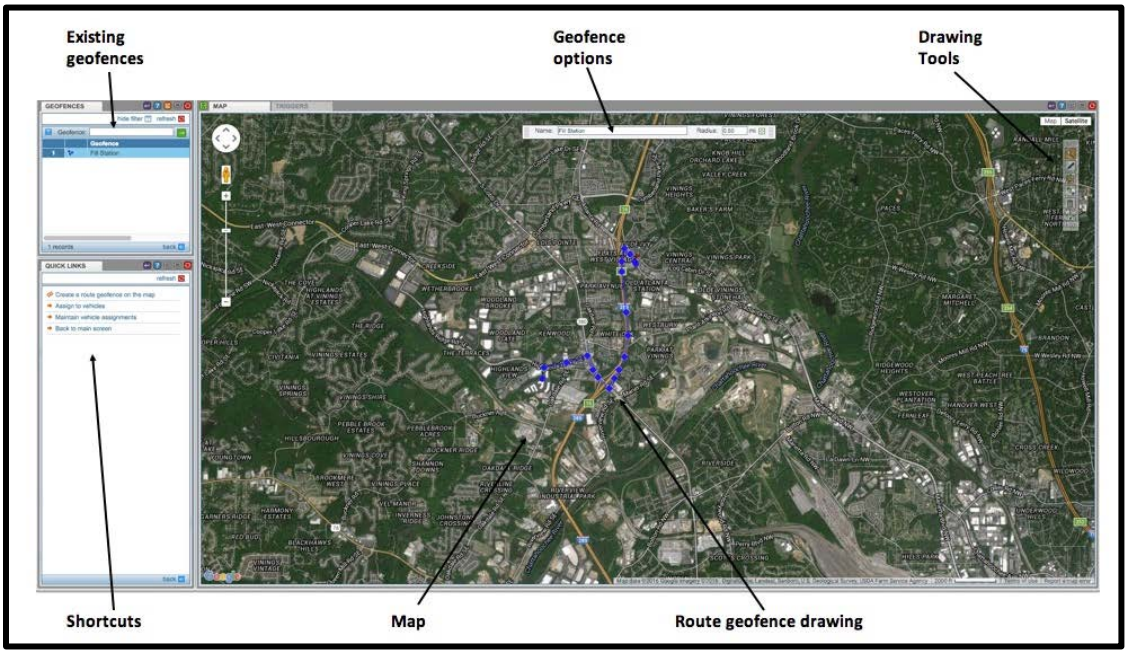

Figure 10. Screen capture. CarrierWeb (ID Systems) route geofencing interface. Image from www.carrierweb.com.

Navigation

Route-finding applications for smartphones are well-known for driving, but less so for walking. Foot-travel navigation applications allow the user to find a predetermined location on foot or to return to a marked location (such as a parked vehicle). One application allows the user to create a

series of data points for a parking location. Users can record the GPS coordinates of a parking space, take pictures, and leave a voice memo. Other implementations allow the user to navigate to a location, such as to meet a friend for lunch or to go to an appointment, in much the same way as one would in a vehicle. For example, some apps feature a navigation screen that guides the user with an arrow, directions, and waypoints until the destination is reached.

Navigation applications for on-foot destinations can increase older adults' confidence. They can explore unknown areas without the fear of getting lost, as the app can function as a safety net and guide them to a destination or back to their vehicle. All mobile applications for older adults can come with usability concerns, however. For example, seniors may find it difficult to program a destination or interact with the device.

In-vehicle navigation implementations have become quite prevalent over the last several years, with many vehicles offering it from the factory. Even in the event the vehicle does not come equipped with GPS navigation, many aftermarket applications are available. While these devices focus on travel via roadway networks, one company has supplemented navigation directions with landmarks. Users may find the landmarks beneficial, as street names may be difficult to find, printed in small text, obscured by vegetation, or even missing. Such redundancy may prove to be quite helpful to older drivers.

Personal navigation does not require investment from the local community; users of the software and hardware pay all the costs. Apps on smartphones are quite inexpensive. For instance, the user often pays less than $10 for navigation, and in some cases apps are free. If the driver does not already own a smartphone to run the navigation applications, the cost can rise dramatically when the purchase price of the phone is added in. In the case of stand-alone in-vehicle devices, after the initial purchase price, many of which can be found for under $150, no subscription service is required. Taken together, the costs to the user for navigation services range from inexpensive if the driver already owns the device, to moderately expensive if unowned.

Example Program: Anchor Pointer. Anchor Pointer is a for-profit mobile application developed for users of all ages, though seniors may find it particularly helpful. The application functions similarly to a road-based GPS navigation system except that it is designed to guide the user to a given walking location. The application is intended for use anywhere in the United States and uses navigational arrows to guide the user through stores or across streets to reach a desired location. Waypoints can be set up as intermediate goals on the way to another destination. Users can use this application to meet with friends or family members, to remember the location of a parked car, or even to increase confidence while shopping in a busy or unfamiliar environment (Figure 11). The application is currently available for $7.99 in Apple's App Store as a one-time purchase.

