

Descriptive Title: Perspectives from Canadians with visual impairments in everyday environments outside the home: insights for assistive technology development

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Abstract

Background: Despite the abundance of assistive devices available, the accomplishment of many everyday tasks remains complex for people with visual impairments (PVI). While several studies have been conducted to identify the obstacles encountered when moving around outdoors, current knowledge is less abundant when it comes to the difficulties encountered in complex, indoor environments.

Objective: The present study aimed to identify the most important obstacles and facilitators encountered in common dynamic, indoor environments outside the home for people with low vision and blindness.

Methods: Data were collected from twenty participants with varying levels of vision from several cities across Canada in two virtual focus groups in both English and French. Using open-ended questions, participants shared obstacles and facilitators experienced or imagined during independent navigation in the following scenarios: coffee shop, hospital, big-box store, party with friends, and bus rides. Thematic analysis was conducted, and responses were either categorized as barriers or facilitators for each scenario. These were ranked by all participants via email according to their perceived importance in completing each scenario.

Results: Across scenarios, the principal barriers to perceived success were inaccessible signage, difficulties walking around, problems finding a specific location, and unsuccessful interactions with others. The main facilitators across scenarios were helpful interactions with others, planning, accessible signage, and websites. The use of mobile applications was discussed but ranked as less important by participants. Though similar amongst the French and English groups, the rankings of the different facilitators and barriers were largely scenario-specific. The most barriers were mentioned in the coffee shop (n=8) followed by the department store (n=7) and bus or metro (n=7) for the English group, whereas the most barriers were in the department store (n=9), followed by the hospital or clinic (n=7) and coffee shop (n=6) for the French group.

Conclusions: Though promising technologies have been developed to resolve some of the issues surrounding indoor navigation for PVI, they were not perceived as helpful as some other traditional methods of assistance, such as asking for help, by our participants. For the successful incorporation of indoor navigation technologies, it is important to understand how they integrate into the experience of people as they move in these dynamic environments. The successful use of technology is only possible if the physical environment permits and facilitates independent navigation.

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Original Manuscript

Descriptive Title: Perspectives from Canadians with visual impairments in everyday environments outside the home: insights for assistive technology development

Short title: Perspectives of visually impaired Canadians

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Conclusion: Though promising technologies have been developed to resolve some of the issues surrounding indoor navigation for PVI, they were not perceived as helpful as some other traditional methods of assistance, such as asking for help, by our participants. For the successful incorporation of indoor navigation technologies, it is important to understand how they integrate into the experience of people as they move in these dynamic environments. The successful use of technology is only possible if the physical environment permits and facilitates independent navigation.

Keywords: Visual impairment, rehabilitation, mobility, accessibility, assistive technology

1. INTRODUCTION

According to the current estimates, globally more than 2.2 billion people have visual impairments and the number is estimated to double by 2050 [1]. More than 1,519,000 Canadians reported having a visual disability in 2017, representing 5.4% of the Canadian population [2]. These individuals experience a variety of barriers daily that hinder their full social participation. Amongst the most common barriers cited are reading and accessing textual information [3], participation in leisure activities, and shopping [3, 4], and using public transport [6]. More specifically, some tasks

considered important are reading packaging labels and signs, using the buttons and controls on various appliances, locating an item on a filled shelf, and using the computer [6, 7]. These barriers affect social inclusion and therefore the quality of life of people living with visual impairment (PVI) [2, 8].

1.1 Assistive technology in vision rehabilitation

The Lancet Global Health Commission on Global Eye Health identified the provision of vision rehabilitation services and assistive technologies as key to improving the functional abilities of people living with vision impairment [10]. Assistive technologies (AT) maintain or improve the functional capabilities of people with disabilities and have a considerable influence on the quality of life [11]. People living with low vision or blindness often receive vision rehabilitation services from orientation and mobility specialists who instruct on the use of assistive devices that facilitate independent travel including optical aids (e.g., magnifier, telescope), a long white cane for assistance with obstacle detection, and the use of a dog guide trained for obstacle avoidance while following route directions provided by the handler [12]. Low vision therapists often teach the use of assistive devices, such as screen enhancement software, magnification aids, or other visual enhancement devices to improve activities of daily living, such as reading, cooking, or watching television [13]. Vision rehabilitation therapists often provide training on screen reading software, refreshable braille displays, or other compensatory aids [14]. Once the individual has completed vision rehabilitation training, they should be able to perform many daily activities more independently and/or effectively, such as traveling, reading, or cooking.

Mainstream smartphones and tablets are increasingly being incorporated into vision rehabilitation training, due to their built-in accessibility features (i.e. screen magnification, electronic braille connectivity, text-to-speech software) that can be activated by all users [15]. Because of their versatility, these devices represent an affordable option [3], are less socially stigmatizing, and generate fewer negative reactions from peers or the public than some specialized devices, such as electronic glasses and telescopes [16]. The accessibility features enable users to access applications that support daily living activities, including reading email, accessing websites, managing calendars, and providing GPS support during travel [17]. Recent studies have found that these modern devices are increasingly replacing the use of traditional visual aids (i.e., specialized stand-alone GPS devices for blind users, and optical magnification aids for those with low vision) for navigation-based tasks [16, 17].

The use of these portable electronic devices enables visually impaired people to maintain a previously unattainable level of independence [9]. Smartphone apps, like Seeing AI and Supersense, have been developed using AI-based computer vision to provide object detection or scene description while human assistance apps, like AIRA or Be My Eyes, may allow for remote assistance. Modern mobile GPS-based applications are often successful in facilitating outdoor navigation, allowing people with blindness or low vision to be able to plan a route, use public transportation, or identify their current location [17]. Though there are hundreds of mobile apps that could be used as AT, there is little knowledge as to their real-world benefits [19].

1.2 Assistive technology for social inclusion

Despite advances and awareness regarding the importance of inclusivity for people with visual impairments as part of the design process, a recent review found that less than 4% of studies had them implicated in the design and development process in AT. [20]. This lack of inclusion and the sense that devices are not responding to their needs often leads to the abandonment of devices, which has been a common issue in vision rehabilitation. [6, 18, 20, 21]. A recent study with people with low vision points out that 57% of everyday tasks are still performed without the support of visual aids or adaptive strategies, making it impossible to perform them without the help of another person

in a third of the tasks recorded in their study. [8]. Despite the wide array of indoor navigation systems tested and developed [23], indoor navigation remains a challenge for people with low vision and blindness [17]. To develop versatile mobile applications that respond to the needs of people with visual impairment, it is important to identify the elements of a task that do not allow a person with visual impairment to complete it. For example, the inability to identify an item at the store would not allow them to shop independently. However, hitting an object with the white cane would not necessarily hinder their ability to shop.

