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Understanding Travel Considerations and Barriers for People with Disabilities to Using Current Modes of Transportation Through Journey Mapping

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Abstract

This study aimed to apply a journey mapping methodology to identify travel considerations and barriers for people with disabilities (PWDs) at each travel stage, from considering a trip through to arriving at the destination for their current modes of transportation, with the objective of understanding and avoiding “pain points” during a transition to autonomous driving systems. Twenty PWDs, including those with physical, visual, aural, cognitive, and combined physical/visual impairments, participated in a semistructured one-on-one interview. Descriptive statistics were used for demographic information, and qualitative content analysis was used

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Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: C.D. Lee, A.M. Koontz, R. Cooper, C.R. Lopes, B.E. Dicianno, R.A. Cooper; data collection: C.D. Lee, R. Cooper, A. Brunswick, N. Deepak, H.R. Kulich, N.L. Collins; analysis and interpretation of results: C.D. Lee, A.M. Koontz, R. Cooper, S. Sivakanthan, W. Chernicoff, J. LaFerrier; draft manuscript preparation: C.D. Lee, A.M. Koontz, S. Sivakanthan, W. Chernicoff, J. LaFerrier, C.R. Lopes, B.E. Dicianno, R.A. Cooper. All authors reviewed the results and approved the final version of the manuscript.

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Supplemental Material

Supplemental material for this article is available online.

to analyze the transcribed interviews and extract themes. Themes were further organized by the modes of transportation used. The top four themes in considering and planning a trip were third-party assistance availability (private vehicle, public transportation, and paratransit), finding an accessible or suitable parking space (private vehicle), access to a service location (public transportation and paratransit), and transportation schedules (public transportation and paratransit). The top four travel barriers to locating, entering, riding, and exiting transportation and arriving at the destination were vehicle ingress/egress (private vehicle and public transportation), concerns about wheelchair securement (public transportation and paratransit), requiring third-party assistance (private vehicle and public transportation), and accessibility to service locations (public transportation). The study suggests that to mitigate travel considerations and barriers for PWDs, vehicle-specific barriers and infrastructure issues should be addressed simultaneously. We anticipate that the findings will provide insights into the design and development of autonomous vehicles, to better accommodate the needs of PWDs.

Keywords

sustainability and resilience; transportation and society; accessible transportation and mobility; disability; community resources and impacts; transportation equity

Access to transportation provides people with disabilities (PWDs) with a sense of autonomy and freedom, increasing participation in daily activities, social engagement, job opportunities, and access to healthcare and education (1, 2). However, access to transportation is currently limited for PWDs. In the United States, of about 61million PWDs, 25.5million (41.8%) experience difficulties traveling outside the home because of their disabilities (3, 4), and PWDs are known to travel less frequently than their counterparts without disabilities (3). To reduce the travel-related inequity between individuals with and without disabilities, many researchers have studied barriers for PWDs in using transportation. Previous studies report that the primary mode of transportation among PWDs is the personal vehicle (i.e., as a passenger or as a driver), followed by public transportation (i.e., bus and subway), taxi (i.e., taxicab and rideshare), and lastly paratransit (5–7). Most studies on barriers to using transportation are focused on public transportation and paratransit (8–13): the most common barriers encountered in using public transportation are inadequate transit systems (i.e., the area that the system covers is restrictive), absence of a public address (PA) system, inappropriate driver attitudes, no accessible route to the stop/station, adverse climate conditions, and insufficient floor or aisle space for mobility devices. Studies found that the most common barriers encountered using paratransit were scheduling problems, long wait times, and long ride durations (8, 9). Previous studies revealed that PWDs who experienced the most frequent and significant travel barriers were individuals with mobility impairments (physical impairments) or visual impairments, followed by intellectual disability and hearing impairment (6–8).

These previous studies explored barriers through surveys, which have the advantage of larger sample sizes and being able to identify general issues and trends. However, this approach can limit comprehension of the context and in-depth details of the responses (14). For example, surveys can identify accessibility issues while using buses. However,

it is difficult to identify in detail what the accessibility issues are (e.g., accessibility of a stop, of a vehicle, or the pay stand, or whether the issue could be solved with assistance from the driver or staff), the circumstances surrounding the issue (e.g., difficulty boarding on roads with no sidewalks; able to use a lift but unable to use a ramp; or can access when using a walker, but accessibility is limited when using a wheelchair), and the underlying feelings and reasons that lead to an individual's decision. Accordingly, one-on-one interviews may help to elucidate the travel barriers for PWDs in greater depth and detail. In previous studies, travel barriers were identified only as overall barriers for each means of transportation, but transportation involves various phases. For example, a study found that using transportation consists of eight stages: setting off from origin, walking to stop/station, waiting for the transportation, entering the transportation, riding the transportation, exiting the transportation, leaving stop/station, and arriving at the destination (15). Accessibility barriers can therefore exist in different forms at each stage of travel. For instance, a person could have difficulty entering a vehicle but have no difficulty exiting the vehicle; or a person could have no difficulty entering or exiting a train or subway but may be unable to get to the platform from the street owing to physical accessibility barriers (e.g., no access to ramp, lift, elevator). Thus, to better understand current travel barriers for PWDs and their needs, knowing what barriers exist for each phase of the process is essential.

Journey mapping in this application is a strategic approach to identifying travel barriers during each travel stage (16). Journey mapping is a more comprehensive, empathy-driven approach to understanding the customer experience than a customer survey. It facilitates in-depth understanding of unmet user needs, allowing organizations to identify "pain points," that is, areas for improvement and opportunities for innovation (17). It can also help organizations to better understand the emotions and motivations driving customer behavior and decision making (17). Because of these benefits, journey mapping has been extended and used in clinical studies (industry) and research to obtain insights into the individual's experiences at each stage of a process until they exit or complete it, by having them visualize their journey from conceptualization, to initiation, through to completion (16). Knowing the potential barriers, pain points, and needs at each stage of travel could help stakeholders, including users, service providers, and experts, better plan, design, modify, and help mitigate or overcome barriers in a practical, realistic, and feasible way. Therefore, the objectives of this study were to use a journey mapping strategy to identify and describe travel barriers for PWDs and their needs for each travel stage. Stages investigated in our study included considering a trip (CT), planning a trip (PT), locating transportation (LT), entering the transportation (EnT), riding the transportation (RT), exiting the transportation (ExT), and arriving at the destination (AD). The objective in using the journey mapping approach, covering all stages of travel, was to allow us to identify travel barriers that may not have been identified in previous surveys or interview studies, and to better understand why the issues specified constitute barriers for different individuals. Furthermore, based on the findings, a flowchart was developed to present what factors are involved in CT and PT, and in choosing an appropriate mode of transportation, and to present the common considerations identified that are related to each type of transportation.

Method

Participants

We recruited 20 PWDs (comprising individuals with physical, hearing, vision, and cognitive impairments) for this study. The participants were recruited using cascade methods, flyers/posters, brochures (in-person, by email, or posted in local rehabilitation facilities, outpatient facilities, and disability organizations), approved text in print media (magazines, newspapers, and newsletters), and web-based and social media postings. Although a comprehensive literature review indicated that a sample size of 12 to 15 participants is adequate to achieve code saturation in qualitative research using interviewing techniques (18, 19), the necessary number of participants for journey mapping is determined when no new information is being generated and a comprehensive set of personas may be generated from the interviewees and their decision processes. Although 20 is not comprehensive of all personas, the number is sufficient to generate insights and validate the journey mapping methodology.

Inclusion criteria of the study were 1) aged 16years and over; 2) current use of one or more forms of accessible/nonaccessible transportation (e.g., personal or public) for travel to destinations in the community (“current” defined as using transportation mode[s] to travel at least once a week); 3) have a disability—disability was defined according to the definition provided by the Americans with Disabilities Act (ADA): “a physical or mental impairment that substantially limits one or more major life activities; a record (or history) of such an impairment; or being regarded as having a disability” (20); and 4) able to communicate online (or over the phone) with or without an ADA accommodation. Individuals unable to speak English were excluded from this study. All participants provided informed consent, and parental consent was required for those under 18. After the screening procedures, based on the inclusion and exclusion criteria, but before the interview, verbal consent was obtained from the participant and documented. The Institutional Review Board approved this study protocol at the University of Pittsburgh.