Anchor Pointer

Location: United States

Rides Offered: N/A

Population Served: 329,000,000

Cost: $8

Restrictions: Must use iOS device

Unique Traits: Uses waypoints to direct user similar to vehicle GPS, but while on foot

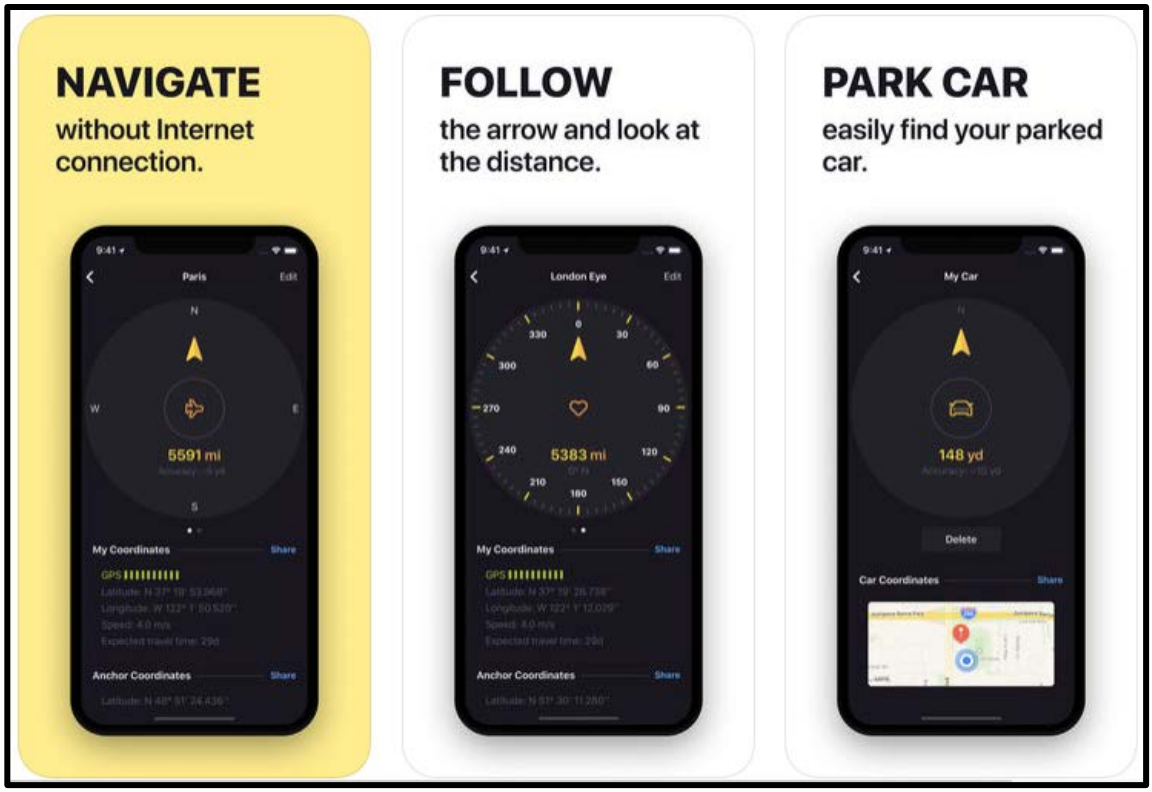

Figure 11. Screen capture. Anchor Pointer application showing examples of personal route-finding on foot. Image from www.apps.apple.com/us/app/anchor-pointer-compass-gps

Traffic Modeling

Traffic modeling analyzes data from local roadways to predict traffic flow or volume under certain characteristics or load. The resulting information is then delivered to end users, who have the choice to alter their route. Typically, traffic models have focused on traffic flow and traffic timing and are usually focused on metropolitan areas (Zhong, 2009). For seniors, forecasts can help them to determine when there will be high traffic volumes, construction, or planned events that could affect route choice. For example, AAA presented a table containing the poorest days and times to travel for Memorial Day in 2019 for major metropolitan areas. Traffic modeling programs currently exist for cities such as Tallahassee, Florida; Scottsdale, Arizona; and Calgary, Alberta, Canada.

Unlike the GPS-based technologies discussed above, traffic modeling development and software is funded by the local community (or grants from the state and federal governments). While the development of an algorithm in one location may reduce the cost and time for development in another area, it is still not without a high cost. Some installations may require sensors and cameras for data collection. Another approach may be to utilize crowd-sourced data collected by smartphones during routine travel. Beyond the logistical challenge, it is likely that the maintenance associated with hundreds of sensors, cameras, and various servers would be costly. From the driver's perspective, the interface with the model (typically a webpage) is free and is accessible anywhere an internet connection is available.