One of the major advantages of using modern AT is their rapid response time. Whereas vision rehabilitation specialists are not able to provide immediate assistance when an individual encounters problems in their daily lives, a smartphone may be able to adequately provide the necessary information within seconds. For instance, a smartphone may use AI-based computer vision technology to rapidly identify an item at the store. A vision rehabilitation specialist can teach the person how to use a smartphone and interact and navigate with it in each situation, but they cannot be available for a wide array of potential scenarios. This is particularly problematic in environments where the potential risks and environmental obstacles are varied and dynamic, such as when an individual goes to a restaurant, has a clinical appointment, goes shopping, goes to a party, or takes the bus. Thus, the ability of AT to respond to the needs of people with visual impairments may influence their ability and willingness to participate independently in each of these scenarios. Since a single AT could not possibly respond to the diversity of needs of people with visual impairments, it is important to understand which barriers and facilitators are perceived as more important to a diverse sample of people with visual impairments.

1.3 Research objectives

This exploratory research investigates the common barriers and facilitators that people with low vision and blindness experience in common indoor, dynamic environments outside of the home. A Delphi-style [24] mixed methods approach was used to inform AT developers about common obstacles that are encountered amongst people with a variety of visual conditions and lived experiences. Five scenarios were chosen based on the previously reported challenges of people with visual impairments, as well as the reported challenges of current AT to respond to their needs in indoor, dynamic environments:

1. Getting a drink at your favorite local coffee shop
2. Going to the clinic for a scheduled appointment
3. Shopping at a big box store
4. Going to a party to meet friends
5. Taking the bus

Specifically, the research questions addressed in each of these scenarios above were:

1. Which barriers hinder your ability to successfully complete the scenario?
2. What facilitates your ability to successfully complete the scenario?
3. How do mobile applications assist you in completing the scenario?
4. Which of these barriers and facilitators are the most important to achieve success in the scenario?

This is the first study, to our knowledge, that examines the perceived importance of barriers and facilitators to completing a variety of everyday indoor tasks outside the home for people with low vision and blindness.

2. METHODS

Data was collected from February through June 2023. Ethics approval consistent with the Declaration of Helsinki [29] was obtained through the Université de Montréal Clinical Research Ethics Committee (CERC 2022-1800) on January 13th, 2023. Each participant provided their

informed consent to participate via an accessible Word document sent by email.

2.1 Study design

Applying a phenomenological perspective, this research delved into the experiences of people living with low vision and blindness in a variety of indoor, dynamic environments. This exploratory study embraces the principles of transdisciplinary development of assistive technology [25] and user-centered design [26]. Thus, the opinions and perspectives of diverse groups of individuals with visual impairments were at the core of the study. To avoid influencing the responses of the participants, no specific technologies were mentioned throughout the study. This reduces the bias that technology, as opposed to other means (i.e. human assistance, physical accessibility measures), are preferred methods to resolve a specific travel problem in these environments. The study methods and research findings were explicitly and comprehensively reported using the COREQ Checklist [27].

2.2 Eligibility and Recruitment

Participants were recruited between February 5th and March 26th, 2023. Information was circulated by e-mail to several organizations working with the visually impaired (e.g. CNIB Foundation, *Regroupement des Aveugles et Amblyopes du Montréal Métropolitain*, etc.). A recruitment ad was also published on social media groups, such as Facebook. Finally, recruitment was carried out via a snowball effect, encouraging respondents to tell others in their circle who met the inclusion criteria about the project. The inclusion criteria consisted of choosing only participants 18 years of age or older who reside in Canada, self-identify as having a visual impairment (low vision, blindness or deaf-blindness), are at least partially independent while traveling, (make trips outside the home, independently, at least occasionally), are regular users of smartphones (at least once weekly for at least a year), can express themselves in French or English, have basic skills in using the internet and the Zoom platform to participate adequately, have access to a good-quality internet connection to take part in an audiovisual virtual encounter, and declare that they had no intellectual or cognitive disabilities. Those that did not fulfill all these criteria were excluded from the study.

Individuals who expressed interest and self-identified as meeting the inclusion criteria were asked to contact the research team via the email addresses provided, whereby the research team provided the consent form in an accessible Microsoft Word format via their email correspondence provided to the researcher. A 20-minute phone or videoconference selection interview was performed to ensure the eligibility of the participants and to classify them according to their age, gender, ethnicity, place of residence, travel habits, and level of vision (See Appendix 1 for the full instrument). This information was recorded by the research team and was used to select a diverse group of participants corresponding to the categories A-H, shown below. At least one participant that was classified into each category was requested to be present at each focus group. A participant may be classified into more than one category.

- A. Low vision and not legally blind
- B. Low vision and legally blind
- C. Low vision determined by visual acuity defect
- D. Low vision determined by visual field defect
- E. Low vision between 18 and 49 years of age
- F. Low vision 50 years of age or older
- G. Blind and between 18 and 49 years of age
- H. Blind and 50 years of age or older

The individuals who expressed interest and were deemed eligible for selection interviews were contacted on a second occasion once they were selected by the research team based on their profile, considering the categories and encouraging the highest levels of diversity possible. The selected participants who agreed to participate in the virtual focus group were requested to respond to an accessible scheduling form to determine their availabilities, whereby the research team scheduled the

online focus group session via Zoom.

2.3 Data collection and analysis

2.3.1 Selection interviews

For the initial data collection from the selection interview, the researchers input information regarding the age, gender, ethnic origin, place of residence, travel habits, visual diagnosis, age of diagnosis, other disabilities, smartphone use, type of mobility aid used, level of vision, type of deficit, and category (A-H).

The goal was to gather 8 to 10 people for a focus group, to encourage rich, diversified exchanges, as well as the participation of everyone in a pleasant atmosphere. [28]. Considering potential attrition throughout the project, 10 to 12 participants were considered for each focus group.

2.3.2 Focus group sessions

Two focus groups of 10-12 participants were chosen to encourage diversified exchanges of ideas through Zoom meetings being conducted in French and English respectively to allow the participants to express their thoughts and opinions in either of the languages and to examine any potential language-related differences in the responses (i.e. inaccessibility of signage/applications in one language). Each session, lasting a maximum of two hours, was moderated over Zoom by two members of the research team who provided the structure and rules for the session, managing time and taking notes. The moderators prepared open-ended questions and prompts to guide the conversation, but no limits were given to the type of response to be provided. Each of the everyday scenarios was addressed by discussing one sub-aspect at a time to help control the flow of discussion and order the data collection. For each sub-aspect or sub-task, participants were asked to name an obstacle or facilitator, or what made it harder or easier to accomplish that sub-task independently. They were invited to share their opinions based on their own previous experience and expertise. If they had not experienced any of the scenarios independently in the past, they were asked to imagine themselves performing each subtask on their own. Each participant's intervention was limited to 2 minutes per sub-task, to encourage as many people as possible to speak.

