Mobility-Related Accidents Experienced by People with Visual Impairment

Roberto Manduchi, PhD*
Sri Kurniawan, PhD
University of Santa Cruz
Santa Cruz, CA

Abstract

1 Walking without sight brings forth the risk of falls and collisions. This contribution reports on the results of a survey interview with more than 300 legally blind or blind individuals, focusing on the frequency, nature, and causes of head-level and fall accidents.

Keywords: orientation & mobility, assistive technology injuries

Introduction

Vision loss increases the risk of unintentional injury (Arfken, Lach, McGee, Birge, & Philip Miller, 1994; Felson et al., 1989; Glynn et al., 1992; Ivers, Cumming, Mitchell, & Attebo, 1998; Legood, Scuffham, & Cryer, 2002; Lord, 2006; Roberts & Roberts, 1995). Previous research highlighted the correlation between the type, severity, and frequency of injuries and the type and degree of vision loss. The categories of injuries considered included falls, occupational injuries, and traffic-related injuries. A thorough review of the literature (Legood et al., 2002) established that the risk of unintentional injury due to falls is higher for those with visual impairment than for the general population. Other than the literature about falls, very few studies are available relating visual impairment to other types of injuries, including occupational and traffic-related injuries. Only one other study (Arfken et al., 1994) briefly addressed the risk of collision against obstacles, which is one of the main themes of this contribution. In that study, each person in a cohort of elderly persons was asked to provide a visual self-assessment, with questions that included how often the person bumped into objects that he or she missed seeing. It was shown that bumping into objects was not correlated with visual acuity, and it was only weakly correlated with limited ambulation due to poor vision. Bumping into objects, however, was shown to be a good predictor of falls and recurrent falls.

This article is concerned with two specific categories of injuries: head-level accidents (bumping into things at chest height or higher) and falls while walking. It reports on the results of a survey interview with more than 300 respondents who are legally blind or blind. The questions in the survey focused on the frequency, nature, and causes of head-level and fall accidents, as well as on other factors such as the level of blindness, the type of mobility aid used, and the frequency of independent trips. The quantitative and qualitative data that emerged from this survey may be useful to orientation and mobility professionals and researchers or practitioners in assistive technology alike.

Motivation and Research Questions

Walking without sight brings forth the risk of falls and collisions. Although mitigated by the use of mobility aids such as the long cane and the dog guide, this risk needs special consideration. The first

* Please address correspondence to manduchi@soe.ucsc.edu.

Received July 29, 2010; Accepted February 9, 2011

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:12 1 Cust # AERJOURNAL-D-10-00048R1

research question addressed by this article was whether accidents involving a blind ambulator in a "static" environment (i.e., accidents that are not due to traffic or to moving objects or persons near the person who is blind) represent a significant aspect of the experience of walking without sight, or if they should be considered sporadic and inconsequential incidents. This question should be relevant, among others, to anyone involved in the development of new mobility tools for people with visual impairments (such as electronic travel aids). Of course, other types of accidents (e.g., traffic-related accidents) are also important and should be addressed by appropriate research; they are, however, outside the scope of this work. A second research question was whether there is a difference in terms of frequency of accidents between cane users and dog guide users. These two mobility aids (cane and dog guide) are intrinsically different, and so it is interesting to ascertain whether they provide the same level of protection, or if one proves superior to the other in this particular context. A third question related to whether persons who venture out to unfamiliar routes are more likely to experience this type of accidents. This information may help identify which population segments may be more in need of technology to prevent injuries associated with independent ambulation.

Data Collection Methodology

The survey was composed of four main parts: (1) demographics; (2) travel habits, including the type of mobility aid used and the frequency of travel outside one's residence and outside familiar routes; (3) occurrence of head-level accidents, their frequency, circumstances, and consequences; and (4) occurrence of trips resulting in a fall, their frequency, circumstances, and consequences. Some of the questions called for a quantitative answer, while some were open-ended. Respondents were able to take the survey on the Internet (using SurveyMonkey™, an accessible online service providing secure data transfer) or by phone. Online surveys are appealing because of their characteristics of flexibility, speed and timeliness, and convenience (Evans & Mathur, 2005). Those without access to the Internet or not willing to use the online survey tool were given the option of taking the survey interview by phone.

The only inclusion criteria were for the participants to be blind (with at most some light perception) or legally blind and to be at least 18 years of age. The survey, which ran from October 13 to December 15, 2009, was announced by e-mail to multiple organizations working with persons with visually impairment throughout the United States. To encourage participation, a random draw for two $100 Amazon gift certificates was announced and later conducted on December 15, 2009. A total of 307 persons participated in the survey, of whom 268 took the survey online and 39 over the phone. Some who participated online were unable to complete the survey due to incompatibility with their screen reader. In these cases, all of the completed answers were considered in the subsequent analysis. All who took the survey over the phone completed the survey. Two hundred eighty-nine respondents were located in the United States (32 different states were represented). Ten respondents were located in Canada, 2 in New Zealand, 2 in Bulgaria, 1 in Mexico, 1 in Indonesia, 1 in the United Kingdom, and 1 in Germany.