Participants reported their disability based on the definition within the American Community Survey (21): hearing difficulty (deaf or having severe difficulty hearing; DEAR); vision difficulty (blind or having serious difficulty seeing, even when wearing glasses; DEYE); cognitive difficulty (because of a physical, mental, or emotional problem, having difficulty remembering, concentrating, or making decisions; DREM); and ambulatory difficulty (having severe difficulty walking or climbing stairs; DPHY). The participants were then classified into different groups according to their disability type. The classification was based on a previous study in which physical disabilities and visual impairments posed the most significant transportation difficulties, followed by intellectual disability and hearing impairments (6–8). For example, if a participant had one or more difficulties and had a DPHY, the participant was classified in the DPHY group. Likewise, an individual with DEYE and other difficulties was classified in the DEYE group. Those with both DPHY and DEYE were classified as a separate group. Among people who did not have a DPHY or DEYE, an individual with DREM or DEAR was classified in the DREM or DEAR group, respectively.

Journey Mapping Interview

The interview started with an introduction, including a brief description of the purpose of the study, discussion points, session logistics, and ground rules for the session. Next, each participant provided a verbal agreement of consent, and then the interviewer started recording the interview.

At the beginning of the questioning, participants were asked to take a moment to imagine a specific trip they took outside of their home and to answer each question for each stage of travel (Supplemental Table 1). The semistructured interview covered all trip stages: CT, PT, LT, EnT, RT, ExT, and AD. Each stage had multiple questions and multiple follow-up probe questions used to prompt and elicit more information around the topic. Respondents provided unconstrained responses and follow-up questions were asked, as appropriate. Each interview took about 60min.

Data Reduction

One-on-one interviews were conducted with PWDs by an interviewer with over 20years' experience in conducting such interviews. The interviews were conducted using Zoom, and each was recorded and transcribed (i.e., auto transcribed using Zoom services and later reviewed by study staff for accuracy against the recorded audio). The transcripts were then deidentified.

Statistical Analyses

Descriptive analyses of the participant sociodemographic characteristics were conducted. Qualitative content analysis was used to process the interview data. The transcripts were independently reviewed and coded by two study team members. They read through the first three transcripts and highlighted codes that pertained to specific pain points experienced during each phase of the transportation process. An initial group of categories/themes (e.g., types of transportation; access: physical/cognitive; safety: reliability/physical/psychological; and personal factors: physical/cognitive/psychological/preference/resources/knowledge) and phases was generated and revised through discussion until convergence was achieved. Then the coders began to assign codes to the categories. While analyzing the transcripts, a coder could add a new category/theme if necessary (22). To reduce bias and enhance the reliability of the analysis, a third investigator then independently reviewed the transcripts and reconciled the category/themes and coding discrepancies between the two coders. Multiple categories could be selected for each response.

Barriers were identified by classifying transportation into three types (i.e., private vehicle, public transportation, and paratransit/taxi) according to the characteristics of each type of transportation: private vehicle—door-to-door, flexible route, and flexible schedule; paratransit/taxi—door-to-door, semiflexible route, and semiflexible schedule; and public transportation—stop (station)-to-stop (station), fixed route, and fixed schedule.

Results

The sociodemographic information for the participants is presented in Table 1. The age range was from 26 to 82, and the 55 to 64 age group had the most participants (n = 6, 30%), followed by the 45 to 54 and 65+ age groups (both n = 4, 20%). The majority of study participants were non-Hispanic (n = 19, 95%); White (n = 15, 75%); male (n = 12, 60%), engaged/married (n = 11, 55%); own/renting house (n = 17, 85%); living in an urban area (n = 12, 60%); employed (n = 15, 75%); driving their personal vehicle as a primary mode of transportation to work (n = 8, 40%); and living with disabilities for 25years or more (n = 15, 75%).

Travel Considerations/Barriers to Using Private Vehicles

The considerations (CT and PT stages) and barriers (LT, EnT, RT, ExT, and AD stages) to using a private vehicle (either as a driver or a passenger) are presented in Table 2. Eight of the 10 individuals with DPHY, three of the four individuals with DEYE, and all four individuals with DREM mentioned considerations and barriers to using a private vehicle. Those reporting the most diverse travel considerations and barriers were individuals with DPHY, followed by individuals with DREM. Since the person with DPHY and DEYE did not use private vehicles (neither as a driver nor a passenger), no barriers to using a private vehicle were reported.

Considerations in CT and PT Stages.—The most frequent concerns in the CT stage across all disability groups related to third-party assistance requirements (i.e., whether they can get assistance from caregivers, family members, or friends when needing to travel). Individuals with DPHY also reported difficulty finding a parking spot (i.e., accessible parking availability; n = 5), adverse weather conditions (n = 2), motivation (i.e., whether they are willing to take a trip; n = 1), and vehicle ingress/egress (n = 2) as a travel consideration in the CT and/or PT stages. Individuals with DREM reported high-traffic patterns (i.e., heavy traffic and traffic congestion; n = 2) and health conditions (n = 1) as a travel considerations in the CT and/or PT stages.

Consideration in LT, EnT, RT, ExT, and AD Stages.—No barriers were reported in the LT stage by individuals with DPHY. Some individuals with DPHY reported third-party assistance required (i.e., requiring assistance from caregivers, family members, or friends; n = 2) and vehicle ingress/egress (e.g., transfer-related difficulties owing to the height of the passenger seat, either too high or low; n = 2) as barriers in the EnT stage. A barrier identified in the RT stage was health condition (e.g., unable to do long-distance/-duration travel because of their medical condition; n = 1). Adverse weather conditions (e.g., snow or rain; n = 2) and vehicle ingress/egress (e.g., transfer-related difficulties because of the passenger seat height, either too high or low; n = 1) were barriers in the ExT stage. The identified barrier in the stage of AD was third-party assistance required (n = 2).

In the LT stage, third-party assistance required was a travel barrier for individuals with DREM because they had difficulty identifying their vehicle. Difficulty finding a parking spot (i.e., finding a parking spot where they easily can identify their vehicle among other

vehicles; n = 2) was a travel barrier in the ExT stage; adverse weather conditions (n = 1) was a barrier in the AD stage.

Travel Considerations/Barriers to Using Public Transportation

The considerations and barriers to using public transportation are presented in Table 3. Eight of the 10 individuals with DPHY, all four individuals with DEYE, the one individual with DPHY and DEYE, and three of the four individuals with DREM confirmed barriers to using public transportation. Those reporting the most diverse travel considerations and barriers were individuals with DPHY, followed by individuals with DEYE, with DPHY and DEYE, and lastly with DREM.

Considerations in CT and PT Stages.—The most frequently addressed factors to consider for individuals with DPHY in the stages of CT and PT were accessibility of service locations (e.g., accessibility of a stop or platform, being too far to/from a stop/station, and the distance between stops/stations), followed by adverse weather conditions, and problems with transportation schedules (i.e., needing to check the schedule to plan the trip). Vehicle ingress/egress, third-party assistance required, and public perceptions were also reported as travel considerations in the PT stage.

The most frequently reported considerations for individuals with DEYE in the CT stage were accessibility to service location (e.g., lack of transportation services; $n = 3$), followed by transportation schedules (i.e., needing to check the schedule to plan the trip; $n = 2$), and motivation ($n = 1$). In the PT stage, third-party assistance required ($n = 2$), lack of knowledge about services ($n = 2$), transportation schedules ($n = 1$), and transportation app challenges ($n = 1$) were identified as barriers for individuals with DEYE.

For individuals with DPHY and DEYE, transportation schedules (i.e., needing to check the schedule to plan the trip), third-party assistance required (i.e., whether there is anyone who can ride with and assist them), and adverse weather conditions were the factors under consideration in the CT stage; the transportation schedule was expressed to be consideration in the PT stage.

For individuals with DREM, adverse weather conditions ($n = 1$) and the transportation schedule (i.e., needing to check the schedule to plan the trip; $n = 2$) were reported as the factors to consider in the CT stage; the transportation schedule ($n = 1$) and health conditions ($n = 1$) were considerations in the PT stage.