Example Program: Tallahassee Driver Information System (TDIS). The TDIS program is a publicly funded online dashboard created by local government. The system allows drivers to view real-time traffic information for the city of Tallahassee and the surrounding areas for free (Figure 12). The interactive map also allows riders to see other types of relevant information such as future maintenance, camera locations, and planned events. While Tallahassee hosts a population of 191,000 people, the concept could be applied to lower-density areas as well.

Tallahassee Driver Information System

Location: Tallahassee, FL

Rides Offered: N/A

Population Served: 191,000

Cost: Free

Restrictions: None

Unique Traits: Real-time traffic conditions including construction and events that may affect travel

Figure 12. Screen capture. Graphical representation of traffic flow for the city of Tallahassee, FL. Image from www.talgov.com.

Outreach and Care

Health and Mobile Care

One approach to increasing the safety and mobility of older adults is to remove barriers to medical care. To accomplish this, some companies have created mobile clinics to address a portion of medical issues. Mobile clinics are staffed by doctors and nurses who provide a variety of care focused on medication reviews, vaccines, preventative exams, dental work, diabetes management, and nutrition or physical therapy. The goal of these mobile clinics is to minimize barriers to care, which will improve health and potentially increase driver mobility. Uber provided a similar, but more narrowly focused service, where flu shots were delivered to users in need who were not readily able to travel.

Health and mobile care organizations help to mitigate the distance concerns of rural residents. A close health care location allows older adults to receive the care needed without the need to drive to a larger city, or in some instances, drive in uncomfortable environments or scenarios (high-speed roadways, for example). Mobile care also encourages the screening and discussion of health issues more frequently with a health care professional. Ideally, increased frequency of care will prove helpful in the detection of physical or cognitive decrements.

Mobile care clinics are often only available for those on either Medicare/Medicaid or those who have health insurance from the company running the program. While many older individuals are enrolled in Medicare, those younger than 65 may find themselves unable to take advantage of the care clinics. Another impediment faced by mobile clinics is staffing. In many cases, mobile clinics are staffed by doctors, nurses, and administrative personnel. While it is possible that they are volunteers (in an already likely overworked population), for widespread implementation a significant funding source is required. Mobile clinics are also not well known, and therefore advertising is required to attract as many older individuals as possible. Without marketing efforts, the ability to affect health and mobility is diminished.

From a community perspective, initiating a health care clinic can come with steep prices. The process would involve organizing and paying staff, purchasing and outfitting a vehicle, and incurring various maintenance costs, including consumables. These costs are likely insurmountable without financial subsidies from a local hospital or health insurance company. Patients would see moderate to high costs as the treatments are often tied to health insurance. However, for low-income individuals, insurance co-pays and deductibles may be prohibitive.

Example Program: Health Care on the Go. Heath Care on the Go is funded by Highmark, a health care company located in Pennsylvania and West Virginia. The company runs a mobile clinic (Figure 13) that provides health care to individuals in rural communities. While the number of those treated is not available, the estimated population of Pennsylvania and West Virginia is 14.6 million, signifying a potentially large number of users. The clinic focuses on preventative exams, medication reviews, vaccines and immunizations, smoking cessation, annual visits, and testing for chronic conditions. While costs for the user are not explicitly stated, prices likely reflect the costs associated with visiting a health care facility. The goal for the company is to reduce barriers to health care and by doing so increase the health of the individual. Individuals with Medicare, Medicaid, or coverage through the Affordable Care Act are served.

Health Care on the Go

Location: Pennsylvania and West Virginia

Rides Offered: N/A

Population Served: 14,600,000

Cost: Insurance copay

Restrictions: Member of Highmark health insurance

Unique Traits: Supports rural health care in a variety of services

HIGHMARK.

Figure 13. Photo. Highmark mobile health clinic. Image from www.highmark.com.

Emergency Response

Several locations (New York, Georgia, and Boise, Idaho) are promoting enhanced emergency response in the event of a crash, with the goal of improving survivability and health outcomes. These improvements may be limited in rural areas. The likelihood of survival is impacted by reductions in response time, on-scene access to medical information, and quicker access to local hospitals. Stitzel et al. (2016) were able to accurately predict injury severity using advanced automatic crash notification, which allows first responders to arrive with a more-accurate image of the situational needs. Immediate reporting of crash information to local emergency responders reduces response time. Additionally, the city of Boise, Idaho, trains local firefighters to the level of Emergency Medical Technician or higher. Not only does this training maximize tax dollars, but a greater number of skilled workers with proper training ensures a high level of care regardless of which emergency team arrives first.