Results

In this section we report and analyze the results of the survey. The section is organized in four subsections, corresponding to the four parts of the survey as mentioned previously. At the beginning of each subsection, we report the related survey questions. For multiple choice questions, we list the possible answers in square brackets.

Demographics

Q1. *Contact information:*

Q2. *Gender:*

Q3. *Age:*

Q4. *Occupation:*

Q5. *Level of vision loss: [Blind, Legally blind]*

Q5.1. *Please describe your vision loss:*

Q6: *Do you use any mobility aids such as a cane, a guide dog, or an electronic aid? [Yes; No (please skip the next question)]*

Q6.1. *If you answer is "Yes," please describe what mobility aids you use, how often you use them, and in what situations.*

Q7. *When did you start using a mobility aid?*

Q8. *Do you have any other impairments that affect your ability to walk? [Yes (please describe); No]* 2

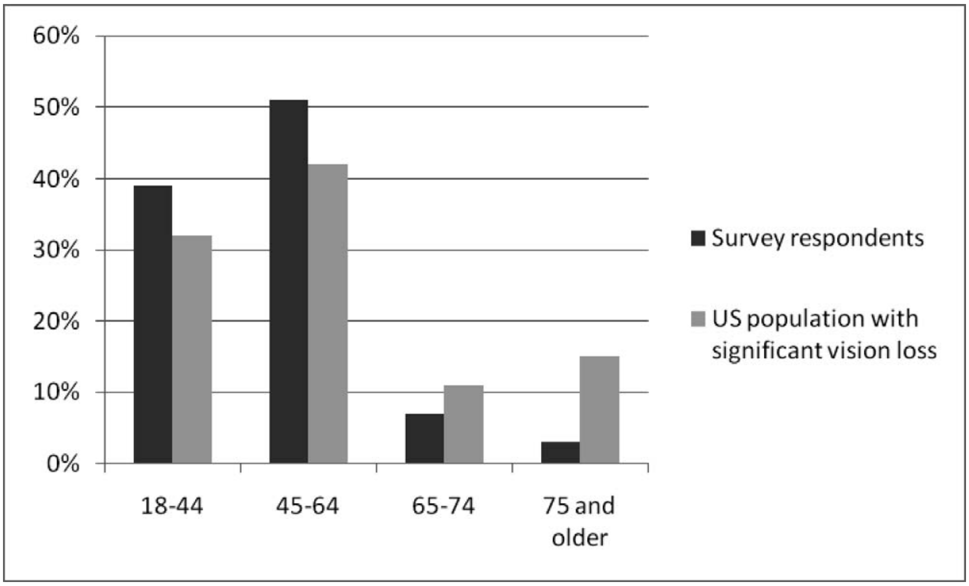

Fig. 1. *Distribution of ages for survey respondents and for the U.S. population with significant vision loss.*

Gender distribution was 65.5 percent women and 34.5 percent men. Ages ranged from 18 to 83 years (mean = 47 years, standard deviation = 15.2 years). Figure 1 compares the age distribution of the respondents with the age distribution of U.S. population with "vision trouble" as reported in the National Health Interview Survey (Pleis & Lucas, 2009). It can be noted that the age distribution of the survey respondents is skewed toward younger age groups. A possible justification for this is the fact that this survey focused on independent ambulation and therefore naturally attracted the younger and more mobile segment of the visually impaired community. It should also be noted that the survey restricted participation to respondents who were legally blind or blind, representing only a subset of the population with vision trouble considered in the National Health Interview Survey (Pleis & Lucas, 2009), where vision trouble was defined as "trouble seeing, even with glasses or contact lenses."

A total of 58.3 percent of the respondents affirmed to be blind (with at most some light perception), while 41.7 percent affirmed to be only legally blind (not blind). Compared with national statistics, which indicate that about 20 percent of persons who are legally blind have light perception or less (Leonard, 1999), it is seen that the community of blind individuals were overrepresented in this survey. In the remainder of this article, the term *blind* refers to "at most some light perception," while the term *legally blind* indicates "legally blind but not blind."

Respondents reported a wide variety of causes of vision loss, including birth defects such as retinopathy of prematurity, retinitis pigmentosa, retinoblastoma, Leber's congenital amaurosis, and age-related impairment such as cataract and glaucoma. Sixty-eight respondents (22 percent) had other impairments affecting their ability to walk, the most common being bad balance and arthritis. Fifty-two respondents (17 percent) were retired, either due to age or disabilities, and 15 (5 percent) were unemployed, while the remaining ones were either employed or students.