Barriers in LT, EnT, RT, ExT, and AD Stages.—For individuals with DPHY, transportation app (i.e., smartphone application) challenges (e.g., difficulty checking bus schedules and identifying the current location of the next bus owing to a malfunctioning app; $n = 2$), transportation schedules (e.g., unreliable transportation schedules; $n = 1$), and lack of knowledge about services (e.g., not easy to use for first-time users; $n = 2$) were the barriers identified in the LT stage. Individuals with DPHY responded that vehicle ingress/egress (e.g., difficulties getting in and out of a vehicle and difficulties using a ramp or lift; $n = 2$), wheelchair securement (e.g., malfunctioning tie-down, untrained drivers, and drivers unwilling to help; $n = 2$), third-party assistance required ($n = 1$), and lack of knowledge

about services (n = 1) were the barriers in the EnT stage. Reported barriers in the RT stage included wheelchair securement (n = 3), public perceptions (i.e., getting resistance from drivers or other passengers because of the delays caused by the additional assistance PWDs received, such as using ramp/lift, or tie-down service, while using the transportation; n = 2), and accessibility to service location (n = 1). The most frequently reported barrier in the ExT stage was vehicle ingress/egress (n = 4), followed by third-party assistance required (n = 1) and wheelchair securement (n = 1). Accessibility to service location (e.g., unable to leave the stop or to access the curb cut [i.e., ramp] or sidewalk; n = 2) was reported as a barrier in the AD stage.

Across the LT to ExT stages, third-party assistance required was a travel barrier for individuals with DEYE. In addition to that, unsafe driving was a barrier in the RT stage; malfunctioning PA system and transportation app challenges were barriers in the ExT stage. Adverse weather conditions were reported as a travel barrier in the AD stage.

An identified barrier for the individual with DPHY and DEYE in the EnT stage was accessibility to a vehicle (i.e., difficulties in using ramp/lift). The individuals with DREM reported there are no travel barriers across LT to AD stages.

Travel Considerations/Barriers to Using Paratransit/Taxi

The considerations and barriers to using the paratransit/taxi are presented in Table 4. Eight of the 10 individuals with DPHY; all four individuals with DEYE; the one individual with DPHY and DEYE; and two of the four individuals with DREM mentioned considerations and barriers when using paratransit/taxi. Those reporting the most diverse travel considerations and barriers were individuals with DPHY, followed by individuals with DREM, with DEYE, and lastly with DPHY and DEYE. Individuals with DEYE, and with DPHY and DEYE did not report travel barriers across LT to AD stages.

Considerations in CT and PT Stages.—The most reported factors for individuals with DPHY to consider in the CT stage was third-party assistance required (n = 2), followed by transportation schedule (n = 1), and adverse weather conditions (n = 1). In the PT stage, the most frequently reported consideration was accessibility to service location (e.g., lack of transportation services; n = 4), followed by wheelchair securement (n = 2) and transportation schedule (n = 1).

For individuals with DEYE, accessibility to service locations and transportation schedules were considerations during the stages of CT and PT. Factors to consider for individuals with DPHY and DEYE in the CT stage were adverse weather conditions (n = 1) and accessibility to service location (n = 1). For individuals with DREM, cost (n = 1), adverse weather conditions (n = 1), and accessibility to service location (n = 1) were the factors to consider in the CT and PT stages.

Barriers in LT, EnT, RT, ExT, and AD Stages.—In the LT stage, transportation schedule (n = 1) and vehicle identification challenges (n = 1) were travel barriers for individuals with DPHY. They had difficulties in vehicle ingress (n = 1) in the EnT stage;

wheelchair securement (n = 3) was a barrier in the RT stage. For individuals with DREM, unsafe driving (n = 1) was a travel barrier in the RT stage.

Travel Considerations/Barriers for Individuals with DEAR

There was only one person with DEAR. They reported no specific barriers to transportation; however, because they rely exclusively on their vision, they use extra mirrors to support safe, independent driving.

Taking a Trip as an Individual with a Disability—Based on the categories/themes and codes we used to analyze the journey mapping data, we developed a flowchart (Figure 1) representing considerations/barriers for individuals with- and without disabilities when using transportation. For example, in Figure 1, the solid line illustrates a story of taking a trip as a PWD, and the dotted line illustrates the experience of individuals without disabilities. The individual without a disability represents the ideal scenario for which they only need to consider their travel purpose (i.e., work/school, groceries/supplies/appointments, short business/leisure, or long business/leisure), their residing community setting, and typical standard trip considerations such as weather, time of day, preferences, resources, knowledge, and public perceptions. PWDs, on the other hand, first need to consider their type of disability, medical equipment, mobility assistive technology, and availability of a service animal and/or a caregiver. In addition to their community setting, standard trip considerations and accessible transportation barriers (for public transportation, private vehicles, or paratransit) must also be considered. Lastly, if everything goes according to plan, the individual reaches their final destination. Conversely, it cycles back to common trip considerations.

Discussion

This study investigated travel considerations and barriers at each stage of travel for PWDs using various modes of transportation. Those reporting the most diverse travel barriers were individuals with DPHY, followed by individuals with DEYE, DREM, and DEAR, which is consistent with previous findings (6–8). Identified travel considerations and barriers for PWDs were health conditions, difficulty finding an accessible or suitable parking space, accessible service locations, motivation, adverse weather conditions, third-party assistance availability, transportation schedules, vehicle ingress/egress, public perceptions, wheelchair securement and occupant restraints, transportation app challenges, high or complex traffic patterns, knowledge about services, cost, PA system function, unsafe drivers, and vehicle identification. The identified travel considerations and barriers can be categorized into modifiable barriers and nonmodifiable barriers. Modifiable barriers can be further divided into vehicle-specific, infrastructural, and educational barriers.

Modifiable Barriers: Vehicle-Specific

Third-Party Assistance.—Interestingly, our study identified the third-party assistance as both a travel consideration and barrier for PWDs. Several PWDs, across all disability types, responded that whether they receive assistance from others such as caregivers, family members, or friends is an essential factor in considering taking a trip. Several of the PWDs

reported that they require assistance from others across almost all stages of travel (LT through AD). The assistance required includes finding someone who can provide a ride: “Well, my caregiver—that’s easy. That’s always the easiest option. I just hop in the car, and we go” (participant with DPHY and DEAR); and “The second thing I consider is if there’s someone else that can drive me. And that would be attendant care or a friend” (participant with DPHY); vehicle ingress/egress: “Normally, one of my children will go with me in case I need to get out of the car. They can help with that” (participant with DPHY); selecting a driving route: “We drove out to where it was going to be the day before and planned a safe route to get there” (participant with DREM); and requiring assistance at the destination: “I could spend all day in the grocery store, but uh I need someone who is able to help put things into the cart, get things out of the cart, and carry them into the house” (participant with DPHY); and “A doctor’s visit, where I have to get undressed. Then, I take my aid with me” (participant with DPHY and DEYE). Furthermore, requiring assistance from others was different according to the situation: “I guess my circumstances then dictate whether or not I travel by myself, or I’m comfortable, or if I need to have a personal caregiving assistant with me” (participant with DPHY); and “if I need my wheelchair, then I have to bring somebody with me, so my own car is the easiest” (participant with DPHY.

Vehicle Ingress/Egress.—Vehicle ingress/egress was one of the frequently experienced travel barriers for individuals with DPHY, which is in line with previous findings (7). In addition, our findings showed that individuals with DPHY using assistive devices such as ramps or lifts to access public transportation or paratransit/taxi experienced accessibility-related barriers. Given that these barriers were related to mechanical issues (e.g., ramp/lift malfunction) and operator-related issues (e.g., operator’s inexperience in using the ramp/lift), the results suggest that public transportation operators (i.e., drivers) need regular training in ramp/lift operation and maintenance.