Once all the scenarios had been discussed, more general open-ended questions were addressed to the participants, including the strengths and shortcomings of current mobile applications, the scenarios most difficult to complete alone, and the participants' wishes for tools to remedy the obstacles encountered.

The Zoom software was used to record the audio file of the session and transcribe it into English. The study team manually completed the French transcription. The transcriptions were validated to ensure accuracy. A third member of the research team resolved any discrepancies after two team members independently identified themes in the participants' responses. Each participant's code, the scenario they described, and the frequency of each theme's occurrences were recorded. The list of themes was organized according to the scenario in which it was mentioned and whether it was considered a barrier or facilitator.

2.3.3 Email ranking

The list of themes was then emailed to each participant for an individual ranking two weeks after the Zoom session. The participants were only sent themes mentioned during their focus group session. Thus, each focus group had a different set of themes to choose from, but each participant in that focus group received the same set of themes. Each participant was asked to rank the themes in each scenario according to their perceived level of importance in completing the scenario independently or having a pleasant experience. They were asked to write 1 for the most important facilitator or barrier, 2 for the second most important, and so on. For each scenario, participants could also add a new idea that was not included in the proposed themes, using the "Other" line. Their responses

allowed the research team to re-order the themes based on the level of perceived importance. Themes with an average value closer to 1 were determined to have a higher level of perceived importance as either a barrier or facilitator in their respective scenarios. If two themes received the same average value, they received the same score of relative importance.

2.3.3 Data Analysis

The audio file of the session was recorded and transcribed into English via the Zoom software. The French transcription was performed manually by the research team. The transcriptions were validated to ensure accuracy. The code of the participant that mentioned each theme, the scenario mentioned, and the number of occurrences of each theme were logged in Microsoft Excel. The list of themes was organized according to the scenario. Each participant was asked to rank the themes in each scenario according to their perceived level of importance with 1 being the most important. Due to the limited number of participants and high level of diversity amongst the participants, the authors did not perform comparative statistical tests (i.e. ANOVA, t-tests) to analyze the ranking data. Instead, the themes were analyzed according to their level of perceived importance and the information received from each participant during the selection interview.

3 RESULTS

3.1 Demographics

Thirty-eight people were interviewed between February 24 and March 24, 2023, using the selection questionnaire. A profile of each person can be found in Appendix 2.

The selection for each focus group was made according to the methodology described above to have a diverse group of participants. Ten English-speaking or bilingual individuals were selected for the focus group conducted in English, and 12 French-speaking individuals for the focus group conducted in French. One individual in each group did not attend their respective focus group.

The final portrait of the two groups is presented in Table 1 below. Participants who are English-speaking have a code beginning with A, and those who are French-speaking have a code beginning with F, bilingual participants are coded AF. Those in the focus group conducted in English are shaded in gray, while the French focus group is unshaded. Though recorded by the research team, the visual diagnosis, travel habits, and additional handicaps are not listed in the table to de-identify the participants.

Table 1. Demographics of all participants in focus groups.

Code	Age	Gender	Ethnicity	City, Province	Age at diagnosis	Mobility aids	Level of vision	Type of vision loss
A07	69	M	Caucasian	Toronto, Ont.	Birth	None	LVB	VA
A10	75	F	Asian and African	Ottawa, Ont.	68	None	LVB	VAF
A18	24	F	Afro-American	Edmonton, Alberta	12	Guide dog, white cane	LVFB	VAF
AF03	62	M	Indian	Montreal, Qc	58	White cane	LVFB	VAF
AF08	60	F	Middle	Toronto,	30	Guide	CB	VAF

			Eastern	Ont.		dog, white cane		
AF26	59	M	Caucasian	Montreal, Qc	Birth	White cane	CB	VAF
AF29	51	F	Caucasian	Montreal, Qc	Birth	Support cane, walker	LVNL B	VAF
AF33	63	M	Caucasian	Granby, Qc	50	White cane	LVFB	VAF
AF37	30	F	South American	Montreal, Qc	Birth	White cane	CB	VAF
F01	50	F	Caucasian	Montreal, Qc	22	White cane	CB	VAF
F02	56	F	Caucasian	Laval, Qc	51	White cane	LP	VAF
F05	50	M	Caucasian	Mont St-Hilaire, Qc	23	Guide dog, White cane	LVB	VAF
F20	57	F	Caucasian	Laval, Qc	27	White cane	LVB	VAF
F23	58	F	Caucasian	Laval, Qc	57	White cane	LVB	VF
F25	66	M	Caucasian	Quebec, Qc	55	White cane	LP	VAF
F27	32	F	African	Longueuil, Qc	8	White cane	CB	VAF
F28	61	M	Caucasian	Granby, Qc	20	Guide dog, White cane	LP	VAF
F30	56	F	Caucasian	Montreal, Qc	Birth	White cane, support cane, telescope	LVNL B	VA
F35	58	F	Caucasian	St-Hubert, Qc	32	White cane	LVFB	VAF
F36	56	F	Caucasian	Granby, Qc	17	None	LVB	VA

M=male, F= female, LVB = low vision and legally blind, LVFB = low vision functionally blind, CB = completely blind, LVNLB = low vision not legally blind, VA = visual acuity loss, VAF = visual acuity and field loss, VF = visual field loss

3.2 Coffee shop

The participants were asked to imagine getting a drink at their favorite coffee shop and this scenario consisted of multiple steps (Appendix 3). In each of the steps of this scenario, the participants in both

focus groups were asked to indicate any obstacles and facilitators. They were then asked to rank these themes in an email. This process was repeated in each scenario. The full list of themes is shown in Appendix 4.

The themes extracted for the facilitators for this scenario were the following: human assistance, preparedness, accessible physical space, environmental sensory cues, accessible payment, accessible signage, smartphone applications with GPS, and smartphone applications with computer vision. See Appendix 5 for the complete ranking of themes.

Participant AF37 mentioned that human assistance is an important factor, stating that “If I go to a known place, I already know kind of the prices on what they sell, and so I just ask them, what do you have today?” More quotes on each theme used by participants are mentioned in Appendix 6.

The themes extracted for the barriers for this scenario were the following: difficulty finding an exact location, difficulty finding human assistance, inaccessible signage, difficulties walking around, inaccessible payment, high ambient noise, hand occupied, inaccessible online information, and lighting. The rankings of the barriers and facilitators in each group, and their averages, are indicated in Table 2.

Participant AF08 mentioned that precise location is difficult to find, stating “Locating where the terminal is very difficult. It's never in a standard place that is close to the customer. Sometimes you must reach and try to find where it is.”

