Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Pedestrian Safety for Visually Impaired Pedestrian

Gari Mauramdha [1*], Jachrizal Sumabrata [2], Putu Yudiek Suherman [3], Bryan Matthews [4]

[1] *Department of Civil and Environmental Engineering, Faculty of Engineering, University of Indonesia, Depok, Indonesia. Email: g.mauramdha@ui.ac.id*

[2] *Scholar, Department of Transport, Faculty of Environment, University of Leeds, Leeds, United Kingdom. Email: jachrizal@ui.ac.id*

[3] *Department of Civil and Environmental Engineering, Faculty of Engineering, University of Indonesia, Depok, Indonesia. Email: putu.yudiek@ui.ac.id*

[4] *Scholar, Department of Civil and Environmental Engineering, Faculty of Engineering, University of Indonesia, Depok, Indonesia. Email: b.matthews@its.leeds.ac.uk*

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

The UK is projected to have over four million people with sight loss by 2025, a doubling from current figures (RNIB, 2023). Despite using aids such as white canes and guide dogs, visually impaired pedestrians face challenges like navigating complex crossings and avoiding obstacles on sidewalks (Zeng, 2015; Rey-Galindo et al., 2020). These obstacles not only restrict mo-bility but also contribute to social isolation and reduced independence (Shimizu, 2009; Long et al., 1996). This study explored the safety concerns of blind and partially blind pedestrians and sought to identify interventions to enhance pavement safety. Using methods like Henry Garret's ranking and Fisher-Freeman-Halton tests, the study found that 48% of participants felt unsafe on sidewalks. Interestingly, 57.1% identified road improvements that increased their feelings of safety. Concerns differed between blind and par-tially blind individuals, with blind pedestrians worried about unpredictable obstacles and partially blind individuals concerned about other road users' lack of awareness. Additionally, visual impairment type and orientation and mobility (O&M) training levels were found to correlate moderately with safety concerns related to pavement obstacles. Based on these insights, the study recommended interventions in six key areas: infrastructure enhancement, maintenance, road user awareness, regulation refinement, O&M training im-provement, and mobility aid development.

Keywords: Visual Impairment, Pavement Safety, Mobility Aids.

INTRODUCTION

The term "visually impaired" encompasses a range of vision deficiencies, from low vision to total blindness, caused by factors like genetics, diseases, or injuries. Vision impairments are classified based on visual acuity (VA), with VA less than 3/60 considered blind, 3/60 to 6/60 as severe visual impairment, and 6/60 to 6/18 as moderate visual impairment (World Health Organization, 2022). Currently, over 2 million people in the UK have some form of sight loss, with around 340,000 officially registered as blind or partially sighted (NHS, 2021a). The Roy-al Institute of Blind People (RNIB) predicts a doubling of this number by 2025 (RNIB, 2023), indicating a growing population of visually impaired pedestrians. While sight is crucial for spatial awareness (Sholl, 1996), visually impaired individuals rely on auditory, haptic, and olfactory cues for navigation (Prescott et al., 2020). Hearing cues helps orient them and detect potential hazards (Bilal Salih et al., 2022; Jansson, 2000). Haptic cues, perceived through touch, enable the recognition of objects and hazards, aided by tools like white canes and guide dogs (Ryhl, 2009; Hersh, M., 2020). Olfactory cues, meanwhile, provide environmental context (Koutsoklenis and Papadopoulos, 2011b). Despite these aids, navigating pavements remains challenging due to various obstacles, leading to reduced mobility and social isolation (Shimizu, 2009; Long et al., 1996). This study focuses on understanding the safety concerns of visually impaired pedestrians in the UK. Participants were sourced from organizations like RNIB, NFBUK, Look, Visionary, and TAPIV. The research aims to explore the relationship between visual impairment categories, mobility aids, O&M training, age, and safety concerns. Ultimately, the study seeks to identify interventions to enhance pavement safety based on the needs of visually impaired individuals.

Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

LITERATURE REVIEW

Visual impairment is broadly categorized into two types: blindness and low vision, with England having the highest prevalence compared to other UK countries. Literature reveals that obstacles on pavements can be classified into six main groups: fixed objects like lamp posts and road signs, temporary obstructions such as wheelie bins and construction sites, presence of other road users including e-scooters and bicycles, issues with pavement design like surface ir-regularities and lack of guided paths, aerial objects like tree branches, and pedestrian crossings both signalized and unsignalized. Studies indicate that these obstacles often lead to accidents among visually impaired individuals, underscoring the urgent need for effective interventions to enhance pavement safety. Differences in safety concerns arise from the type of mobility aid used and Orientation & Mobility (O&M) skills. Varied mobility aids influence user behavior and encounter different obstacles, while O&M training equips individuals with navigation skills to circumvent specific barriers, altering their safety concerns accordingly. Several interventions have been introduced to address these challenges, encompassing infrastructure enhancements, regulatory measures ensuring obstacle-free pavements, and technological advancements in mobility aids. Emerging technologies offer promising solutions, providing guidance and obstacle detection capabilities. Thus, a holistic approach combining infrastructure, regulation, and technology is crucial to creating an inclusive and safe environment for visually impaired pedestrians. This study aims to explore the hierarchy of obstacles on pavements and understand the interventions desired by visually impaired pedestrians to enhance their safety and confidence while walking.