An interesting finding from our study was that these accessibility issues have been reported when using a private vehicle tailored to individuals with DPHY. Notably, they had more difficulty getting on than when getting off because if the vehicle’s seat was much higher than the height of the wheelchair, getting down from the seat into the wheelchair was relatively easy, but climbing up from the wheelchair to the seat was challenging:

> I’m putting my prosthetic leg in first, so it’s more difficult to get into the car because I have to, it has to bear all my weight, and I have to you know kind of instead of pulling, trying to find a way to describe this, I’m like keeping I have to push deadweight in and then put my real leg that actually moves in after me so it’s difficult to put that in and my seat has to be in a certain position, it has to be all the way back. And the steering wheel has to be up (participant with DPHY).
>
> I have to get my leg higher, and I have to like kind of back into it. I have to like backwards into it and lift myself up. And that, yeah, so that, that is challenging” (participant with DPHY).

This result highlighted the need for regular services (e.g., retraining related to ingress/egress of their modified vehicle and providing opportunities to experience new assistive technology devices) of occupational therapists, physical therapists, and certified driver rehabilitation

specialists; such regular services would help mitigate the accessibility-related travel barriers for individuals with DPHY.

Wheelchair Securement.—Wheelchair securement was reported as a travel barrier to public transportation in individuals with DPHY and is consistent with previous findings (8). This barrier is primarily related to public perceptions (described above). For example, public transport operators often do not provide tie-down services owing to their tight schedules, and as a result, many wheelchair users report that public transport riding is unsafe: “No, I never, I never feel safe. . No, I feel jostled around and not and very not safe,” according to a participant with DPHY. Nevertheless, wheelchair users reported that they are reluctant to request tie-down services because, as mentioned, drivers and other passengers often resist/are not supportive of this because of the ensuing delay when they insist on the tie-down services: “And if you want that, you’re going to get some resistance from the driver and the passengers. They are not happy about you needing to do that. They want to get to where they’re going as quickly as possible, and they don’t want to take the time,” according to a participant with DPHY. Thus, regular driver training is necessary to operate the vehicle in a safe and sound manner (23)

Malfunctioning PA System.—A malfunctioning PA system was a reported barrier that is unique to individuals with DEYE. They described how some public transportation options do not have PA systems, and even if a system in place, it often does not work, depending on the vehicle: “Public buses were announcing stops. Generally, that system is working correctly. However, once or twice, it’s not; it is announced to stop much before when it is coming. So, that can be a problem” (participant with DEYE). The lack of a PA system being a barrier to using public transportation for PWDs outside of our study has also been identified (8). In the absence of PA systems, a transportation app can assist PWDs’ travel by identifying the current location of the vehicle they are using. However, this app often does not work correctly, increasing their reliance on the driver or other passengers to assist them. These results suggest that a PA system or transportation app, when working correctly, can help pinpoint a vehicle’s location and should therefore be implemented in all public transportation to lower the travel barriers for individuals with visual impairments. Additionally, this resource is likely to benefit not only PWDs but other public transportation passengers.

Vehicle Identification Challenges.—Vehicle identification challenges were reported as a travel barrier to using paratransit/taxi/rideshare. However, more PWDs responded that they had no problem identifying their driver and vehicle as the drivers generally confirm with their name: “I usually stand out at a certain location with my cane. And then, if a vehicle opens its doors and says, *participant’s name* and I usually say yes” (participant with DEYE), and

> I mean, he often asks for your name, and you know the cab number or something like that. And then, you say, ‘Okay. Are you this particular cab number?’ I’m because I’m waiting for this particular cab number. So that’s how yeah, so that’s how I make sure. And then, of course, so those checks are what you do. And that’s how you make sure you’re in the right vehicle.”— participant with DEYE).

However, some PWDs have experienced difficulties identifying their driver and vehicle: “I don’t know cars, I you know I just I know colors, but I don’t know what kind of car this is, I can’t identify them and so that’s difficult” (participant with DPHY). Since recognizing vehicles remains a challenge for some individuals, making vehicles easier to identify by adding a design to the vehicle (e.g., identification number) or alternative solutions should be explored.

Modifiable Barriers: Infrastructural (Non-Vehicle-Specific)

Difficulty Finding a Parking Spot.—Difficulty finding a parking spot was identified as a travel consideration for PWDs. Significantly, individuals with DPHY who use a private vehicle reported difficulty finding accessible parking. This issue of accessible parking availability was a new finding. There are three possible reasons this particular barrier has not been identified in previous studies. The first is that the previous studies have mainly investigated the barriers to PWDs using public transportation (6, 8), whereas the current study investigated the travel considerations and barriers to using various ground transportation modes and was therefore able to identify the parking-related barriers associated with private vehicle use. Some study participants reported that finding accessible parking is generally challenging: “I have to look for accessible parking. There’s usually only one or two parking spots, and if you don’t go really early, you don’t get them” (participant with DPHY). Thus, individuals with DPHY may not have reported it, believing this to be an inevitable part of travel rather than a travel barrier: “I look at the area I tried to find out about accessible parking um and I also tried to look at transportation” (participant with DPHY). The final reason the accessible parking-related barrier has not been reported in previous studies may be that it became more challenging to find an accessible parking lot during the COVID-19 pandemic. A participant with DPHY suggested this: “Umm accessible parking is great except sometimes where it is or how much there is of it. Especially post-pandemic, a lot of stores have moved their accessible parking farther out because they have their pickup in that area, so that makes it more difficult.” Since our study has revealed that individuals with DPHY have difficulty finding accessible parking, the businesses should pay more attention to the installation, operation, and maintenance of accessible parking to encourage PWDs to engage in more personal and social activities.

Difficulty finding a parking spot was also reported as a travel barrier by individuals with DREM. To the best of the authors’ knowledge, our study is the first to identify this barrier for individuals with DREM. Participants described how it is difficult to find an accessible parking spot that helps them identify their vehicle from other vehicles: “I choose a spot where nobody can park on either side of me,” and “I park away from everybody else” (participant with DREM). Another participant with DREM reported: “Oh, parking can be a pain in the butt, but again I use my anxiety as a tool, I’ll park all the way at the back of a parking lot, rather than trying to jockey the first spot up front.” To reduce the cognitive effort of identifying their vehicle, they attempt to park their car in the same parking space every time—despite this being far from their destination, they park where they can more easily identify their car. Furthermore, for the aforementioned reasons, because the outdoor travel distance from the parking spot to their destination may be far, this aspect may be associated

with what individuals with DREM reported about adverse weather conditions being a travel barrier in the AD stage.

Accessible Service Locations.—Accessibility of service locations was a travel consideration across groups of PWDs using public transportation and paratransit/taxi, and was consistent with previous findings (7, 13). However, our study found that it was more prominent among individuals with DPHY and/or DEYE. This may be because of the nature of those particular disabilities and having more general mobility challenges than individuals with other conditions. For example, individuals with DPHY and/or DEYE sometimes spend more time on their outdoor travel than their counterparts, owing to their lower walking speed (24). Also, because of environmental accessibility issues (e.g., malfunctioning ramps or lifts, inaccessible curb cuts), individuals with DPHY often have difficulties accessing transportation services.

Furthermore, most of the service location accessibility-related issues were associated with public transportation rather than paratransit/taxi, and were mainly reported by those living in urban areas where public transportation services were provided. Since paratransit/taxi is a door-to-door service, it has fewer difficulties accessing a service location.

Transportation Schedule.—Transportation scheduling is reported by many PWDs regardless of disability type as a travel consideration in public transportation and paratransit/taxi (11, 13). The results of our study revealed that PWDs checked the schedule to consider and plan a trip, including choosing the mode of transportation, calculating departure time, finding the best route: “So, and then depending on the timing so where I want to go. What will be the timing of the bus? Will I have to change buses? Is it going to be just a single ride that I get on a bus, and it takes me to the destination, or do I have to change two or three buses” (participant with DEYE).

Transportation scheduling was reported as a travel barrier. PWDs often have difficulties using public transportation owing to unreliable schedules (e.g., a bus arrives late or early, or sometimes does not appear at all). PWDs also have difficulties using paratransit because they cannot use this service on demand. For example, to use paratransit, it is necessary to book it at least 24 to 72h in advance, depending on the company or region, and it has a 30 min or longer arrival window (e.g., transportation can arrive any time between 10:00 and 10:30 a.m.).