Table 2. Top 3 rankings of facilitators and barriers in order of importance to visit a coffee shop

Facilitators - Coffeeshop				
Rank	English Group	Average	French Group	Average
1	Human Assistance	2.6	Human Assistance	1.9
2	Preparedness	3.4	Accessible payment	2.4
3	Accessible physical space	4.3	Sensory cues	2.6
Barriers – Coffeeshop				
1	Difficulty finding an exact location	2.7	Lighting	2.0
2	Unsuccessful interactions with staff	3.1	Inaccessible signage	2.5
3	Inaccessible signage	3.8	Difficulty walking around	2.9

3.3 Hospital

The participants were then asked to imagine going to a hospital or a clinic for their regular checkup. The themes extracted for the facilitators for this scenario were the following: human assistance, mobility aid, preparedness, smartphone apps using human assistance, smartphone apps with computer vision, accessible signage, accessible physical space, and accessible payment.

Participant AF28 mentioned that it was convenient to use human assistance as he quoted “Ask the security guard to go to the right floor. Then ask the receptionist and tell him or her.”

The themes extracted for the barriers for this scenario were the following: difficulty finding an exact location, unsuccessful human interaction, difficulties walking around, inaccessible signage, noisy environment, hands occupied, and inaccessible payment.

Participant A07 pointed out the problem of finding a precise location by mentioning “You’ve got to find the right floor. Just find the elevator. There are all kinds of challenges with that if you want to go a big place like, say, St. Michael's Hospital, and you have to go up to floor 8 or 10, which is very

difficult to pinpoint.”

Table 3. Top 3 rankings of facilitators and barriers in order of importance to visit a hospital or clinic

Facilitators – Clinic				
Ran k	English Group	Averag e	French Group	Averag e
1	Human assistance	1.4	Human assistance	2.1
2	Mobility aid	2.0	Preparedness	2.1
3	Preparedness	2.2	Accessible signage	2.7
Barriers – Clinic				
1	Difficulty finding an exact location	1.9	Inaccessible signage	2.4
2	Unsuccessful interactions	2.3	Unsuccessful interactions	2.9
3	Difficulties walking around	2.6	Difficulty walking around	3.1

3.4 Big box store

The participants were then asked to imagine shopping in a big box department store. The themes extracted for the facilitators for this scenario were the following: human assistance, preparedness, website accessibility, accessible signage, accessible physical space, environmental sensory cues, smartphone apps using human assistance, smartphone apps with computer vision, accessible payment, and alternatives available.

Participant A10 mentioned the importance of human assistance by saying “If you are making a comparison between items and prices. I find that having human intervention helps.”

The themes extracted for the barriers for this scenario were the following: difficulties walking around, difficulty finding an exact location, problems locating an exact item, inaccessible signage, inaccessible payment, problems identifying a price, hands occupied, employee assistance request, unsuccessful interactions with employees, unexpected events, and difficulty finding what fits. Summarized data can also be found in Table 4.

Participant AF33 mentioned the problems locating a precise item, quoting that “One thing that makes it difficult for me is, is it's either the top row or completely the bottom row.”

Table 4. Top 3 rankings of facilitators and barriers in order of importance to shop at a department store

Facilitators – Shopping				
Ran k	English Group	Averag e	French Group	Averag e
1	Human assistance	2.6	Website accessibility	1.9
2	Preparedness	3.9	Preparedness	2.5
3	Website accessibility	4.1	Human assistance	3.2
Barriers – Shopping				

1	Difficulties walking around	2.8	Employee assistance request	1.0
2	Difficulty finding an exact location	3.1	Inaccessible signage	2.4
3	Problems locating a precise item	3.6	Difficulties walking around	2.5

3.5 Party

The participants were then asked to imagine going to a party with friends. The themes extracted for the facilitators for this scenario were the following: preparedness, accessible physical space, helpful friends, accessible signage, availability of alternatives, smartphone app with GPS, smartphone app with computer vision, environmental sensory cues, introducing yourself, and approaching people.

Participant AF37 mentioned how help from friends can be an immense help to join a party by quoting "I usually call when I am arriving, and how my friend, or whoever can you please meet me downstairs? That would be helpful because I usually will not know where the house is".

The themes extracted for the barriers for this scenario were the following: difficulties walking around, unsuccessful interactions with friends, noisy environment, hands occupied, problems locating a precise item, inaccessible signage, fear of spilling food or drink on others, unsuccessful interactions, and problems finding people. Summarized data can also be found in Table 5.

Participant AF37 also mentioned how unsuccessful interaction with friends creates more difficulty by quoting "For me the challenge is that in some kind, of course, people are moving around all the time, you know, going from group to group to group to group, and it's very over overwhelming to kind of follow that it's someone I know, and even work with there's people that I don't know, because I cannot pinpoint, or it's very hard for me to kind of just join a random group."

Table 5. Top 3 rankings of facilitators and barriers in order of importance while going to a party with friends.

Facilitators - Party				
Rank	English Group	Average	French Group	Average
1	Preparedness	2.0	Human Assistance	1.2
2	Accessible physical space	2.4	Accessible physical space	2.7
3	Human Assistance	2.6	Alternatives available	3.1
Barriers – Party				
1	Difficulties walking around	2.6	Fear of spilling food or drink on others	2.0
2	Unsuccessful interactions	3.0	Noisy environment	2.46
3	High ambient noise	3.4	Difficulties walking around	2.5

3.6 Bus travel

The participants were then asked to imagine going on public transportation like a bus or metro station. The themes extracted for the facilitators for this scenario were the following: accessibility of

signage, accessibility of physical space, preparation, human assistance, smartphone applications with GPS, website accessibility, availability of alternatives, and mobility aid.

Participant A10 mentioned what preparations could be made to make traveling on the bus more convenient, quoting “There's a lot of research to be done ahead of time. You must know the stop numbers. You must know the intersections where those bus stops are. These are things you must know before getting there.”

The themes extracted for the barriers for this scenario were the following: inaccessible signage, unsuccessful interaction with staff, inaccessible payment, difficulties walking around, problems locating a precise item, unexpected events, inaccessible online information, inaccessible payment, and problems with technology. Summarized data can also be found in Table 6.

Participant AF33 mentioned that the inaccessible signage was one of the major barriers, quoting that “one thing is that the sign is way too high. It is sometimes 8 to 12, and even 14 feet high. I cannot reach it by phone to be able to see if I am at the right spot.”

Table 6. Rankings of facilitators and barriers in order of importance while going on public transportation.

Facilitators - public transit				
Rank	English Group	Average	French Group	Average
1	Accessibility of signage	2.8	Accessible signage	1.9
2	Preparedness	3.00	Accessible physical space	2.4
3	Accessible physical space	3.0	Human assistance	2.8
Barriers – public transit				
1	Inaccessible signage	2.1	Inaccessible signage	1,00
2	Unsuccessful interactions with staff/patrons	3.7	Difficulty finding an exact location	2.4
3	Difficulties walking around	3.9	Unexpected events	2.5

3.7 Use of smartphone

To understand how smartphones can bring independence to PVI, we asked five questions, which were:

1. What are the strengths and weaknesses of the currently available apps that you use?
2. What is missing from the currently available apps for the scenarios we described?
3. What would the ideal mobile app contain?
4. Among the above-given scenarios, in which situation would you prefer an app, and in which one would you prefer human assistance?
5. Which of the above scenarios was the most difficult to navigate on your own?