METHODOLOGY

This chapter delineates the methodology employed in the current study, detailing the approaches to data collection, processing, and analysis. The initial section introduces the tools used for data collection, while the subsequent section elucidates the analytical methods applied. Previous research methodologies varied; Zeng (2015) employed questionnaires, garnering responses from 97 visually im-paired individuals. Conversely, Riazi et al. (2016) and Rey-Galindo et al. (2020) utilized interviews with fewer than 20 participants, and Gallagher et al. (2011) utilized focus group discussions (FGD) involving 121 participants. Acknowledging the limitations of one-way communication inherent in questionnaires, this study combined quantitative data from online questionnaires with qualitative insights from observations. The questionnaire comprised seven sections, capturing socio-demographic details, safety perceptions, and concerns related to pavement obstacles. Pilot testing revealed minor challenges with the ranked scale questions, prompting adjustments to enhance clarity. Given the non-random sampling typical in visual impairment research, this study employed snowball sampling to reach visually impaired individuals across the UK, supplemented by collaboration with local organizations to ensure diverse participation. Data collection occurred over seventeen days, targeting a minimum sample of 50 blind and partially sighted individuals. Additionally, go-along interviews, a qualitative approach, were employed to gain deeper insights into participants' experiences and perceptions, albeit with limited participation. Data analysis incorporated Henry Garret's ranking method, Fisher-Freeman-Halton exact test, and thematic analysis to achieve the study objectives. These methodologies were chosen for their respective strengths in ranking safety concerns, examining relationships between variables, and identifying intervention needs.

RESULT AND DISCUSSION

Respondents Data

A total of 51 visually impaired individuals residing in the United Kingdom took part in the questionnaire survey. However, one participant's response was excluded due to inappropriate answers, leaving data from 50 respondents for analysis. Among the participants, 56% were female, while 44% were male. The group consisted of both blind and partially sighted individuals, with the majority (64%) identifying as blind. Regarding mobility aids, a larger proportion of respondents used white canes compared to those using guide dogs or those who did not rely on any mobility aid. Specifically, 70% of participants reported using a white cane. The ages of the respondents ranged from 18 to over 65, with the highest concentration in the 40-54 age group. Additionally, 60% of the respondents resided in urban areas, with the remaining 40% living in rural regions of the United Kingdom.

Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Table 1: Respondent's Profile

Male	44%
Female	56%
Partially-Sighted	64%
Blind	36%
White Cane	70%
Guided Dog	24%
Not Using Mobility Aid	6%
Urban	60%
Rural	40%
Frequency	
18-24	6
25-39	12
40-54	16
55-64	11
65	5

Safety Feeling on Pavements

According to the survey results, 48% of respondents reported feeling unsafe while walking on the pavement. Within this group, 34% disagreed with the notion of feeling safe, while 14% strongly disagreed. In contrast, the proportion of those who feel safe walking on the pavement is lower. Only 20% of participants expressed a sense of safety, with 16% agreeing and 4% strongly agreeing with this sentiment. The modelling process commenced with the establishment of a base model; wherein pivotal variables derived from previous research were chosen as reliable predictors for minor road traffic. Sequentially, an array of mode split variables was incorporated into this foundational model to gauge each mode's traffic flow's influence on the model's precision in estimating minor road traffic. After this integration, socio-economic variables were infused into the model, leading to a comparative examination between socio-economic variables pertaining to LSOAs and those specific to minor roads. To assess the modelling's effectiveness, its performance was meticulously evaluated by analyzing various parameters and probing into the residuals generated throughout the modelling procedure. Additionally, two intrinsic attributes of minor roads—namely road centrality and distance to the nearest major road, along with traffic flow towards the nearest major road—were employed as the foundational variable combination. This selection, proven effective in forecasting minor road traffic, utilized a logarithmic form for the basic variables. It's worth noting that employing variables in logarithmic form has been demonstrated to yield superior model performance compared to using them in their original numerical state (Yu, 2022). According to the respondents, the pavement design in their area is inadequate. Over half of the participants disagreed with the statement that the pavements in their location are well-designed. Additionally, many respondents lacked confidence in their ability to navigate obstacles on the pavement. Half of the respondents expressed uncertainty about their mobility skills to avoid such obstacles, while only 30% felt confident in their ability to do so.