Transportation App Challenges.—PWDs reported transportation app challenges as a travel barrier in using public transportation—a finding unique to our study. PWDs use transportation apps to plan a trip or to identify the current locations of the transportation (13). However, as apps sometimes malfunction, PWDs can experience difficulties planning trips and using public transportation. For example, individuals with DEYE might use a transportation app on the bus, primarily relying on the app if the bus does not have a PA system (as stated, the app notifies them of their current location and when they arrive at their destination stop). However, if the app malfunctions, they may have difficulty identifying their destination stop: “sometimes the GPS that operates with the buses gets a little out of

sequence, with our current location versus where the bus says or thinks that we are" (a participant with DEYE).

High-Traffic Patterns.—High-traffic patterns was a travel barrier reported only by individuals with DREM. They recounted that they drive only at times when the traffic is similar to or quieter than the conditions they are accustomed to driving in. This finding was consistent with previous studies that found that PWDs are less likely to drive during peak hours or on unfamiliar roads or to new places (5). They prefer to drive in light traffic because high-traffic conditions can be cognitively challenging as they must deal with more diverse, complex, and unexpected situations (25). Other strategies individuals with DREM use for minimizing cognitively challenging situations when driving include practicing several times with their guardian before going to an unfamiliar destination and using only familiar roads to reach the destination: "We drove out to where it was going to be the day before and planned a safe route to get there" (participant with DREM).

Cost.—Cost was reported as a travel consideration, especially when PWDs considered whether to travel by taxi or by another means of transportation: "But I think if I don't need to take an Uber-like, I would probably take a bus because it's cheaper" (participant with DREM). Therefore, since cost is a travel consideration, introducing a more convenient and cheaper mode of transportation or increasing cost subsidies for PWDs could encourage engagement in personal and social activities.

Modifiable Barriers: Educational

Public Perception.—Public perception was primarily reported by individuals with DPHY as a travel barrier to using public transportation. Public perception was identified in a previous study, yet this mainly focused on the attitudes or resistance of transport operators (e.g., inappropriate driver attitudes or drivers refusing to stop) (8). In addition to the previous findings, our study identified that PWDs experience resistance from bus drivers and also from other passengers. For example, individuals with DPHY experience resistance from bus drivers and other passengers as a result of the delays caused when using the ramp/lift for ingress/egress or getting wheelchair securement (i.e., tieing the wheelchair down). One participant with DPHY said,

> Yeah, a lot of people like to be tied down. In the vehicle, there's tie downs, so the driver, if you want that, the driver has to flip up the seat, get out of their seat, flip up the seat, and then tie you down, and that takes a lot of time. And if you want that, you're going to get some resistance from the driver and the passengers. They are not happy about you needing to do that. They want to get to where they're going as quickly as possible, and they don't want to take the time.

This finding shows the need to raise awareness in drivers and the public about the needs of PWDs (23).

Another public perception issue is that the bus drivers do not recognize wheelchair users at the stops. This perception is because PWDs reported occasionally having missed a bus because the bus driver did not see them. For example, a participant with DPHY, said: "I do.

You'd be amazed how many of us are at the bus stop with bright pink colors. And we're like, yay, we can be seen! And I always stand, like if there's a group down there, always like, huddle in the middle of the group, so I don't get missed."

Lack of Knowledge About a Service.—Our study identified a lack of knowledge about service as a travel consideration and barrier in using public transportation (11, 13). Participants reported that using public transportation can be challenging if the person is new to it: "Well, initially my experience entering was really a little bit of, uh, embarrassing. It was embarrassing. Because I didn't know what to do. You know? I didn't know where to put the money" (participant with DPHY); and "public transports buses can be challenging see us especially when you're new to it. Like I said I've been riding the bus for many years now, but when I first began, the drivers were, and this was before all the APP that exists" (participant with DEYE). Since there is no unified method for using public transportation (e.g., payment method, means of entering/exiting the vehicle, rules of use), any public transporation service should be designed and operated intuitively so that even first-timers can easily use them, and appropriate explanations for using the service should be accessible when necessary (11, 13). Furthermore, for PWDs, provision of transport options, related information, and travel/mobility training should also be offered (23).

Unsafe Driving.—A few PWDs reported unsafe (reckless) driving as a travel barrier to public transportation and paratransit/taxi use. For example, a participant with DEYE, said, "Depends on who's driving if generally, it is a person who is a safe driver, I have no problems. And if it's a dangerous driver I am lucky enough to get out I don't get in the next time." Another participant with DREM, said, "in some cases where would catch like an Uber or a taxi home from an airport or someplace like that, those drivers they drive extra fast and they swerve in and out of traffic, and it is just hair raising. So, I prefer not to take those because I don't feel secure." Since unsafe driving raises such concerns, drivers should be trained to operate vehicles in a manner that is comfortable and secure for passengers (23).

Nonmodifiable Barriers

Health Conditions.—Health conditions were mostly reported to be a travel consideration and barrier by individuals with DPHY. Our finding was in line with previous studies reporting that individuals with chronic health conditions are more likely to have difficulties using public transportation when traveling (6). Specifically, our findings identified that a health condition is a factor to consider before taking a trip rather than a barrier needing to be confronted during a trip. Individuals with medical conditions decide whether to take a trip based on their symptoms (e.g., strength, endurance, fatigue). For example, such individuals might avoid long-distance travel or long duration trips, or prefer to travel during a certain period of the day. This idea was described by a participant with DPHY: "sitting for a long time is difficult. I don't have a lot of room with the hand controls, and it's difficult to move my feet. So, the longer I sit without being able to move, the more, the worse it is. So, longer trips are kind of out for me to drive myself." Another participant with DREM noted, "Oh, I also don't like to drive at night. I would prefer not to drive at night. As a matter of fact, because the headlights exacerbate my headaches."

Motivation.—A unique finding in our study related to motivation—a vital travel consideration for PWDs when taking a trip. A participant with DPHY said, “Um, but in the opposite effect, of late have felt like I needed to go out and needed to see people so, um, that comes into play also. You know, if I’m feeling especially isolated, you know I’ll just go out to CVS and walk around. I’m, you know, picking up a script, but it’s a way of socializing.” Another participant with DEYE, said, “Well the first thing is my motivation to go towards the trip, how motivated I am.” This finding illustrates that in addition to physical and environmental factors, psychological factors also play a role in CT and PT. Accordingly, further research might identify what other psychological factors are involved in CT and PT

Adverse Weather Conditions.—Adverse weather conditions were identified by all PWDs to be a travel consideration, which was in line with a previous study showing that PWDs are less likely to drive in bad weather than individuals without disabilities (5). However, individuals with DPHY were more likely to report it as a travel barrier. This may be because individuals with DPHY might have to wait longer outdoors, or to use a lift or ramp to enter/leave a vehicle. Similarly, most participants reported adverse weather conditions as a barrier to using public transport rather than a private vehicle or taxi/paratransit. Since private and paratransit/taxi are door-to-door services, whereas public transportation is a stop-to-stop or station-to-station service, traveling by public transit requires more outdoor travel elements and is therefore more likely to be affected by adverse weather conditions.

Individuals with DEAR

We investigated travel considerations and barriers to ground transportation for individuals with DEAR. Although it was not reported to be a travel consideration or barrier, we did find that individuals with DEAR required extra mirrors to ensure safe, independent driving because, as they cannot rely on their sense of hearing, they mainly rely on their vision. In addition to the extra mirrors, inserting vibrating alerts and/or visual alert devices (flashing lights) that are only activated by specific sounds (e.g., ambulance or police sirens, honking from car horns) using sound recognition technology could enable people with DEAR to experience safer and less stressful driving conditions (26).

No other considerations and barriers were identified in the current study, which was consistent with prior reports that individuals with DEAR have fewer challenges when using transportation than other disability groups (8). However, because we interviewed only one individual with DEAR in the current study, there could be other travel considerations and barriers that our study did not identify.