The cost to a local community for emergency response programs ranges from low to moderate depending on the program. Implementations that train employees to look for critical medical information in the vehicle, such as in a glove box, can be quite inexpensive to implement. Programs that expand training to include skills not in the worker's primary profession require more time and expense. Drivers, however, gain access to the benefits of these programs without any cost, as in the case of the Yellow Dot program (see below), where materials are provided for free.

Example Program: Yellow Dot Program. Several states (Pennsylvania, Tennessee, Alabama, Illinois, Kentucky, Maine, Utah, Georgia, and New York) utilize a Yellow Dot program. Individuals can affix a yellow dot to the windshield, rear window, or side window of the vehicle to notify emergency responders of a medical envelope in the glove box (Figure 14). The contents of the envelope contain health information critical to the care provided following a crash. The program is designed to support care during the "golden hour" immediately following a crash, the period crucial to survivability. Costs to implement for both skilled workers and drivers are minimal.

Yellow Dot Program

Location: Multiple states

Rides Offered: N/A

Population Served: 81,300,000

Cost: Free

Restrictions: None

Unique Traits: Improves crash survivability by providing critical information to emergency responders

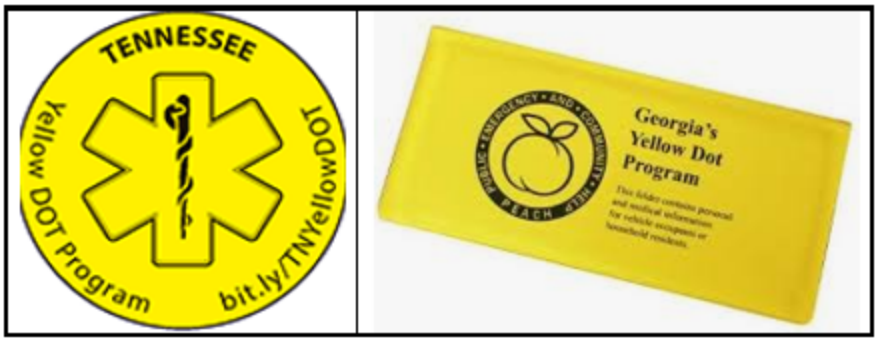

Figure 14. Illustration. Yellow dot sticker (left) and glove box envelope (right). Images from www.wrcbtv.com (left) and www.seniorcitizensinc.org (right).

Outreach and Advocacy

Some organizations specialize in outreach and/or advocacy on behalf of older adults. For example, Alzheimer's Aware focuses on training for law enforcement. The goal of training is to improve officers' understanding of cognitive impairments, interactions with those who have cognitive decline, and communication with caregivers and special search and rescue protocols related to that specific population. Other organizations create pamphlets or post information online, with topics covering such things as crash safety specific to older drivers, keeping a senior driver mobile and safe, or even having a conversation about driving cessation.

Organizations working in the areas of outreach and advocacy for older drivers can have an enormous impact. In terms of advocacy, organizations have the capacity to effect change in federal and state laws to better suit older adult mobility. This potential for large-scale impact is unmatched by other programs. For outreach organizations, many of the materials, once developed, can be freely deployed across the country, allowing for a widespread audience and large number of organizations to participate. Additionally, outreach materials posted on a website are often grouped with other relevant materials, making information easy to find. These sites often provide relevant links to driver evaluation referrals and licensing requirements, health information, senior transportation options, and available alternative transportation requests.

Unfortunately, advocacy can be expensive and requires individuals with specialized skills, especially in the case of those traveling to Washington, DC, to advocate for policies in front of Congress. In contrast, outreach materials often contain a large amount of information that many find useful at an inexpensive cost. However, if the materials are only located on a website, many may not know they exist and therefore not seek them out.

Advocacy and outreach place the burden of cost on the local community (or rely on federal and state grants) rather than the older adult. While information can be readily shared across communities, dissemination and outreach can be expensive. For example, a local community would likely require a brick-and-mortar location to support dissemination. Funding for travel to state and federal meetings may be required for advocacy efforts. However, older adults gain access to the benefits of outreach and advocacy without any direct costs.

Example Program: National Association of Area Agencies on Aging (N4A). The N4A is a publicly funded, nationwide organization that provides a large number of services to older adults. One of the main focuses for the N4A is an Eldercare Locator, which receives 57,000 calls annually regarding transportation rides. Riders may request a companion for medical visits or other door-through-door services. A current advocacy objective is the Older Americans Act, which connects older adults and caregivers to much-needed resources like meals, caregiver support, transportation, and job training. The Older Americans Act was recently reauthorized through the year 2024. Reauthorization allows connections between older adults and needed services to continue uninterrupted. Additionally, N4A is advocating against cuts to Medicaid being considered as part of the current effort to repeal parts of the Affordable Care Act. By preventing cuts to Medicaid, caregivers and those who need help can continue having access to the services needed for independence and mobility.