For the first question, the participants provided examples of a few smartphone applications (apps) to share their strengths, such as being able to have voice commands and being user-friendly. Participants went on to discuss apps such as Seeing AI, Google Maps, Soundscape, and BlindSquare which they found especially useful and user-friendly. However, each app had its weaknesses. It was difficult to switch from one tab to another in Seeing AI. Google Maps is unable to work in indoor

environments and accuracy depends somewhat on the weather conditions. Soundscape though was very promising and user-friendly but was discontinued and required training. Similarly, BlindSquare app also required training which made the work tiring.

For the second question, participants explained that most of the apps do not have accessibility options like a back button. Furthermore, there was an issue with the GPS not being accurate and a few participants mentioned the difficulty of navigating indoors. Additionally, all participants agreed that each app is incomplete and that to do each different task they would have to switch between the different apps which was troublesome. Further, they found it difficult to hold their phones to scan most of the time and advised creating a method with which they could be hands-free, which might not be as expensive as smart glasses.

For the third question, participants agreed that the ideal content would be to have all the features in one app so that they would not have to switch between the apps. Other ideal features included voice commands and hands-free operation. They also wanted the software to be sustainable and not drain excessive batteries from their phone.

For the fourth and fifth questions, there was a split in opinion among participants, while most of them agreed that any of them would love to have an app on their phone that would allow them to successfully navigate any of the given scenarios, a few participants expressed doubts about the feasibility of an app enabling independent travel in certain scenarios due to the complexity of tasks required in those environments.

More participant quotes can be found in Appendix 6.

3.8 Scenario comparison

Participants were asked which scenario was the most difficult to navigate on their own and were asked to explain their reasoning. The most barriers for the English group were indicated in the coffee shop ($n=8$) followed by department store ($n=7$) and bus or metro ($n=7$). For the French group, the most barriers were in the department store ($n=9$), followed by the hospital or clinic ($n=7$) and coffee shop ($n=6$). The fewest facilitators were mentioned in the hospital or clinic ($n=5$) for the English group while it was the coffee shop ($n=4$) for the French group. For the French group, the department store had one of the largest barriers ($n=9$) and the largest number of facilitators ($n=8$). Meanwhile, the coffee shop scenario had both the most barriers ($n=8$) and facilitators ($n=8$) for the English group. Elaborated data are presented in graphs in Figures 1 and 2. Among the facilitators, human assistance was regarded as one of the major facilitators being present in all scenarios, while accessibility of physical space was also available in most of the scenarios (4 times in English and 5 times in French) and preparation was present in (5 times in English and 2 times in French). As for the major barriers, non-accessible signage and difficulty walking around were addressed in almost all scenarios (5 times in English and 4 times in French) and unsuccessful interactions with others were found (4 times in English and 4 times in French) scenarios and difficulty locating precise locations emerged in (4 times in English and 4 times in French) scenarios. Details of each scenario are tabulated in Appendix 5.

When comparing between the French and English groups, they were similar. While the groups perceived an equal number of barriers, the French group experienced fewer facilitators. The English group considered smartphone application as one of the facilitators in every five scenarios, while the French group considered it as a facilitator in only two scenarios. Similarly, the English group seemed to be prepared and found preparedness as a major facilitator while the French group pointed out preparedness as a facilitator in only two scenarios. Even though both the groups had an equal number of barriers, non-accessible signage, as well as difficulty walking around, were present in all five scenarios for the English group while it was present in four scenarios for the French group.

Figure 1. Graph showing the number of barriers and facilitators experienced by PVI in each scenario

among the English group.

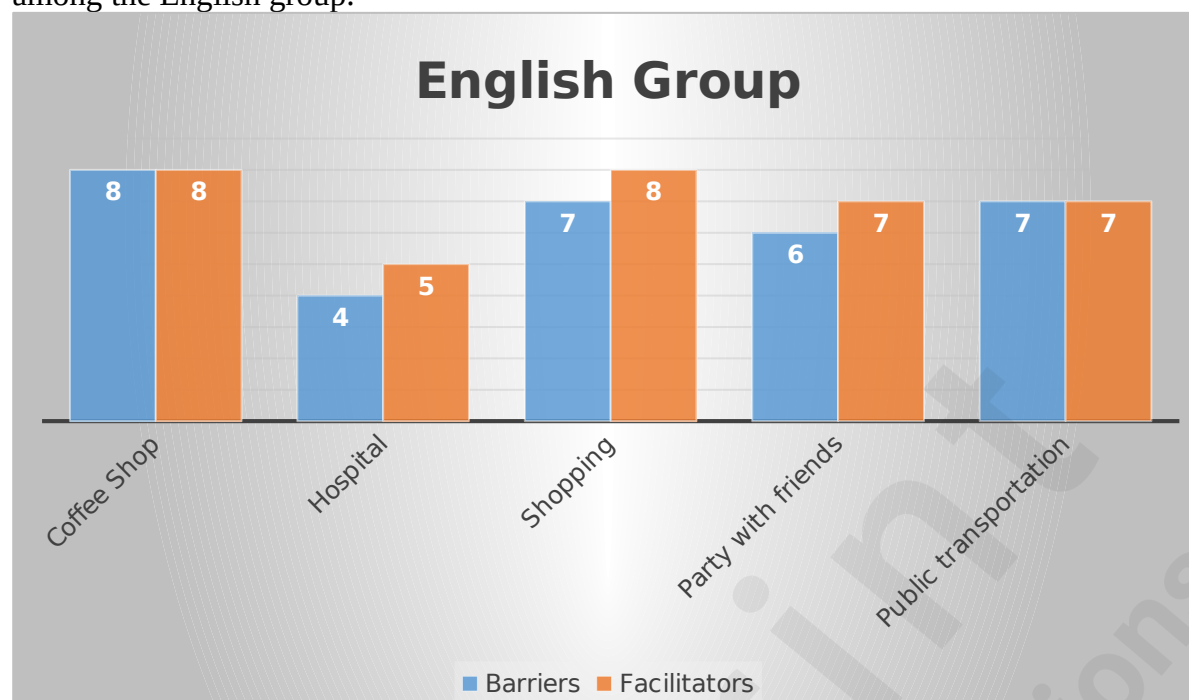
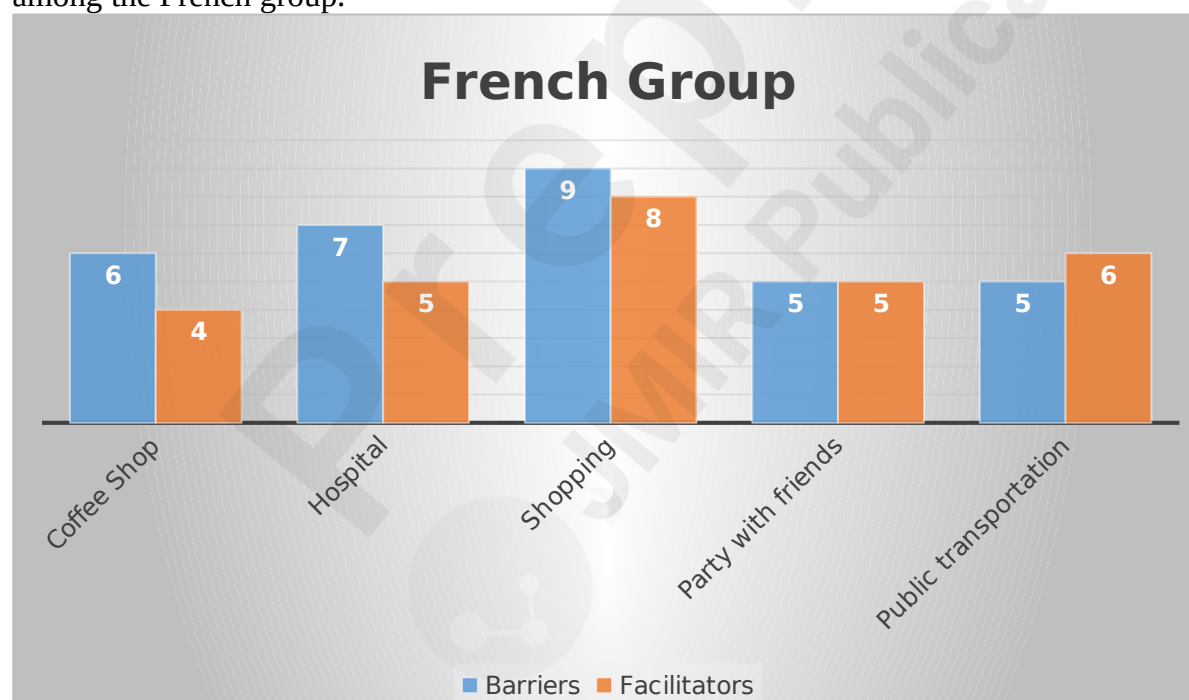