Fifty-five percent of the respondents stated that they use a long cane but not a dog guide, 12 percent stated that they use a dog guide but not a cane, and 26 percent stated that they have used both a dog guide and a cane, possibly at different times of their life. Some of the respondents confused what technically is considered a wayfinding aid for a mobility aid. Twenty-nine respondent (9 percent) stated that they use GPS, which is normally considered a wayfinding device. All of the GPS users also used a cane or a dog guide. Twenty-nine respondents (9 percent) stated that they also use aids such as monoculars, telescopes, TalkingSigns, tactile maps, or sighted companions. For subsequent statistical analysis, only two populations were

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:13 3 Cust # AERJOURNAL-D-10-00048R1

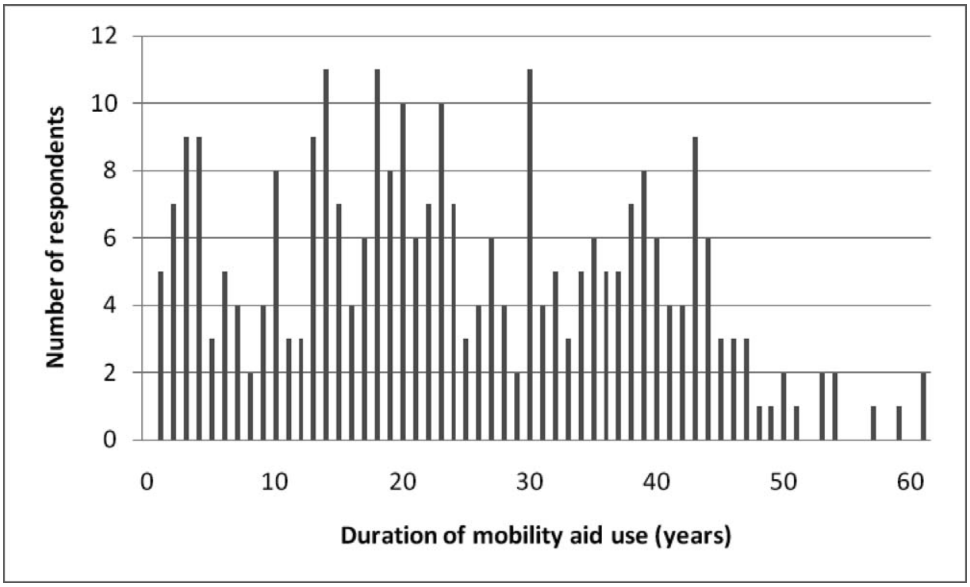

Fig. 2. *Distribution of duration of use of mobility aids.*

considered: those who used a long cane only, and those who used a dog guide, possibly complemented by a long cane. Legally blind respondents accounted for 45 percent of long cane users and for 35 percent of dog guide users.

It should be clear that this sample is not representative of the distribution of mobility aid usage within the general visually impaired community. For example, only about 42 percent of the persons who are blind in the United States used a cane in 1990 (Demographic Updates, 1994), and only 2 percent used a dog guide (Demographic Updates, 1995). The high ratio of persons using a mobility aid in this survey may be explained by the fact that the vast majority (96 percent) of the respondents were independent travelers, meaning that they were able to walk independently outside of their house, and thus were very likely to use a mobility aid. The reason for the disproportionally high ratio of dog guide users among the respondents is less clear. It could be conjectured that the survey received good advertisement by dog guide organizations.

Figure 2 shows the distribution of duration of use of mobility aids across respondents. Some respondents used different mobility aids during different periods of their life. In these cases, the cumulative duration of use of all mobility aids was recorded.

Travel Habits

> ***Q9***. *In a typical week, how often do you travel alone outside your house/apartment/garden? (If your answer is "never," then please skip the next question.)*
>
> ***Q10***. *How often do you travel alone outside of your familiar routes?*

Q10 generated a substantial number (35) of answers containing what could be termed "conjecture words" (about, maybe, probably, etc.). Q9 only generated five such conjecture words. It seems that the notion of "familiar route" is not well defined or that it was difficult for the respondents to clearly assess how often they travel outside familiar routes.

All 307 respondents to Q9 provided quantitative data. Answers to Q10, however, were often qualitative in nature (frequently, rarely, occasionally, as needed). Because it is impossible to clearly quantify such responses, these answers were discarded before subsequent quantitative analysis, resulting in only 177 answers to Q10 containing quantitative data. Based on these quantitative answers, it was decided to group replies to Q9 and Q10 into the following categories: never, once a month or more, once a week or more, five times a week or more, more often than once a day. The results are shown by the histogram of Figures 3 and

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:15 4 Cust # AERJOURNAL-D-10-00048R1