National Association of Area Agencies on Aging

Location: United States

Rides Offered: 57,000

Population Served: 329,000,000

Cost: Free

Restrictions: None

Unique Traits: Provides a number of additional resources to help older adults and caregivers as well as national advocacy

n4a

advocacy | action | answers on aging

N4A also provides several resources for the general population to help care for loved ones and maintain mobility. For example, one pamphlet, titled "Dementia, Caregiving and Transportation," provides tips for caregivers, describes what role transportation providers can play, provides information on how to be a dementia-friendly driver, and lists national resources available. The pamphlet contains information on how to compile a travel kit for older adults. It contains ID tags, picture identification, prescription medications, emergency contacts, and travel home and destination information (Figure 15).

Figure 15. Illustration. Travel kit for older adults with dementia as suggested by N4A. Image from www.n4a.org.

Time Banks and Community Living

Time banks exchange services between individuals. The goal of these programs is to create a marketspace for individuals to trade services with each other. For example, a senior offers a cooking class to a younger individual in exchange for a ride to a medical facility. Or, an older adult who no longer has a license may provide a cooking lesson in exchange for a ride to the local grocery store. A wide variety of services can be exchanged, from cleaning gutters and computer lessons to medical transportation and gardening advice. The range of services offered allows seniors to retain a sense of societal usefulness and place in the community and receive assistance when required.

Community living models have the benefit that, once initiated, a sense of community and trust can be developed. That trust may allow participants to feel more comfortable soliciting help from another individual as opposed to interacting with an unknown person.

The largest drawback of time banks and community living models is that while all implementations could potentially use a shared internet infrastructure, each town or area is unique in terms of what services are offered and desired. For example, one location may have greater opportunities for a senior's services and that senior will find it easier to build credits to use on rides. Someone in another community, however, may not find their particular services in demand and struggle to build credits for rides. An installation in each town allows those who are local to one another to interact and exchange services without the need to travel long distances. A program covering an expansive rural area may not prove as useful given that it contains fewer individuals to exchange services. This restriction suggests that efficient implementations should

be relatively small in area so their usefulness is not eroded by long travel distances. Additional problems that may hinder widespread use include interaction with a graphical user interface to request help, something the older population may have difficulty navigating. Finally, joining a time bank varies from location to location. For instance, some require a background check whereas others do not. Absent screening, the time bank could become a vehicle for those who try to take advantage of older adults. Larger organizations like Uber or Lyft have successfully provided screening and background checks on drivers, suggesting aspects of their model may be applicable to time bank organizations.

Establishing a time bank does not require a large investment of money from the community. A website to display and run the program is a relatively modest cost and may be subsidized by users' membership fees. In some locations, users of the time bank cover the low cost of the program with a $20 annual membership fee. Many other time banks do not appear to charge a user fee for enrollment, allowing those on a fixed budget to participate. Local time banks can be searched through a nationwide directory (https://community.timebanks.org/).

Example Program: New River Time Bank. The New River Time Bank is a nonprofit program located in southwest Virginia, which is home to a community of 183,000. Through the website, users can either offer services or search for individuals who need a given service. After signing up for free, the user can provide a service for members of the community in exchange for another service such as a ride, help cleaning gutters, running errands, etc. Figure 16 shows a portion of the current services requested by members. Here, the requests range from crafts and lessons to errands or shopping.

New River Time Bank

Location: New River Valley, VA

Hours Exchanged: 2,865

Population Served: 183,000

Cost: $20 membership fee

Restrictions: None

Unique Traits: Provides a number of additional resources to help older adults and caregivers as well as national advocacy