Figure 2. Graph showing the number of barriers and facilitators experienced by PVI in each scenario among the French group.



4 DISCUSSION

People with visual impairments encounter numerous issues in daily life that reduce their participation in social and leisure activities. The goal of our study was to better understand the perceived barriers and facilitators for everyday travel for five of these activities outside the home for people living with both low vision and blindness. This study was particularly focused on elucidating the context of the problems associated with dynamic, indoor spaces to inform technology developers about priorities from those with a variety of lived experiences. This study takes a user-centered approach to enumerate perceptions and opinions even for individuals who may not be able to complete these tasks independently. Here we discuss some of the major points that were prioritized by individuals in our focus groups and examine how technology developers may attempt to reduce the barriers while facilitating the use of mobile applications and other technologies to respond to the needs of people with visual impairments in the environments studied.

4.1 Barriers

Non-accessible signage and difficulty walking around emerged as a major concern and were addressed in almost all scenarios. Particularly, inaccessible signage contributes significantly to the challenge of accessing written information for people with visual impairments, as highlighted in studies by Brown et al., [29] and da Silva et al. [3]. Several attempts have been made to improve the readability of signage for this population. For instance, Lan et al. [30] developed lightweight smart glass equipped with a tiny computer to assist users in reading signage. While this technology proved helpful in reading street signs, it was not tested in people with visual impairments, and its functionality was limited to this single purpose. This might explain why the product has never reached the market yet. Similarly, William et al. [31] created an infrared audible signage system. However, it failed to gain popularity due to its complex sensor installation requirements and lack of usability. Even after training, the voice output was difficult for people with visual impairments to understand. To develop user-friendly technology, it is essential to involve end-users from the prototype stage and conduct regular testing and refinements until the product meets their needs and ensures their comfort and satisfaction.

The theme of difficulties walking around, highlighted by the participants in our study, echoes the findings of Lamoureux et al. [32]. For people with visual impairments, this remains a significant obstacle. One reason this challenge persists is that many systems are designed to either assist with outdoor navigation or indoor navigation, but rarely both. Transitioning between indoor and outdoor spaces is particularly difficult, possibly due to the challenge of recognizing entry and exit doors, sudden changes in lighting, the sensory overload caused by varying sounds and environmental conditions, and the absence of consistent orientation cues between these settings. The difficulty in finding a precise location and unsuccessful interactions with employees, volunteers, and other people present were identified as major obstacles in the proposed scenarios. Recognizing precise locations indoors is particularly challenging, as indoor environments hinder many sensory cues, and the widely used GPS does not function effectively indoors. To address these challenges, various alternative solutions have been explored, such as a guide beacon [33], Wi-Fi fingerprinting [34], and live-streaming [35]. Each of these methods comes with its own advantages and limitations. Guide beacons, which are low-cost Bluetooth devices, must be strategically installed throughout the indoor spaces. Wi-Fi fingerprinting relies on consistent Wi-Fi signals and detailed floor mapping to operate effectively. Live streaming, on the other hand,

requires a person to view the stream and provide location guidance, which is often impractical, inefficient, and expensive. Further research in these areas might provide us with better technology for overcoming these obstacles.

Unsuccessful interactions with employees have been seen to be one of the major barriers, however, human assistance has also proven to be one of the major facilitators being present in all scenarios. To improve social interaction, a Social-Aware Assistant was developed that could provide PVI cues to enhance their face-to-face interaction using a smart glass and haptic belt [36]. To achieve a level of independence for PVI, assistive technologies, and human assistance are inseparable [37]. Based on this, several attempts have been made such as Facetime [38], AIRA [39], Be My Eyes [40], and Guide Call [41] to use human assistance in assistive devices. Even though these attempts have been made, it has not been widely popular during these scenarios. The major reason for this is being expensive if human agents are used, and the unavailability of assistance when volunteers are used.

4.2 Facilitators

To overcome the obstacles encountered, the participants identified several strategies and tools that they use and the elements that assist them in accomplishing these everyday tasks. The findings indicate that the assistance of staff, volunteers, clients, or other bystanders is the most frequently used strategy, as identified in all five scenarios in each of the focus groups. This reliance on human assistance aligns with the results of the 2017 Canadian Survey on Disability [42] which reports that 58% of people with disabilities, including those with visual impairments, receive help with daily activities such as shopping or attending appointments. However, this dependence on others can be unsettling for people with visual impairments, as it limits their sense of independence. Therefore, technology could offer more empowering alternatives, allowing people with visual impairment to decide when to seek assistance. Some participants even expressed a preference for AI-based assistance over human help, as it made them feel more comfortable and in control.