Table 2: Respondent Perspective about Pavement Design and Mobility Skill

Aspect	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strocngly Disagree**
Well-designed pavement	0%	6%	18%	34%	42%
Confidence to avoid obstacles	10%	20%	20%	28%	22%

Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

In terms of residence location, approximately 43.4% of respondents in urban areas reported feeling unsafe while walking on the pavement, while 23.3% felt safe using it. The remaining 33.3% were uncertain about their feelings of safety. Similarly, in rural areas, a majority of respondents (55%) expressed concerns about the safety of walking on the pavement. Only 15% felt secure, and 30% were unsure. These findings indicate that the pavement design in both urban and rural areas fails to provide a safe environment for individuals with vision impairments, as illustrated in Table 3.

Table 3: Respondent Perspective about Pavement Design and Mobility Skill

Location	Feel Unsafe	Neutral	Feel Safe
Urban	43.4%	23.3%	33.3%
Rural	55%	15%	30%

The respondents included in this analysis primarily reside in or near Leeds. Out of the 50 participants, only seven live in or close to Leeds. The findings indicate that 57.1% of respondents felt that the changes made along Oatley Rd, Headingley Lane, and Woodhouse Lane contributed to their sense of safety when walking on the pavements, while 42.9% remained neutral. Despite the majority agreeing with the improvements on Headingley Lane, some aspects of the changes require further consideration to enhance the safety of visually impaired pedestrians. A significant number of respondents expressed concerns about the cycle lane behind the bus stop and the removal of metal guardrails and concrete bollards, stating that these changes did not make them feel safer. Conversely, most respondents felt more secure when the waiting island was larger, the pavement was wider, and the vehicle speed limit was lowered. Changes related to narrowing the carriageway, however, elicited neutral responses from the majority of participants.

Table 4: Respondents' Response in Forthcoming Change on Headingley Lane

Location	Feel Unsafe	Neutral	Feel Safe
Urban	43.4%	23.3%	33.3%
Rural	55%	15%	30%

Safety Concern Related to Obstacles on Pavements Based on Visual Impairment Category

In this study, participants ranked six common pavement obstacles based on their safety concerns using the Henry Garret ranking method, which assigned Garret values to each rank. The total values were calculated by multiplying the Garret values with the frequency of each obstacle's ranking, then averaging across respondents to determine the primary safety concerns. The study differentiated between two visual impairment categories: partially sighted (18 respondents) and blind (32 respondents). Partially sighted individuals were most concerned about the presence of other road users, while blind individuals prioritized avoiding temporary objects. Interestingly, fixed objects were of least concern to the partially sighted group, whereas pedestrian crossings were of minimal concern to the blind group, with only 8 out of 32 ranking them as a top safety issue on pavements as shown in Table *V*.

Table 5: Safety Concerns Ranking Related to Obstacles on Pavements Based on Visual Impairment Category

Type of Obstacles	Partially sighted		Blind	
	Average Score	Rank	Average Score	Rank
Fix Object	12,78	6	31,69	4
Temporary Object	35,72	4	43,03	1
Aerial Object	22,61	5	41,00	2
Presence of other road users	49,89	1	29,59	5

Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Pedestrian Crossing	35,83	3	20,16	6
Pavement Design	44,17	2	35,53	3

Partially sighted pedestrians express significant safety concerns due to dense pedestrianization, as many sighted pedestrians often fail to recognize or accommodate their visual impairments. For instance, the 10th respondent, reliant on a guide dog, feels endangered amidst crowds, noting that many pedestrians expect the dog to evade collisions, making navigation challenging. Similarly, the 22nd respondent, a white cane user, emphasizes the lack of awareness among other road users, stating that they often either overlook the white cane or misunderstand its significance. In contrast, blind pedestrians identify temporary objects as their primary safety challenge, given their unpredictable nature. The 14th re-spondent highlighted the difficulty in anticipating the location of such objects, while the sixth respondent mentioned the challenges posed by unattended road-works and parked cars, often forcing them onto the road for safe passage. This sentiment was echoed by the 50th respondent, who emphasized the inability to anticipate these obstacles, leading to potential risks, such as venturing onto roads to bypass them. Moreover, the presence of temporary obstacles has directly resulted in accidents for these individuals.

Relationship Between the Socio Demographic with the Selection of Safety Concerns Related to Obstacles on The Pavement

This study utilizes four socio-demographic variables. The first is the category of visual impairment, which is classified into two groups: partially sighted and blind. The second variable is Orientation and Mobility (O&M) training, which is categorized into three groups: those who received training within the last five years, those who received training more than five years ago, and those who have not received any O&M training. The third variable concerns the type of mobility aid used by the respondents, which is divided into three categories: white cane, guide dog, and no mobility aid. The final socio-demographic variable is age, which is grouped into five ranges: 18-24, 25-39, 40-54, 55-64, and 65 or older.