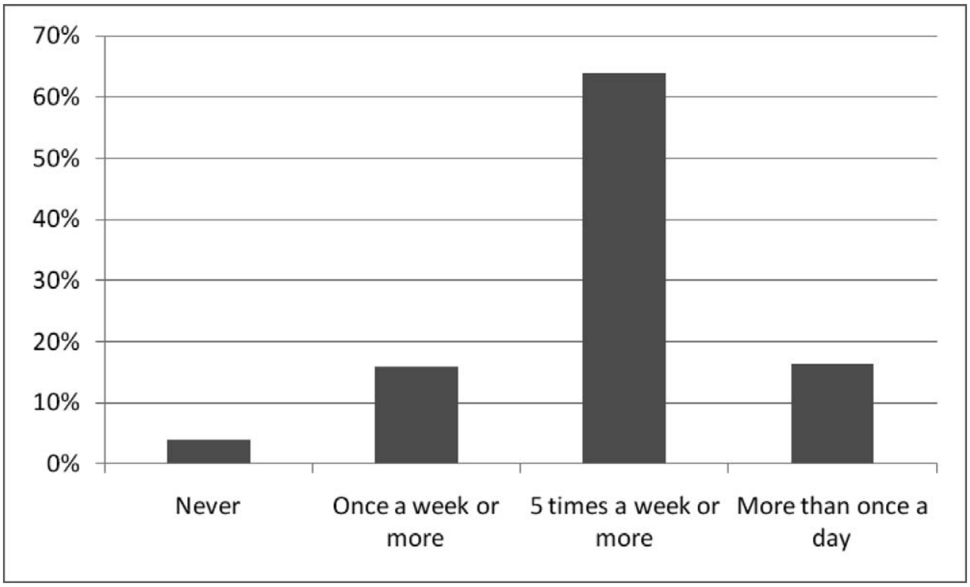

Fig. 3. *Distribution of frequencies of travel outside one's own residence.*

4. Note that about 6 percent of the respondents said that they never take trips outside their familiar routes (Q9). A smaller number of respondents (4 percent) said that they never leave their residence (Q10).

Chi-square analysis of these data reveals the following (please note that for all of the statistical analysis in this article, results with $p < .05$ are considered significant):

- The distribution of frequencies of travel outside one's residence (Q9) for respondents who are legally blind is consistent with the same distribution for respondents who are blind (Pearson's chi-square = 2.809, $df = 3$, $p = .422$). A similar result (Pearson's chi-square = 3.940, $df = 3$, $p = .268$) is obtained comparing the distribution of fre-

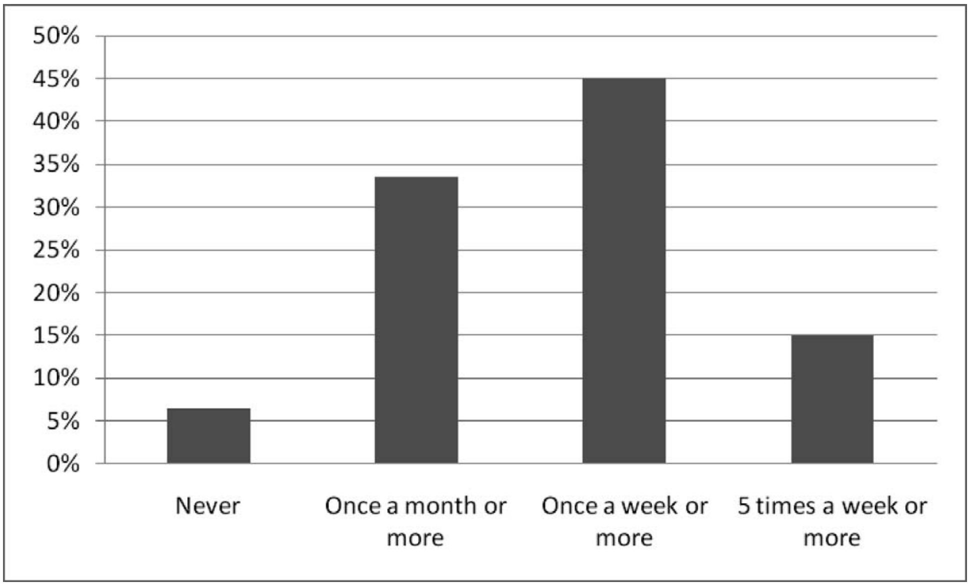

Fig. 4. *Distribution of frequencies of travel outside of familiar routes.*

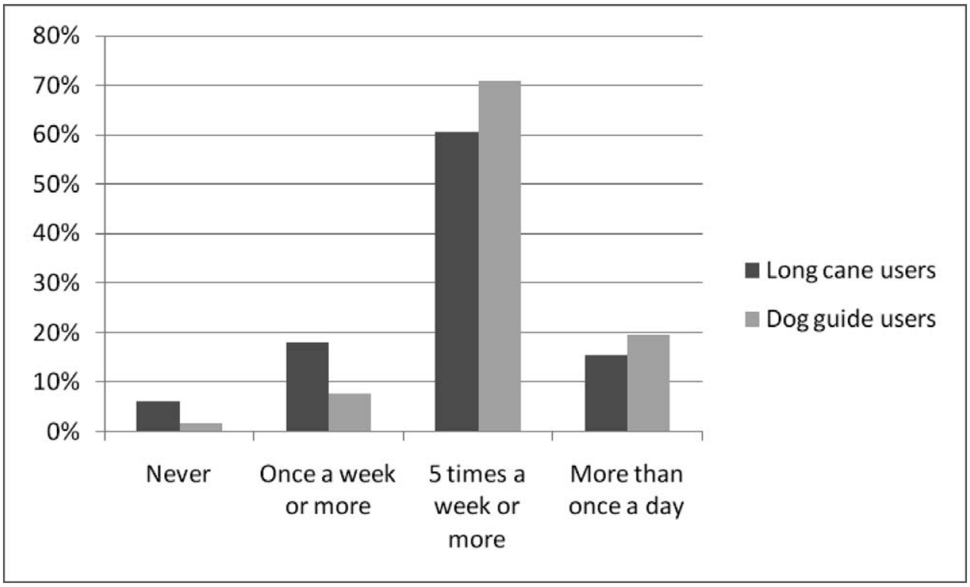

Fig. 5. *Distribution of frequencies of travel of outside one's own residence for long cane users and for dog guide users.*

quencies of travel outside familiar routes (Q10) for respondents who are legally blind and for respondents who are blind. This seems to indicate that the willingness and ability to travel outdoors is not affected by whether one is legally blind or blind