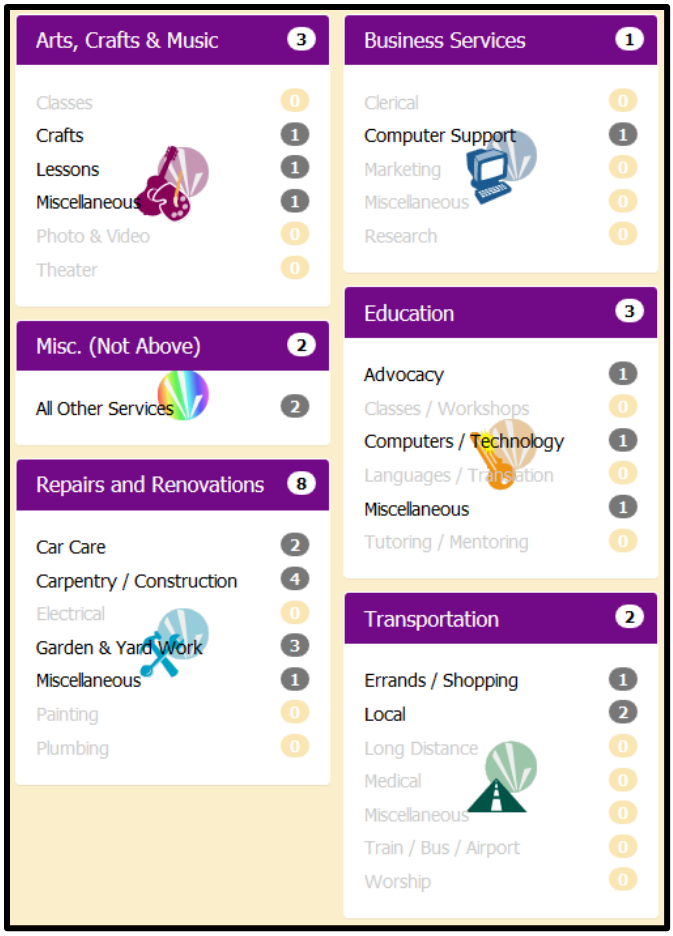

Figure 16. Screen capture. Example set of requests from New River Time Bank website. Image from www.nrv.timebanks.org.

Active Transportation

Active transportation involves some sort of physical activity such as walking or biking to travel. Programs related to active transportation either help to manage the travel or provide a level of physical conditioning to encourage and maintain independent mobility. Some examples of active transportation programs include walking paths, such as those completed by the Rails to Trails Conservancy, or assisted bicycle riding, as exemplified by research at Delft University in the Netherlands.

Active transportation can be a boon to older individuals. One main form of transportation, walking, is free, and it can improve health and well-being. When undertaken in a group, walking can facilitate social relationships. Additionally, improved health and physical conditioning have been shown to aid in improving driving-related fitness (Marmeleira, Godinho, & Fernandes, 2009). Cycling is also minimal cost after the initial purchase of the bicycle.

Despite all the advantages, walking and cycling may lack safe routes. Many roadways may not have adequately sized cycling lanes or even have such lanes. Additionally, if an individual in a rural area chooses to walk or bike, it is likely they will have longer travel distances than their

urban counterparts. Seniors or others with physical limitations may not be able to safely engage in such activities. While walking may be relatively safe, doing so over uneven, wet, or icy surfaces may be challenging. In the case of cycling, older adults may find balance more difficult than when they were younger, especially in the presence of any injuries or cognitive decrements.

Investment in active transportation in a local community can come with significant cost. Many rural roads are not be designed to facilitate active transportation and therefore would require the construction of sidewalks, off-traffic paths, or in-traffic bicycle lanes. In the absence of any state or federal funding, local communities may find the cost prohibitive. However, active transportation users would have free access to the new infrastructure, with their only expense being the upfront purchase of a bicycle or similar.

Example Program: Delft University. Delft University, located in the Netherlands, developed a bicycle supplemented with a series of gyros intended to aid the rider. When the bike begins to tip, the gyros sense the impending fall and provide steering input to prevent the fall by keeping the bicycle upright. Increasing the number of individuals cycling both reduces road congestion and provides an exercise benefit on top of travel. Delft University aims to increase the number of older adults cycling by decreasing the number of falls. The bicycle is not currently on the market, but its developers hope the technology will continue to be improved upon, allowing the bike to reach the market within a few years.

Delft University

Location: Netherlands

Population Served: 17,100,000

Cost: N/A

Restrictions: Ability to ride a bicycle

Unique Traits: Provides a novel intervention to increase bicycle utilization for older adults

TU Delft
Delft University of Technology

Figure. Photo. Delft University bicycle steering system. Image from www.tudelft.nl.

CHAPTER 4. GENERAL DISCUSSION

CURRENT STATE OF PUBLIC TRANSPORTATION

According to the 2017 *Rural Transit Fact Book*, 437 fixed-route rural transportation providers were in operation in 2015 in the United States. Additionally, 1,102 providers operated on a fixed-route and demand/response modality, while 49 operated solely on a demand/response modality, resulting in a total of 1,334 providers. These numbers may even be slightly conservative given that they represent only providers receiving grant funding for rural transit (5,311 federal to state to local government funding). This accounts for 82% of counties in the United States being served by *some* level of rural transit service in 2015 (Mattson, 2017). While public transportation may be a staple of rural mobility, it fails to be a cost-effective route forward. Opportunities to augment public transportation are discussed below.

GAPS AND OPPORTUNITIES

Enhanced Navigation Systems

The review did not uncover a navigation system specifically tailored to aid older drivers by avoiding difficult scenarios. In many mapping programs, a driver can select options to avoid toll roads, highways, or even ferries. Specific options for older adults, however, have not been implemented. These could include locations or scenarios that older drivers tend to avoid or where they have higher crash rates, such as left turns across path (Payyanadan et al., 2017), high-speed roadways (Molnar et al., 2013), roundabouts (Broberg & Willstrand, 2014), intersections (Zhang et al., 1998), high-volume roadways (Ball et al., 1998; Charlton et al., 2001), busy times of the day (Devlin & McGillivray, 2016), or merging/lane change scenarios (Antin, Wotring et al., 2017). Older drivers may benefit greatly from implementation of a navigation system where scenarios can be selected (or preselected) for avoidance. Additionally, one can imagine an implementation where a baseline set of scenarios is automatically enabled so that the driver does not have to interact with the system. By customizing standard navigation programs, older drivers may retain driving independence longer.