Summary and Recommendations

In summary, our study used a journey mapping methodology to investigate travel considerations and barriers for PWDs using private vehicles, public transportation, and paratransit/taxi/rideshare. Our findings make important contributions to the literature as we have demonstrated how journey mapping identified some of the barriers to travel when using various transportation systems, and the underlying reasons for those barriers. The methodology also identified travel barriers and considerations at every stage of travel,

especially in relation to the pretravel stages (i.e., CT and PT). This study's findings, if addressed through new research, development, business, and/or government efforts, could facilitate PWDs using the current modes of transportation more conveniently, effectively, efficiently, and safely; furthermore, the results could enable a more seamless and efficient transition to future transportation efforts incorporating autonomous and other emerging and advanced mobility technologies and services.

For example, PWDs constitute one of the groups who may potentially be significant beneficiaries of autonomous driving systems; however, current autonomous system designs often fail to capture the perspectives of this population and, thus, may be unintentionally excluding them from using these systems (9). There are efforts to develop fully accessible and easy-to-use autonomous driving systems. These efforts include vehicle ingress/egress, third-party assistance required, wheelchair securement, malfunctioning PA systems, vehicle identification challenges, and unsafe driving (27). In addition to these efforts, we expect that with the development of other technologies such as the Internet of Things (IoT), and other features, the non-vehicle-specific barriers will also be removed or mitigated. These technologies and features include smart parking systems, including finding accessible parking near destinations, reserving a parking space in advance, and automatic fee charging; and smart traffic-control systems, including real-time traffic monitoring and traffic-light management, and real-time vehicle/public transit information. When introducing these new technologies and services, transportation professionals should endeavor to identify and implement methodologies that are universally accessible and promote inclusivity.

This study's insights have provided guidance for the design and development of current and future transportation systems, which may include autonomous vehicles and the codes, standards, and best practices that govern and inform them. Transportation-related infrastructure is typically governed, built, and operated by multiple public- and private-sector entities, often with competing or overlapping jurisdictions and responsibilities. State and local governments must address such infrastructural issues and set appropriate codes for public- and private-sector development and operations, including accessibility to service locations, transportation schedules, difficulty finding a parking spot (including accessible parking), the lack of knowledge about services, and cost issues. This research has reinforced the importance of involving all key stakeholders and ensuring their perspectives are heard within the multidisciplinary teams responsible for the development of the overarching codes, standards, and best practices. Our findings further suggest that these diverse stakeholders be included in the design of major infrastructure and transportation systems. Beyond the more typical stakeholders, the research has shown that it is essential to include an expanded group of end users and caregivers, transportation service providers, policy makers (e.g., state and local governments), accessible transportation service providers (e.g., transportation services companies, driver rehabilitation specialists, adaptive driving instructors, paratransit and rideshare operators), healthcare providers and health service providers (e.g., physicians, vocational rehabilitation counselors, social workers), designers (e.g., vehicle manufacturers and modifiers, architects, designers), and engineers. Periodic meetings and organic cooperation among the stakeholders will help mitigate travel considerations and barriers to transportation for PWDs. To mitigate infrastructure issues related to accessible parking, several efforts should be undertaken. State and local

governments should diligently enforce parking regulations while concurrently evaluating their relevance to current needs. Improvements to regulations, standards, and policies could be achieved by actively engaging with and involving a diverse range of stakeholders in the decision-making process. Collaborating with businesses, shopping centers, public facilities, and other organizations to encourage the provision of additional accessible parking spaces cuold yield significant benefits. Offering incentives, such as tax benefits or recognition, could serve as powerful motivators for these entities to invest in enhancing accessibility. Additionally, public awareness campaigns and advocacy could educate the general population about the importance of accessible parking spaces and of leaving such designated areas free for PWDs' use, and, further, could serve to foster empathy, understanding, and respect for these travelers. Lastly, the integration of technologies, including IoT, will play a pivotal role in mitigating the challenges associated with finding accessible parking.

Limitations

Although this was a relatively sizable interview-based study, it was very heterogeneous, that is, it included only small numbers of those with vision, hearing, and combined physical/visual disabilities who, therefore, may not necessarily represent all the perspectives of PWDs. Further, given the sociodemographic characteristics of the participants, they may not fully represent PWDs living in the United States. The study goals were to demonstrate the value of and to validate the journey mapping methodology, as well as to gain initial insights into the potential pain points experienced by these groups over the various transportation phases. Future studies utilizing journey mapping methodology to further investigate such issues within these subgroups are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Samuel PS, Lacey KK, Giertz C, Hobden KL, and LeRoy BW Benefits and Quality of Life Outcomes from Transportation Voucher Use by Adults with Disabilities. Journal of Policy and Practice in Intellectual Disabilities, Vol. 10, No. 4, 2013, pp. 277–288.
2. Labbé D, Miller WC, and Ng R. Participating more, Participating Better: Health Benefits of Adaptive Leisure for People with Disabilities. Disability and Health Journal, Vol. 12, No. 2, 2019, pp. 287–295. [PubMed: 30448102]
3. Brumbaugh S. Issue Brief: Travel Patterns of American Adults with Disabilities. Bureau of Transportation Statistics, Washington, D. C., 2018.
4. Centers for Disease Control and Prevention. Disability Impacts All of US. U.S. Department of Health & Human Services, Washington, D.C., 2020.

5. Rosenbloom STransportation Patterns and Problems of People with Disabilities. In The Future of Disability in America (Field MJ, and Jette AM; Institute of Medicine (US) Committee on Disability in America, eds.), National Academies Press, Washington, D.C., 2007.
6. Bezyak JL, Sabella S, Hammel J, McDonald K, Jones RA, and Barton D. Community Participation and Public Transportation Barriers Experienced by People with Disabilities. Disability and Rehabilitation, Vol. 42, No. 23, 2020, pp. 3275–3283. [PubMed: 30991852]
7. Bascom GW, and Christensen KM The Impacts ofLimited Transportation Access on Persons with Disabilities' Social Participation. Journal of Transport & Health, Vol. 7, 2017, pp. 227–234.
8. Bezyak JL, Sabella SA, and Gattis RH Public Transportation: An Investigation of Barriers for People with Disabilities. Journal of Disability Policy Studies, Vol. 28, No. 1, 2017, pp. 52–60.
9. Dicianno BE, Sivakanthan S, Sundaram SA, Satpute S, Kulich H, Powers E, Deepak N, Russell R, Cooper R, and Cooper RA Systematic Review: Automated Vehicles and Services for People with Disabilities. Neuroscience Letters, Vol. 761, 2021, p. 136103.
10. Fischer G, and Sullivan J. Human-Centered Public Transportation Systems for Persons with Cognitive Disabilities. Proc., Participatory Design Conference, Malmö, Sweden, 2002.
11. Carmien S, Dawe M, Fischer G, Gorman A, Kintsch A,, and Sullivan JF Jr. Socio-Technical Environments Supporting People with Cognitive Disabilities Using Public Transportation. ACM Transactions on Computer-Human Interaction (TOCHI), Vol. 12, No. 2, 2005, pp. 233–262.
12. Alaribe I. Design a Serious Game to Teach Teenagers with Intellectual Disabilities How to Use Public Transportation. Procedia-Social and Behavioral Sciences, Vol. 176, 2015, pp. 840–845.
13. Dziekan K. Ease-of-Use in Public Transportation: A User Perspective on Information and Orientation Aspects. PhD dissertation. Royal Institute of Technology (KTH), Stockholm, Sweden, 2008.
14. Marsland N, Wilson I, Abeyasekera S, and Kleih U. Combining Quantitative (Formal) and Qualitative (Informal) Survey Methods. Socioeconomic Methodologies for Natural Resources Research, Natural Resources Institute, Chatham, 2001.
15. Park J, and Chowdhury S. Investigating the Barriers in a Typical Journey by Public Transport Users with Disabilities. Journal of Transport & Health, Vol. 10, 2018, pp. 361–368.
16. Howard T. Journey Mapping: A Brief Overview. Communication Design Quarterly Review. Vol. 2, No. 3, 2014, pp. 10–13.
17. Verhoef PC, Lemon KN, Parasuraman A, Roggeveen A, Tsiros M, and Schlesinger LA Customer Experience Creation: Determinants, Dynamics and Management Strategies. Journal of Retailing, Vol. 85, No. 1, 2009, pp. 31–41.
18. Ando H, Cousins R, and Young C. Achieving Saturation in Thematic Analysis: Development and Refinement of a Codebook. Comprehensive Psychology, Vol. 3, 2014, p. 03.CP.3.4. 10.2466/03.CP.3.4
19. Guest G, Bunce A, and Johnson L. How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. Field Methods, Vol. 18, No. 1, 2006, pp. 59–82.
20. U.S. Equal Employment Opportunity Commission. Fact Sheet on the EEOC's Final Regulation Implementing the ADAA. 2011;18:2013. https://www.eeoc.gov/laws/guidance/fact-sheet-eeocs-final-regulations-implementing-adaaa.
21. United States Census Bureau. How Disability Data are Collected from The American Community Survey. U.S. Department of Commerce, Washington, D.C., 2021.
22. Hsieh H-F, and Shannon SE Three Approaches to Qualitative Content Analysis. Qualitative Health Research, Vol. 15, No. 9, 2005, pp. 1277–1288. [PubMed: 16204405]
23. Cochran AL Understanding the Role of Transportation-Related Social Interaction in Travel Behavior and Health: A Qualitative Study of Adults with Disabilities. Journal of Transport & Health, Vol. 19, 2020, p. 100948.
24. Sharifi MS, Stuart D, Christensen K, Chen A, Kim YS, and Chen Y. Analysis of Walking Speeds Involving Individuals with Disabilities in Different Indoor Walking Environments. Journal of Urban Planning and Development, Vol. 142, No. 1, 2016, p. 04015010.
25. American Occupational Therapy Association. Occupational therapy practice framework: Domain and process (3rd ed.). American Journal of Occupational Therapy, Vol. 68, Supplement 1, 2014, S1–S48.