- The distribution of frequencies of travel outside one's residence (Q9) for long cane users and dog guide users are not consistent (Pearson's chi-square $= 10.193$, $df = 3$, $p = .017$). Thus, the data support the claim that the type of walking aid influences the frequency of travel outside one's residence. The histogram of travel frequencies for the two populations (long cane users and dog guide users), shown in Figure 5, strongly suggests that using a dog guide results in significant increase in the frequency of outside walks
- The distribution of frequencies of travel outside familiar routes (Q10) for long cane users and dog guide users are not consistent (Pearson's chi-square $= 7.909$, $df = 3$, $p = .048$). These data suggest that the type of walking aid may influence the frequency of travel outside familiar routes. However, no clear pattern emerges from visual observation of the histograms of travel frequencies for the two populations, shown in Figure 6

The respondents' ages are negatively correlated with the frequencies of travel outside one's residence (Spearman's rho $= -0.173$, $p = .033$). This result is perhaps not surprising, as it suggests that the younger respondents travel more often outside their residences than older respondents. It is interesting to notice that age does not appear to be correlated with the frequency of travel outside familiar routes (Spearman's rho $= -0.042$, $p = .581$).

Head-Level Accidents

Q11. *How often have you experienced head-level accidents? (that is, hitting your head against an unexpected obstacle): [Never; Once a year or less frequently; Once a month or more frequently; More often than once a month]*

Q11.1 *Please describe any head-level accidents you have experienced. For example, in which circumstances it occurred and what did you hit.*

Q12. *Have any head-level accidents you experienced resulted in medical consequences? e.g., hospitalization, visit to the emergency room or to the doctor, home rest. [Yes (please elaborate); No]*

Q13. *Have any head-level accidents resulted in time lost (from work, school, appointments,…)? [Yes (please elaborate); No]*

Q14. *Have you ever changed your walking habits as a consequence of a head-level accident? e.g.,*

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:19 6 Cust # AERJOURNAL-D-10-00048R1

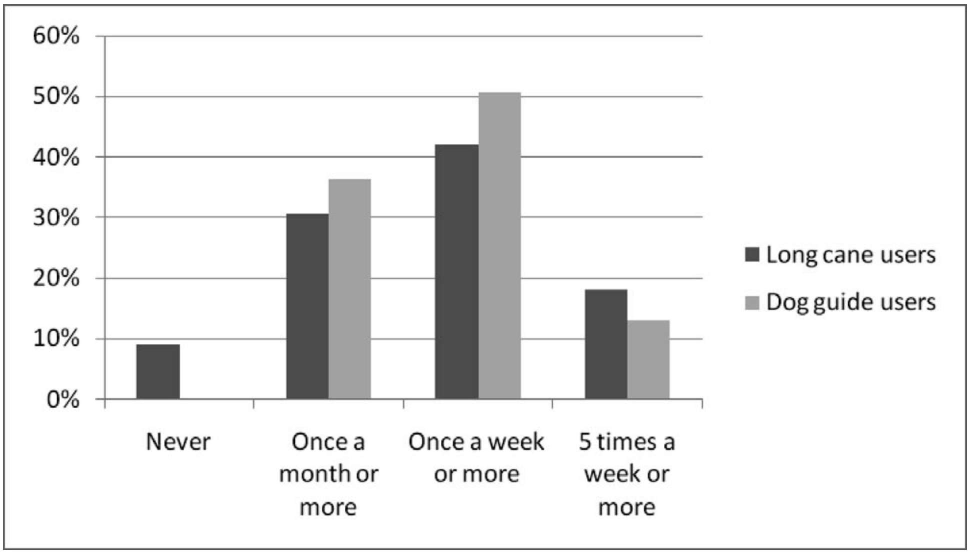

Fig. 6. *Distribution of frequencies of travel of outside of familiar routes for long cane users and for dog guide users.*

you became reluctant to walk in unfamiliar places or you changed your walking strategy. [Yes (please elaborate); No]

***Q15**. Was your confidence as an independent traveler ever affected by a head-level accident? [Yes (please elaborate); No]*

Three hundred participants responded to Q11. Figure 7 shows the distribution of frequencies of head-level accidents as reported by the respondents.