Using smartphones with different functions was also one of the major facilitators. There is a huge improvement in technology, specifically in the smartphone, which has enabled several functions enabling PVI to perform most of their tasks conveniently. There are several apps designed for PVI with specific functions. Functions like zoom-in, improved camera quality, and voice command are the features that PVI mostly uses. Mobile applications that were launched recently, like Blind-Aid [43], HandyApps [44], AKSHI [45], ARIANNA [46] which included multiple features for navigation for PVI could be useful, but were not mentioned by those in our study. Furthermore, there are other applications designed for specific task like Farmaceutic App [47] for drug information, TransmiGuia app [48] for public transportation and money-recognizing applications [49] could be useful as well. It was also interesting to find that, smartphone applications were mostly found useful by English group as opposed to French group, which may be due to the language barriers provided in most of the applications. Mobile application creators should be conscious of the accessibility features in each of the available languages when creating and updating an application.

Preparedness emerged as an important facilitating strategy among study participants, alongside having an accessible environment and clear signage. Many participants relied on Google Maps and a mental image of the places they had previously visited. However, when traveling to unfamiliar locations, especially within complex indoor environments, there remains a lack of sufficient technology to assist people with visual impairments. Indoor maps are particularly challenging to create and maintain due to the complexity and frequent layout changes, making it difficult for existing technologies to offer reliable indoor navigation maps. Recently, SITUM [50] has been working to address this issue by developing comprehensive indoor mapping solutions through

extensive global research. Furthermore, preparedness was found to be an important facilitator in the English group being present in all five scenarios but was only present in two scenarios in the French group. This might be linked with the use of smartphones as preparation is mostly associated with smartphone usage.

Signage is a key facilitator, benefiting both individuals with visual impairments and those with normal vision. To make signage more accessible Rousek and Hallbeck [51] concluded that simple, high-contrast pictograms, depicting human figures, were most easily recognized by participants wearing glasses that simulated different visual conditions. They also recommend standardizing signage within hospitals to facilitate the cognitive processes related to understanding signs. Their findings can certainly be applied to written signage in complex environments.

While several facilitators are used to navigate the obstacles experienced in various environments, some are implemented to avoid environments where these obstacles are particularly overwhelming. One such solution, adopted by many participants, is online shopping, which enables them to bypass department stores and grocery stores altogether. The ability to select items online and have them delivered at home not only eliminates the need for external assistance but also reduces the fatigue associated with in-store shopping. The significant benefit of online shopping for people with visual impairments is also highlighted by Kostyra et al. [52], who studied the barriers and facilitators reported by people with visual impairments, including when visiting grocery stores. Indeed, they already pointed out a few years ago that the development of online shopping was a promising avenue for improving the satisfaction and independence of blind people, which is confirmed by our results. However, website accessibility remains an issue associated with online shopping for PVI.

5 LIMITATIONS

The data were only collected from people with visual impairments living in Canada and most of our participants were from Quebec. Further research could collect data from all the provinces of Canada or other parts of the world to provide richer data. Since the data was collected from online interviews it was only accessible to the people who had internet access and could use videoconferencing technology independently. Also, though the sample size was diverse, it does not necessarily represent the views and opinions of many other visually impaired Canadians. A larger data sets around the world could help the assistive technology industry to have better ideas of the requirements of people with visual impairments in their lived environments.

6 CONCLUSION

The results provide a better understanding of the realities of people with visual impairments in indoor, dynamic environments. Our results highlight those mobile technologies, though while facilitating, are not as critical to completing multiple everyday tasks outside the home. Human assistance, accessibility of physical space, and preparedness were found to be major facilitators, but are considered barriers when absent or inaccessible. Smartphone applications should be considered within the larger context of completing daily tasks, as they may provide some assistance, but will not be the universal solution. Additionally, language barriers must be considered, as many applications often do not have the full range of functionality in both languages, thus leading to a disadvantaged population of non-native English speakers who may encountered additional barriers, such as regarding preparedness. Further research should examine how mobile technologies perform when individuals are interacting with everyday environments outside the home in the context of other human factors (i.e., communication) and accessibility of physical space (i.e., available signage).

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8 CONFLICTS OF INTEREST

None declared.