Currently, the Virginia Tech Transportation Institute and North Carolina A&T State University are developing a navigational program similar to the one described above. It focuses on multimodal transportation, taking into account traveler limitations such as disabilities and the availability of public or private transportation solutions (Vulnerable Road User MAP, 2018). Implementing avoidances for those who choose to travel by personal vehicle would strengthen the usefulness of the program. Additionally, traffic modeling has been used by local and state governments as a guide for drivers. Live traffic information, communicated either directly or via an intermediary, can help older drivers plan their travel for times when the roadways are less busy.

GPS-based Location Restriction

Another application of GPS is to use tracking to formally restrict older individuals from driving in specific locations. For example, a system could be designed to alert monitors whenever a vehicle has accessed a high-speed roadway or traveled to a busy city center. Legal authority for such restrictions would likely have to be based on doctor recommendations or prescriptions,

authorization from the DMV, or even judicial orders based on driving performance or physical and cognitive testing.

GPS vehicle tracking has multiple applications for older drivers. Consumer-grade products, such as MotoSafety, allow a caregiver to track the location of an older driver's vehicle and be alerted when a geofenced area is entered or exited. Navigational apps, such as Apple Maps and Google Maps, allow the user to avoid highways (though avoidance options are minimal). While the technology certainly exists to limit access to some areas, it is not implemented into a device specifically for consumer-level restrictions. One possible implementation would be to create a customized solution for older drivers that could restrict access to driving situations known to increase crash risk for seniors, allowing them to safely maintain their mobility for longer.

Before such an application is developed, however, several questions would have to be answered:

- What avoidances are drivers willing to allow?
- Do drivers feel like restrictions are a violation of individual freedoms?
- Is it technologically feasible to alert police or a caregiver in real-time to restriction violations?
- What sort of interface would be required for law enforcement?
- Does implementing restrictions *reduce* the occurrence of crashes?

Expansion of Ride Share/Volunteer Drivers

One limitation of many public transportation or shuttle services is that these systems do not function 24 hours a day. In addition, many services are restricted to a fixed route. To move riders to an already-established bus stop and/or provide service outside of typical hours, an expansion of ride-hailing services should be considered. Ride-hailing services like Uber or Lyft fill this gap in larger cities, but due to the crowd-sourced modality, rural areas may be underserved.

Research has shown that older drivers prefer volunteer drivers (Battista et al., 2015; Rahman et al., 2016) likely due to inconvenient bus schedules and routes (Battista et al., 2015; Glasgow & Blakely, 2000; Schwarzlose et al., 2014). Research also suggests that older adults in rural areas would benefit from more on-demand options. An expansion of ride-hailing services, either via publicly funded groups or federal incentives, may prove useful. This would allow access when needed, even if to a transportation hub, in areas without the population density to support a ride-hailing program. Independent Transportation Network America capitalizes on seniors' preferences for volunteer drivers. This network promotes volunteerism through a credit system. Credits can be earned many ways: through driving, gift certificates, cash, or in exchange for a personal vehicle being utilized in a CarTrade program. The collection of credits is location independent, which allows trade within the community or between friends and family irrespective of location. The credits can then be used for transportation.

Increased Active Transportation Facilities

As discussed above, active transportation facilities can aid senior mobility, but gaps still exist. Twenty percent of the nearly 6,000 pedestrian fatalities in 2017 occurred in rural areas, showing that a safe environment for rural pedestrians is essential (National Center for Statistics and

Analysis, 2019a). This indicates that rural individuals are still walking despite a lack of safety-enhancing infrastructure like sidewalks, resulting in greater risk due to higher traffic speeds. Increased pedestrian travel may be an artifact of the reduced availability of public transportation in rural areas.

One study in rural Wisconsin showed that the presence of cycling lanes reduced driver violation rates by four to six times compared to just a paved shoulder (Chapman and Noyce, 2012). This strongly suggests that safe travel along rural roadways could be accomplished utilizing bicycle lanes. Another study showed that 25% of 783 fatal bicycle crashes in 2017 occurred in rural areas (National Center for Statistics and Analysis, 2019b). If active transportation is to be a viable alternative, more funding is required to expand cycling lanes and/or separate pathways for bicycles and pedestrians to travel safely.