Chi-square analysis of these data reveals the following:

- The distribution of frequencies of head-level accidents for respondents who are legally blind and respondents who are blind are not consistent (Pearson's chi-square $= 19.065$, $df = 3$, $p = .000$). Visual analysis of the two histograms, shown in Figure 8, reveals a larger variance of frequencies of head-level

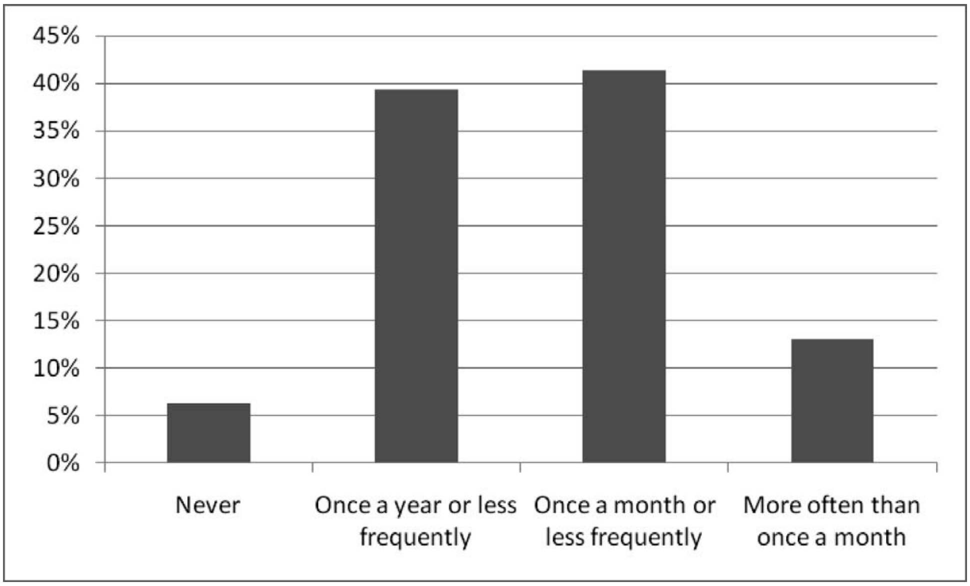

Fig. 7. *Distribution of frequencies of head-level accidents.*

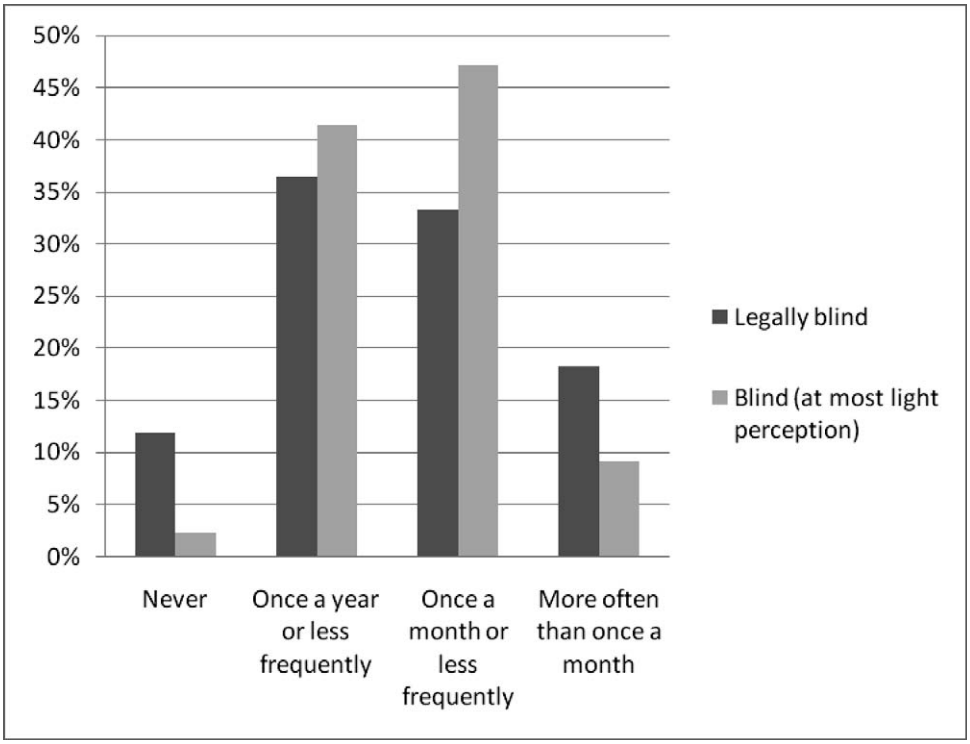

Fig. 8. *Distribution of frequencies of head-level accidents for respondents who are blind and for respondents who are legally blind.*

accidents for the legally blind population than for the blind population. Note that, among the respondents who are blind, only 2 percent never experienced head-level accidents versus 12 percent of the legally blind population. Note also that respondents who are legally blind were twice as likely to experience frequent head-level accidents (more than once a month) than respondents who are blind (with a proportion of 18 percent and 9 percent, respectively)

- The distribution of frequencies of head-level accidents for dog guide users and cane users are consistent (Pearson's chi-square $=$ 2.792, $df = 3$, $p = .425$). This suggests that the type of mobility aid has little influence on this type of accidents

The frequency of head-level accidents is not significantly correlated to the frequency of travel outside one's residence (Spearman's rho $= 0.045$, $p = .563$) or outside of familiar routes (Spearman's rho $= 0.048$, $p = .538$).