26. Ntalampiras S. Audio Surveillance. WIT Transactions on State-of-the-Art in Science and Engineering, Vol. 54, 2012, pp. 191–205.

27. Grier RA Identifying Automated Driving Systems-Dedicated Vehicles (ADS-DVs) Passenger Issues for Persons with Disabilities. SAE No. J3171 Society of Automotive Engineers International, Warrendale, PA, 2019.

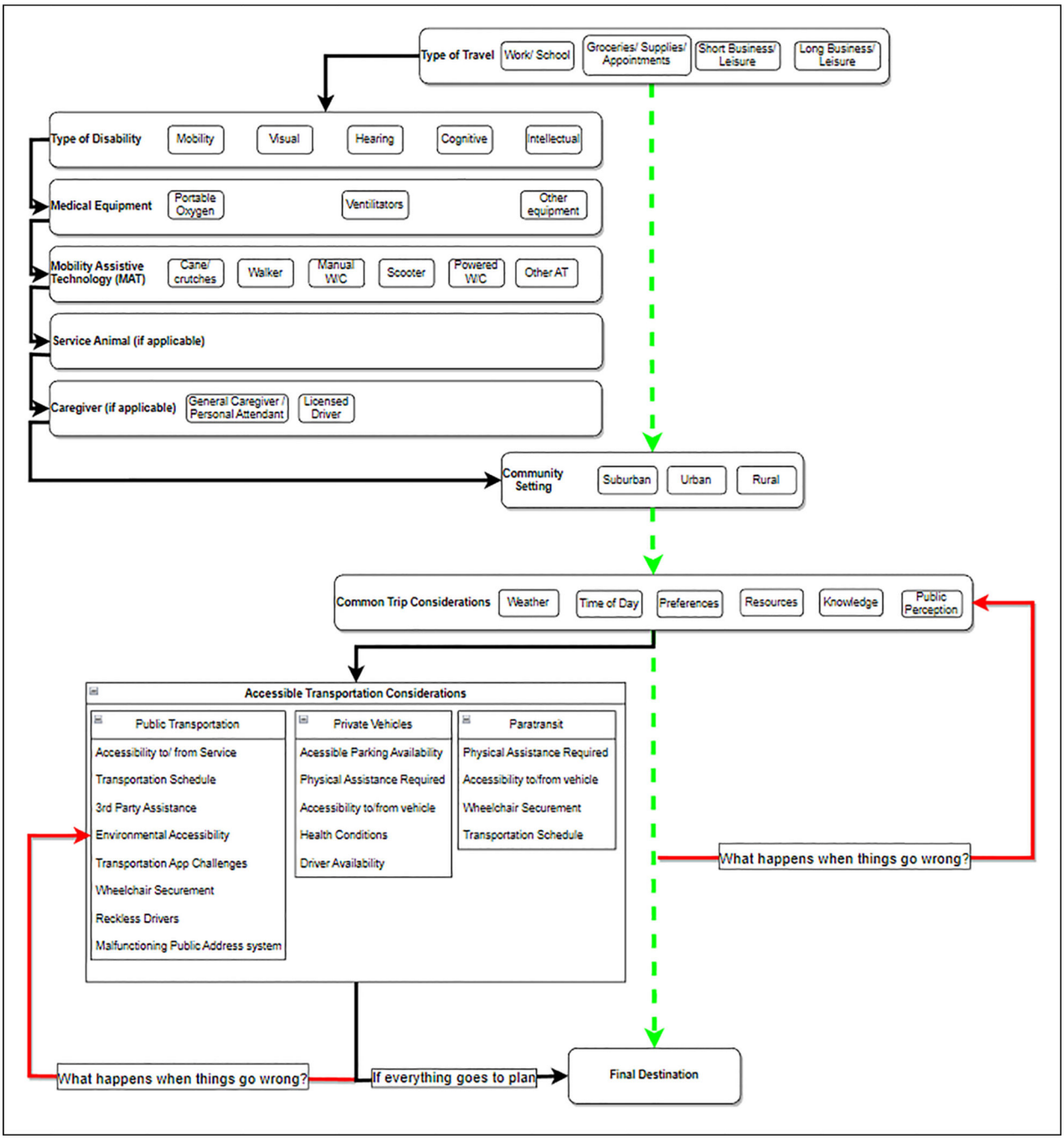

Figure 1.
Example of taking a trip as an individual with disabilities.

Table 1.

Demographic Information

Variables	DPHY (*N* = 10) *n* (%)	DEYE (*N* = 4) *n* (%)	DPHY + DEYE (*N* = 1) *n* (%)	DREM (*N* = 4) *n* (%)	DEAR (*N* = 1) *n* (%)	Total (*N* = 20) *n* (%)
Age						
25–34	0 (0)	0 (0)	0 (0)	2 (50)	0 (0)	2 (10)
35–44	0 (0)	1 (25)	0 (0)	1 (25)	1 (100)	3 (15)
45–54	2 (20)	1 (25)	0 (0)	1 (25)	0 (0)	4 (20)
55–64	5 (50)	1 (25)	0 (0)	0 (0)	0 (0)	6 (30)
65 +	2 (20)	1 (25)	1 (100)	0 (0)	0 (0)	4 (20)
Ethnicity						
Non-Hispanic	10 (100)	4 (100)	0 (0)	4 (100)	1 (100)	19 (95)
Hispanic	0 (0)	0 (0)	0 (00)	0 (0)	0 (0)	0 (0)
Prefer not to answer	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (5)
Race						
White	10 (100)	1 (25)	0 (0)	3 (75)	1 (100)	15 (75)
Asian	0 (0)	2 (50)	0 (0)	0 (0)	0 (0)	2 (10)
American Indian/Alaskan Native	0 (0)	1 (25)	0 (0)	0 (0)	0 (0)	1 (5)
More than one race	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)	1 (5)
Prefer not to answer	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (5)
Gender						
Male	5 (50)	3 (75)	1 (100)	3 (75)	0 (0)	12 (60)
Female	5 (50)	1(25)	0 (0)	1 (25)	1 (100)	8 (40)
Marital status						
Single	2 (20)	1 (25)	0 (0)	3 (75)	0 (0)	6 (30)
Engaged/married	6 (60)	3 (75)	0 (0)	1 (25)	1 (100)	11 (55)
Divorced	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)
Widowed	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (5)
Living arrangement						
Own/rent Facilities	8 (80)	4 (100)	1 (100)	3 (75)	1 (100)	17 (85)
Independent living	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)