CHAPTER 5. CONCLUSION

Structured Interviews

The structured interviews provided valuable insight into what experts working in rural mobility felt was important. The experts all noted that rural seniors face challenges with respect to mobility and that public transportation is integral to rural mobility. Additionally, all experts believed that one-stop/one-call facilities simplify the process for riders by providing them with all of their transportation options at once.

The interviewees argued that the role of public transportation was to fill gaps in the market where businesses did not exist. Businesses will only service an area where there is the potential for profit and are unlikely to service areas with a low population density, which require more resources and offer a smaller chance for profit. Public transportation is needed to fill this gap; that is, cost-sharing for private businesses or taxpayer-funded public transportation is required to go where the market will not.

One-stop or one-call facilities hold much promise for streamlining the ride-hailing process for riders. One interviewee discussed the promise of an umbrella organization over ride-share companies, while others discussed the role being undertaken by public transportation facilities. Currently, some public transportation facilities employ individuals whose job it is to inform riders of available transportation options. Unfortunately, this role is often not a central focus and positions may be understaffed. Amending public transportation facilities to incorporate one-stop/one-call services has several benefits: it provides a single point of contact for all riders requiring a ride, many locations already have some form of public transportation facility to begin with, and it allows riders who travel to any location to know that the local transportation point of contact is the local public transportation facility.

One of the experts suggested that the driver in a public transportation vehicle may serve to provide additional information or services to older riders. While this may work in sparsely populated areas, it is unlikely to be useable if the driver is taxed with other duties. However, this role may shift with the onset of automated vehicles; once the operator becomes more of a monitor than a driver, more resources could be allocated to other supportive tasks.

No One Size Fits All

The results of the program review show a variety of implementations designed to improve or maintain mobility for older drivers. One key difference to note is that some of the programs listed above are currently implemented in areas of higher population density (such as Portland, Oregon, or Austin, Texas) and as such may be efficient for a large urban population but not a rural locality. Examples such as a well-developed public transportation route, shuttle systems, or ride-share companies may be effective in highly dense areas. However, localities with lower population densities such as rural Mississippi can capitalize on programs that increase the cohesiveness of the local community, such as time banks. Given that different population densities will lend themselves to different approaches and modalities, it is likely that some implementations will be better suited for certain population density areas.

Many of the programs reviewed operated during certain hours of service or by a set schedule (shuttle services, bus routes, etc.). In areas of lower population density, structured hours may negatively affect mobility as alternatives may be limited. Additionally, implementations that run at all hours are highly inefficient due to limited demand. However, higher population areas may be able to capitalize on modalities that are active at any hour, such as ride-hailing services. One can imagine the difficulty associated with requesting a ride from Uber at 2:00 a.m. near a town with a population of 3,000 versus the relative ease of doing so near a city of 3 million. Limiting services to a single modality will not appropriately serve the population's needs at all times, especially when large disparities in population exist between localities.

A multimodal approach based on the specific needs of the local community while taking advantage of the local infrastructure already in place is needed to optimize mobility. For instance, some locations may have several public transportation hubs but lack the sidewalk infrastructure for riders to safely travel to those hubs. Another location may operate a shuttle system but find resources are burdened due to high demand. This community may benefit greatly from expanding public bus routes along the more highly traveled routes to reduce strain on the shuttle.

An ideal approach would likely take advantage of complementary services with an overarching data structure, interface, and support. Transportation services can work together in a model optimized for minimum redundancy. Doing so would prove to be a cost-efficient approach while providing the widest breadth of service. With more riders served, companies would be able to specialize and improve efficiency. One complementary approach is the expansion of public transportation to cover high-demand routes while employing ride-share vehicles to transport riders from a wider area to public transportation hubs. Similarly, community shuttles or ride-share vehicles could transport individuals to centralized locations with mobile health, driver training, or public transportation training. In locations that severely lack any public transportation or shuttle access, these communities could implement a combination of law enforcement training to aid local drivers and a car-fitting protocol in the hope of improving mobility without a public system in place. Finally, communities with several established public transportation hubs and available land may find expanding active transportation facilities, such as walkways or bicycle lanes, beneficial to increase access to hubs.

FlexDanmark, a company located in Denmark, utilizes a similar structure to the above. This company maintains a complex algorithm that analyzes standardized data from over 500 private ride-hailing companies and interfaces with ride requests through an app. The algorithm tracks ride requests by location and time to optimize drivers' routes. In the case of riders who require additional aid, such as a lift or wheelchair, the software will automatically allocate that user's request to appropriate drivers; a driver without an available lift will not receive the ride request, but a driver with a lift will. FlexDanmark capitalizes on the cost efficiency of ride-hailing programs relative to fixed-route public transportation and allows the dynamic nature of ride requests to be handled by a sophisticated algorithm rather than the driver. The business started with five vehicles but has expanded to over 1,700 and offers over 6 million rides per year. A similar approach may work well in the United States in areas with several already established private and public transportation companies; the integration of data and backend support are all that is missing.

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