Analysis of the qualitative data provided by the respondents sheds light on the different environments in which accidents are likely to occur. An overwhelming 86 percent of the head-level accidents happened outdoors, with 8 percent of the respondents reporting accidents both indoors and outdoors, and 6 percent only indoors. Outdoor accidents were due to tree branches (the majority), poles and signs, construction equipment, and trucks. Indoor accidents were typically due to doors and cabinets left ajar, shelf and tables, staircases (hit from the side), and walls.

Twenty-three percent of head-level accidents carried some medical consequences, of which 60 percent required assistance by medical professionals and 60 percent required home rest. The most common treatment for those needing medical attention was the application of stitches or staples (in one case, there was the need for plastic surgery) and dental treatment for broken teeth. Twelve percent of head-level accidents resulted in time lost, which includes missed appointments or the need to take time off work. (It should be noted that some of the respondents did not count visits to the emergency room or to the doctor's office as time lost, and therefore their answers only referred to time

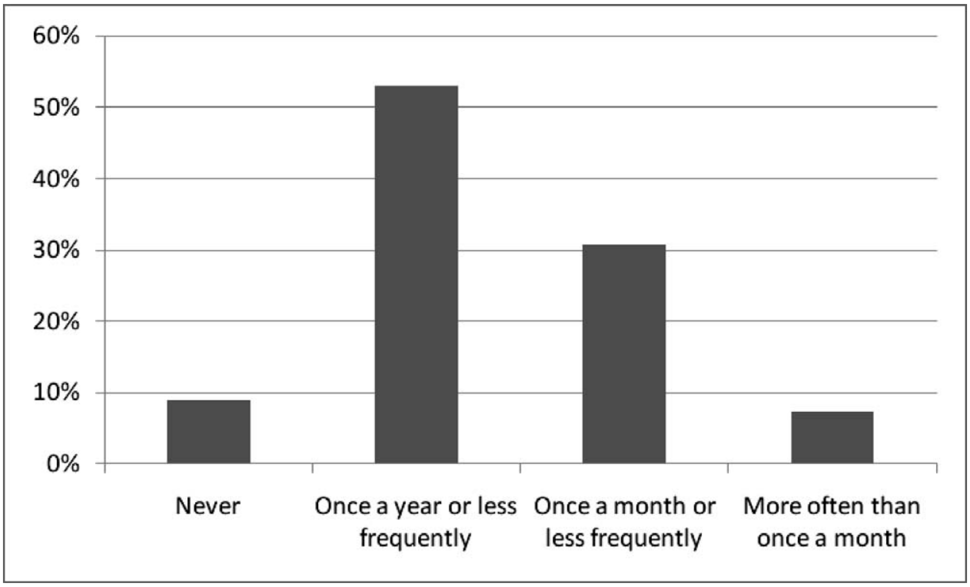

Fig. 9. *Distribution of frequencies of tripping resulting in a fall.*

off work or missed appointments.) Forty-three percent of these accidents resulted in the respondents changing their walking habits after experiencing an accident, with most respondents stating that they walked more slowly and raised their arms whenever possible to protect their head against unexpected obstacles. In 26 percent of the times, a head-level accident affected the respondent's confidence as an independent traveler, with some avoiding certain areas and others opting for a sighted companion for their travels.

Trip/Fall Accidents

Q16. *How often have you tripped resulting in a fall due to your vision loss? [Never; Once a year or less frequently; Once a month or more frequently; More often than once a month]*
Q16.1 *Please describe any accidents resulting in a fall you have experienced. For example, in which circumstances it occurred and what did you trip on.*
Q17. *Have the falls you experienced resulted in medical consequences? e.g., hospitalization, visit to the emergency room or to the doctor, home rest. [Yes (please elaborate); No]*
Q18. *Have the falls you experienced resulted in time lost (from work, school, appointments,…)? [Yes (please elaborate); No]*
Q19. *Have you ever changed your walking habits as a consequence of a fall? e.g., you became reluctant to walk in unfamiliar places or you changed your walking strategy. [Yes (please elaborate); No]*
Q20. *Was your confidence as an independent traveler ever affected by a fall? [Yes (please elaborate); No]*

Two hundred eighty-nine participants responded to Q16. The results are summarized in Figure 9. Among the respondents who are blind, only 8 percent never experienced this type of accidents. This number grows only slightly (10 percent) for the legally blind population surveyed.

Similarly to the case of head-level accidents, respondents who are legally blind were twice as likely to experience frequent fall accidents (more than once a month) than respondents who are blind (with proportions of 10 percent and 5 percent, respectively). Chi-square analysis reveals that the distribution of frequencies of this type of accidents are consistent between respondents who are blind and respondents who are legally blind (Pearson's chi-square $= 5.392$, $df = 3$, $p = .145$) and between long cane and dog guide users (Pearson's chi-square $= 1.494$, $df = 3$, $p = .684$). The frequency of fall accidents is not significantly correlated to the frequency of travel outside one's residence (Spearman's rho $= 0.053$, p

= .505) or outside of familiar routes (Spearman's rho = −0.062, p = .431).