9 ABBREVIATIONS

GPS: Global Positioning System

PVI: People with Visual Impairments

Apps: Smartphone applications

AT: Assistive technology

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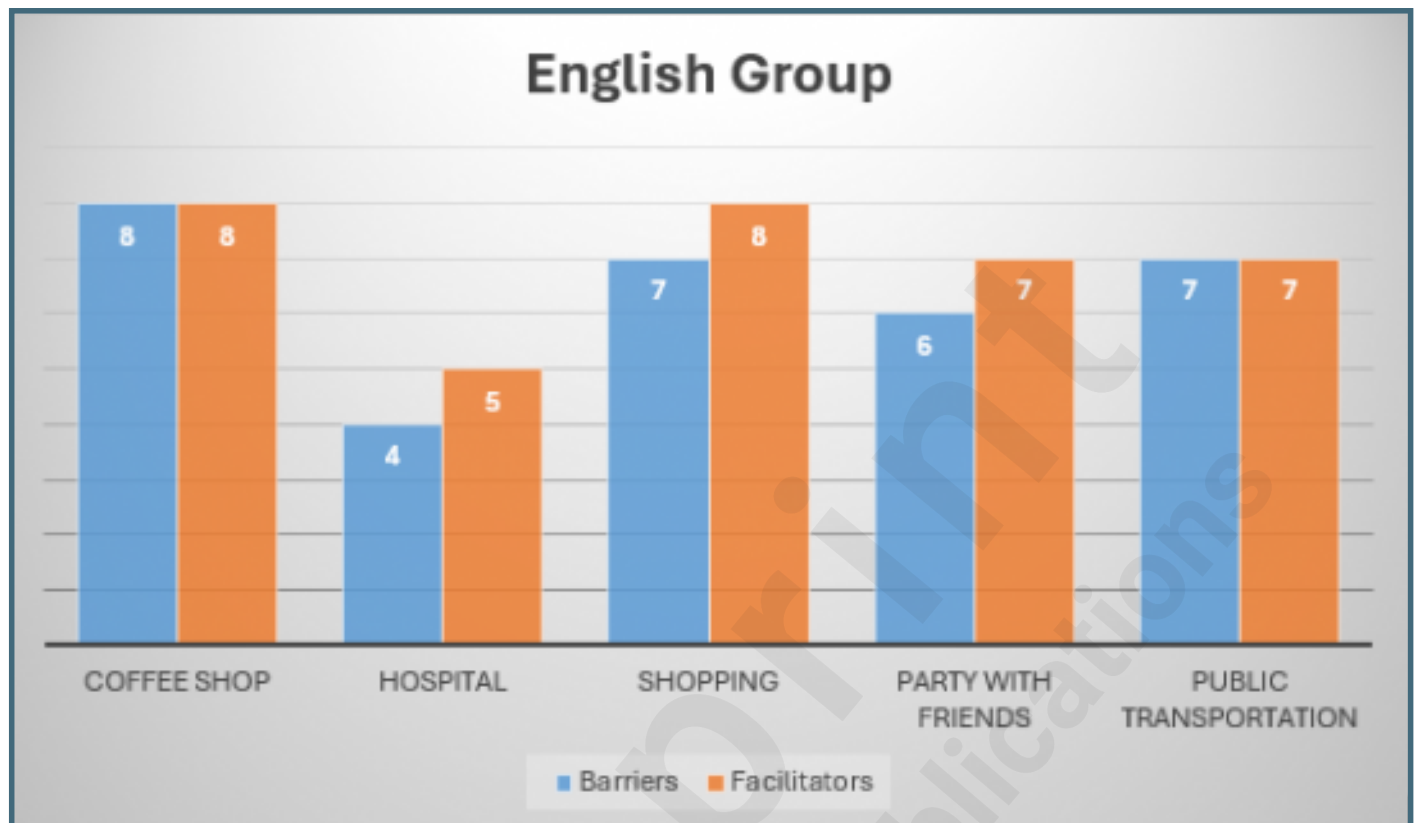
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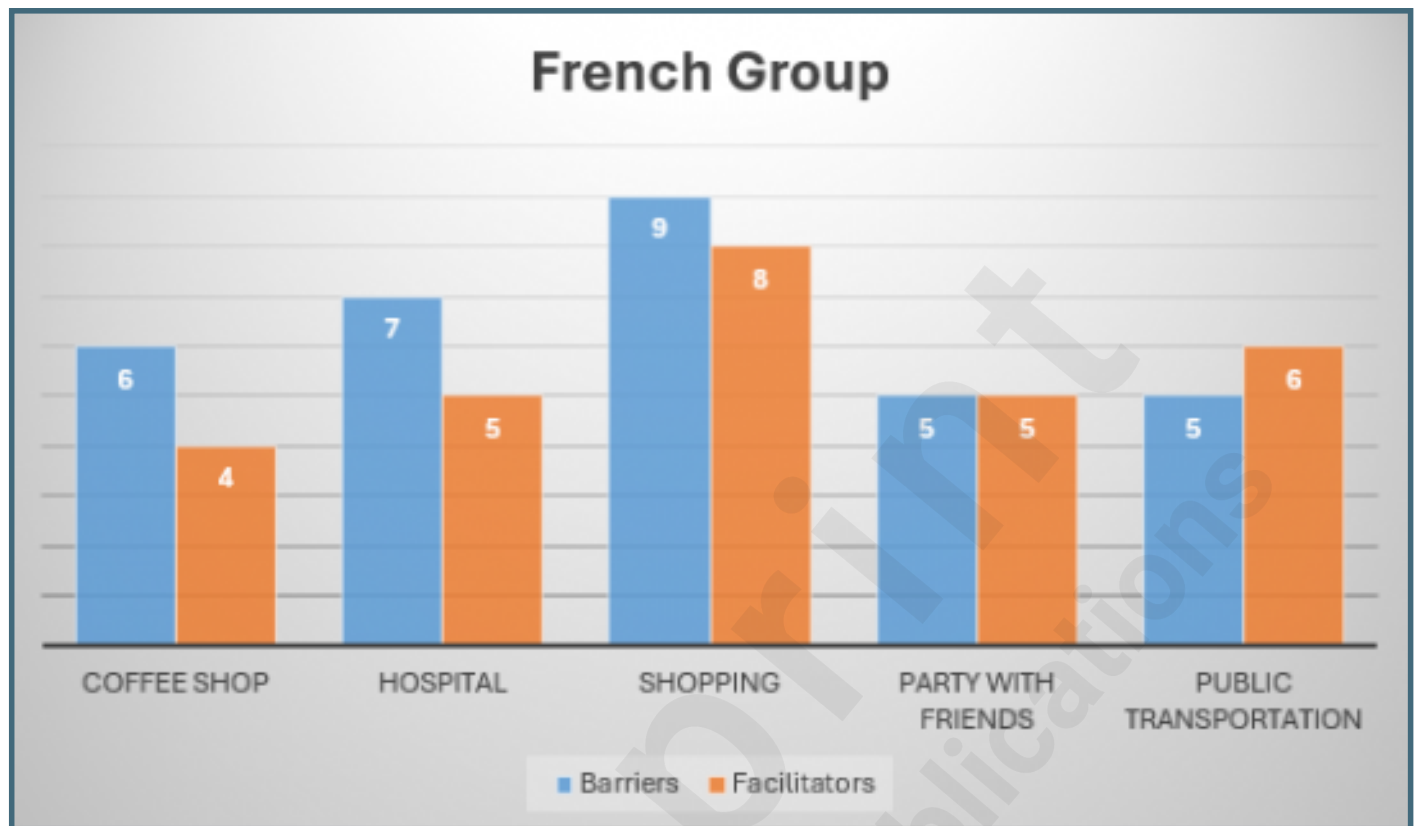
Supplementary Files

Figures

Graph showing the number of barriers and facilitators experienced by PVI in each scenario among the English group.



Graph showing the number of barriers and facilitators experienced by PVI in each scenario among the French group.



Multimedia Appendixes

Questionnaire for selection of participants for Focus Group.

URL: <http://asset.jmir.pub/assets/3d88b47a03b2c86d9396c8f5b85df466.docx>

Profiles of thirty-eight people interviewed, using the selection questionnaire.

URL: <http://asset.jmir.pub/assets/917ae29a42f335eafa9f1689620a04d1.docx>

Scenarios and sub-tasks.

URL: <http://asset.jmir.pub/assets/ec86e1cf0efe13ba07b90b24c46b0f3c.docx>

General themes of obstacles and facilitators were developed from the comments of the participants in the two groups.

URL: <http://asset.jmir.pub/assets/e83e7889a569a3f9d6c085a8abb16769.docx>

Complete rankings of the facilitators and barriers in order of importance to visit different scenarios for the English and the French focus groups.

URL: <http://asset.jmir.pub/assets/c79310aceaceccda814bb6ae508dacb8.docx>

Example quotes from participants for each theme.

URL: <http://asset.jmir.pub/assets/ce8817856b226b44cbbfb43651373cb2.docx>