Variables	DPHY (*N* = 10) *n* (%)	DEYE (*N* = 4) *n* (%)	DPHY + DEYE (*N* = 1) *n* (%)	DREM (*N* = 4) *n* (%)	DEAR (*N* = 1) *n* (%)	Total (*N* = 20) *n* (%)
Group home	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)	1 (5)
Highest educational level						
High school diploma	0 (0)	0 (0)	0 (0)	2 (50)	0 (0)	2 (10)
Some college	1 (10)	0 (0)	1 (100)	0 (0)	1 (100)	3 (15)
Bachelor’s degree	4 (40)	0 (0)	0 (0)	1 (25)	0 (0)	5 (25)
Professional degree	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)	1 (5)
Master’s degree	3 (30)	3 (75)	0 (0)	0 (0)	0 (0)	6 (30)
Doctorate degree	2 (20)	1 (25)	0 (0)	0 (0)	0 (0)	3 (15)
Community setting						
Rural	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)
Suburban	4 (40)	1 (25)	0 (0)	2 (50)	0 (0)	7 (35)
Urban	5 (50)	3 (75)	1 (100)	2 (50)	1 (100)	12 (60)
Employment status						
Employed	6 (60)	4 (100)	0 (0)	4 (100)	1 (100)	15 (75)
Retired	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	3 (15)
Unable to work	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)
Unemployed and not looking for work	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (5)
Household income						
Under $15,000	1 (10)	0 (0)	1 (100)	1 (25)	0 (0)	3 (15)
$15,000–24,999	1 (10)	0 (0)	0 (0)	1 (25)	0 (0)	2 (10)
$25,000–49,999	4 (40)	0 (0)	0 (0)	0 (0)	1 (100)	5 (25)
$50,000–74,999	0 (0)	1 (25)	0 (0)	1 (25)	0 (0)	2 (10)
$75,000–100,000	0 (0)	1 (25)	0 (0)	1 (25)	0 (0)	2 (10)
Above $100,000	4 (40)	2 (50)	0 (0)	0 (0)	0 (0)	6 (30)
Primary mode of transportation for work						
Licensed driver or permit holder	5 (50)	0 (0)	0 (0)	2 (50)	1 (100)	8 (40)
Passenger of personal car	0 (0)	0 (0)	0 (0)	1 (25)	0 (0)	1 (5)
Ground public transportation	0 (0)	3 (75)	0 (0)	0 (0)	0 (0)	3 (15)
Other	1 (10)	1 (25)	0 (0)	1 (25)	0 (0)	3 (15)

Variables	DPHY (*N* = 10) *n* (%)	DEYE (*N* = 4) *n* (%)	DPHY + DEYE (*N* = 1) *n* (%)	DREM (*N* = 4) *n* (%)	DEAR (*N* = 1) *n* (%)	Total (*N* = 20) *n* (%)
Missing	4 (40)	0 (0)	1 (100)	0 (0)	1 (100)	6 (30)
Length of time living with a disability						
Less than 1 year	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1–5 years	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)
6–10 years	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)
11–15 years	1 (10)	0 (0)	0 (0)	1 (25)	0 (0)	2 (10)
16–20 years	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21–25 years	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
25 + years	6 (60)	4 (100)	1 (100)	3 (75)	1 (100)	15 (75)

Note: DPHY = individuals with physical difficulties; DEYE = individuals with visual difficulties; DREM = individuals with cognitive difficulties; DEAR = individuals with hearing difficulties.

Table 2.

Travel Barriers to Using Private Vehicles by Codes

	Codes (*n*)						
	CT	**PT**	**LT**	**EnT**	**RT**	**ExT**	**AD**
Physical disabilities (*N* = 8)							
Third-party assistance required	4	2	0	2	0	0	2
Difficulty finding a parking spot	2	5	0	0	0	0	0
Adverse weather conditions	2	1	0	0	0	2	0
Health conditions	4	0	0	0	1	0	0
Motivation	1	0	0	0	0	0	0
Vehicle ingress/egress	0	2	0	2	0	1	0
Visual impairments (*N* = 3)							
Third-party assistance required	1	1	0	0	0	0	0
Physical and visual difficulties (*N* = 0)							
No response	0	0	0	0	0	0	0
Cognitive difficulties (*N* = 4)							
Third-party assistance required	3	1	1	0	0	0	0
High-traffic patterns	2	1	0	0	0	0	0
Health conditions	1	0	0	0	0	0	0
Difficulty finding a parking spot	0	0	0	0	0	2	0
Adverse weather conditions	0	0	0	0	0	0	1

Note: CT = considering a trip; PT = planning a trip; LT = locating transportation; EnT = entering the transportation; RT = riding the transportation; ExT = exiting the transportation; AD = arriving at the destination.

Table 3.

Travel Barriers to Using Public Transportation by Codes

	Codes (*n*)						
	CT	**PT**	**LT**	**EnT**	**RT**	**ExT**	**AD**
Physical disabilities (*N* = 8)							
Accessibility to service location	3	4	0	0	1	0	3
Adverse weather conditions	2	3	0	0	0	0	0
Transportation schedule	2	3	1	0	0	0	0
Vehicle ingress/egress	0	2	0	2	0	4	0
Third-party assistance required	0	1	0	1	0	1	0
Public perception	0	1	0	0	2	0	0
Transportation app challenges	0	0	2	0	0	0	0
Lack of knowledge about service	0	0	1	1	0	0	0
Wheelchair securement	0	0	0	2	3	1	0
Visual impairments (*N* = 4)							
Transportation schedule	2	1	0	0	0	0	0
Accessibility to service location	3	0	0	0	0	0	0
Motivation	1	0	0	0	0	0	0
Third-party assistance required	0	2	1	1	1	2	0
Transportation app challenges	0	1	0	0	0	1	0
Lack of knowledge about service	0	2	0	0	0	0	0
Unsafe driving	0	0	0	0	1	0	0
Malfunctioning public address system	0	0	0	0	0	1	0
Adverse weather conditions	0	0	0	0	0	0	1
Physical and visual difficulties (*N* = 1)							
Transportation schedule	1	1	0	0	0	0	0
Third-party assistance required	1	0	0	0	0	0	0
Adverse weather conditions	1	0	0	0	0	0	0
Vehicle ingress/egress	0	0	0	1	0	0	0
Cognitive difficulties (*N* = 3)							
Adverse weather conditions	1	0	0	0	0	0	0

	Codes (*n*)						
	CT	**PT**	**LT**	**EnT**	**RT**	**ExT**	**AD**
Transportation schedule	2	1	0	0	0	0	0
Health conditions	0	1	0	0	0	0	0

Note: CT = considering a trip; PT = planning a trip; LT = locating transportation; EnT = entering the transportation; RT = riding the transportation;ExT = exiting the transportation; AD = arriving at the destination.

Table 4.

Travel Barriers Using Paratransit/Taxi by Codes

	Codes (*n*)						
	CT	**PT**	**LT**	**EnT**	**RT**	**ExT**	**AD**
Physical disabilities (*N* = 8)							
Third-party assistance required	2	0	0	0	0	0	0
Transportation schedule	1	1	1	0	0	0	0
Vehicle ingress/egress	0	0	0	1	0	0	0
Adverse weather conditions	1	0	0	0	0	0	0
Wheelchair securement	0	2	0	0	3	0	0
Accessibility to service location	0	4	0	0	0	0	0
Vehicle identification challenges	0	0	1	0	0	0	0
Visual impairments (*N* = 4)							
Accessibility to service location	1	1	0	0	0	0	0
Transportation schedule	1	1	0	0	0	0	0
Physical and visual difficulties (*N* = 1)							
Adverse weather conditions	1	0	0	0	0	0	0
Accessibility to service location	1	0	0	0	0	0	0
Cognitive difficulties (*N* = 2)							
Cost	1	1	0	0	0	0	0
Adverse weather conditions	0	1	0	0	0	0	0
Accessibility to service location	0	1	0	0	0	0	0
Unsafe driving	0	0	0	0	1	0	0

Note: CT = considering a trip; PT = planning a trip; LT = locating a transportation; EnT = entering the transportation; RT = riding the transportation; ExT = exiting the transportation; AD = arriving at your destination.