Qualitative answers suggest that the main causes of falls were (a) lack of attention to the surroundings or to warnings from the dog guide, (b) unexpected obstacles where there were no obstacles before, and (c) misjudgment of distances or angles. The descriptions provided by the respondents were mostly in terms of activities (that led to a fall), whereas in the answers related to head-level accidents, descriptions were mostly in terms of objects (representing obstacles).

Thirty-six percent of the respondents stated that accidents resulting in falls had medical consequences. Sixty-three percent of these required assistance by medical professionals, and 14 percent required home rest. A wide variety of treatments were reported by those who needed medical attention, ranging from stitches to orthopedic surgery to rehabilitation. In 22 percent of the cases reported, an accident of this type resulted in time lost. Fifty-one percent of the respondents said that they changed their walking habits as a consequence of one such accident, and 30 percent reported loss in confidence as independent travelers.

Statistical analysis shows that the frequency of head-level accidents and of trips resulting in a fall are correlated (Spearman's rho = 0.221, p = .006). This suggests that persons who bump into things more often are also those who are more at risk of falls. This result is consistent with the findings of Arfken et al. (1994) who reported that bumping into objects predicts falls and recurrent falls.

Conclusions

This survey interview has highlighted some of the risks and issues related to independent mobility. Referring to the research questions stated previously, analysis of the respondents' data provides a number of interesting insights:

- Head-level and fall accidents represent a nonnegligible risk associated with walking without sight. Thirteen percent of the respondents experienced head-level accidents at least once a month; 7 percent experienced falls while walking at least once a month. These accidents often required medical attention. A substantial portion of respondents stated that this type of accidents changed their walking habits and reduced their confidence as independent travelers
- The type of mobility aid used does not have a significant effect on the frequency of accidents. Use of a dog guide does not seem to provide better protection against head-level or fall accidents than proper use of a long cane
- Individuals who travel more frequently outdoors do not seem to be at higher risk of head-level or fall accidents than those who leave their house less frequently

These results should be interpreted with consideration to the population interviewed, which was skewed toward younger age groups, expert travelers (with several years of experience using mobility aids), and dog guide users (representing 38 percent of the respondents).

References

Arfken, C., Lach, H., McGee, S., Birge, S., & Philip Miller, J. (1994). Visual acuity, visual disabilities and falling in the elderly. *Journal of Aging & Health*, *6*(1), 38.

Demographics Updates. (1994). Use of "white" ("long") canes. *Journal of Visual Impairment & Blindness*, *88*(1), 4.

Demographics Updates. (1995). Demographics update: Alternate estimate of the number of guide dog users. *Journal of Visual Impairment & Blindness*, *89*(2), 4–6.

Evans, J., & Mathur, A. (2005). The value of online surveys. *Internet Research*, *15*(2), 195–219.

Felson, D.T., Anderson, J.J., Hannan, M.T., Milton, R.C., Wilson, P.W., & Kiel, D.P. (1989). Impaired vision and hip fracture. *Journal of the American Geriatric Society*, *37*, 495–500.

Glynn, R.J., Seddon, J.M., Krug, J.H., Jr., Sahagian, C.R., Chiavelli, M.E., & Campion, E.W. (1992). Falls in elderly patients with glaucoma. *Archives of Ophthalmology*, *109*(2), 205–210.

Ivers, R.Q., Cumming, R.G., Mitchell. P., & Attebo, K. (1998). Visual impairment and falls in older adults: The Blue Mountains Eye Study. *Journal of the American Geriatric Society*, *46*(1), 58–64.

Legood, R., Scuffham, P., & Cryer, C. (2002). Are we blind to injuries in the visually impaired? A review of the literature. *Injury Prevention*, *8*, 155–160.

Leonard, R. (1999). *Statistics on vision impairment: A resource manual*. Lighthouse International, February 1999. Retrieved from http://www.gesta.org/estudos/statistics0402.pdf

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:26 10 Cust # AERJOURNAL-D-10-00048R1

Lord, S. (2006). Visual risk factors for falls in older people. *Age & Ageing*, *35*, 42–45.

Pleis J.R., & Lucas J.W. (2009). Provisional report: Summary health statistics for U.S. adults: National Health Interview Survey, 2008. *National Center for Health Statistics. Vital Health Statistics*, *10*(242).

Roberts, I., & Roberts, A. (1995). Sensory deficit and the risk of pedestrian injury. *Injury Prevention*, *1*, 12–14.

Tobis, J.S., Block, M., Steinhaus-Donham, C., Reinsch, S., Tamaru, K., & Weil, D. (1990). Falling among the sensorially impaired elderly. *Archives of Physical Medicine and Rehabilitation*, *71*(2), 144–147. 3

Insight: Research and Practice in Visual Impairment and Blindness aerj-04-02-01.3d 25/2/11 14:46:26 11 Cust # AERJOURNAL-D-10-00048R1