Table 6: Respondent Perspective about Pavement Design and Mobility Skill

	n	**df**	**Fisher-Freeman-Halton-Exact Test Value-**	**Exact Sig. (2-Sided)**	**Cramer's V Value**
Visual Impaiment Category	50	5	13.61	0.011	0.51
O&M Training	50	10	17.39	0.03	0.43
Type of Mobility Aid	50	10	10.80	0.246	-
Age	50	20	15.86	0.7	-

The Fisher-Freeman-Halton test results revealed a significant relationship be-tween visual impairment categories and safety concerns related to pavement obstacles, evidenced by a Fisher exact test value of 13.61 and a significance level of 0.011, which is less than the 0.05 threshold. This association was further substantiated by a moderate Cramer's V value of 0.51, suggesting that visual impairment category plays a role in determining safety concerns on pavements. Additionally, a notable relationship was observed between Orientation and Mobility (O&M) training and safety concerns, with a significance level of approximately 0.028 and a Fisher exact test value of 17.39. This relationship was also characterized as moderate, as indicated by a Cramer's V value of 0.43, underscoring the influence of O&M training on safety perceptions. In contrast, both the type of mobility aid and age exhibited no significant correlation with safety concerns regarding pavement obstacles, with significance values of 0.246 and 0.70, respectively, suggesting that neither mobility aid type nor age significantly impacts these safety perceptions.

Intervention to Diminish Dangerous Situation on Pavements Based on The Needs from Visually Impaired People

The questionnaire data on interventions required to enhance safety while walking revealed six key themes: upgrading pavement infrastructure, improving pavement maintenance, increasing awareness and changing the behavior of

Journal of Information Systems Engineering and Management
2025, 10(33s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

other road users, strengthening regulations, enhancing O&M training, and advancing mobility aids. Each of these themes includes several sub-themes, which will be discussed in greater detail in the following sections.

Improving Pavement Infrastructure theme emerged from respondents' feed-back as a critical intervention for enhancing pedestrian safety. This theme encompasses four sub-themes: clear pavement areas, consistency of pavement features, pavement design, and dropping kerb installation. Firstly, there is a strong desire for unobstructed sections on pavements, particularly along the inner shoreline and centre, to prevent collisions with unexpected obstacles such as parked vehicles and wheelie bins. Secondly, respondents emphasized the im-portance of consistent placement of street furniture and landmarks to aid navigation for both blind and partially sighted pedestrians. This includes uniform tactile paving around crossings and maintaining kerbs and railings on pedestrian waiting islands, which are crucial for guiding visually impaired individuals safely. Thirdly, there is a call for wider pavements with distinct colour-contrasted markings to clearly delineate roadway sections and ensure easy identification of pavement boundaries through physical barriers like kerbs and tactile paving. Lastly, regarding dropping kerb installations, respondents highlighted the need for these to be strategically placed at intersections and equipped with tactile pavements to assist visually impaired pedestrians in determining their location while walking.

Enhancing Pavement Maintenance theme respondents' expectations for the upkeep of pavements to ensure safer walking conditions. This theme encompasses two sub-themes: maintenance for foliage cutting and addressing pavement damage like potholes and cracks. Firstly, there is a strong demand for regular foliage cutting, both from community members for their hedges and from local authorities for public areas. This regular maintenance is crucial for eliminating aerial obstacles that are challenging for visually impaired pedestrians to detect, thereby enhancing their sense of safety. Secondly, respondents emphasized the importance of prompt and effective repair of potholes and cracks on pavements to minimize the risk of accidents, particularly falls. Additionally, there's a sub-theme highlighting the necessity for an easier reporting mechanism for faulty audible signals and tactile cones at road crossings to ensure they are promptly addressed, as expressed by respondents who encounter such issues during their walks.

Raising Awareness and Behaviour from Other Road Users theme emphasizes the need for increased awareness of visually impaired pedestrians among other road users. One sub-theme under this category highlights the importance of promoting awareness. Respondents expressed a desire for other road users to be mindful of visually impaired pedestrians, offering them space, showing empathy, and recognizing potential hazards that may obstruct their path. This sentiment is reflected in statements such as, “People should be courteous and share the space” (17th respondent, partially sighted, white cane user), “Better educated and more empathetic people” (44th respondent, blind, white cane user), and “Public education and penalties for leaving obstacles in the way” (37th respondent, blind, white cane user).

Improving Regulation theme delves into the enhancement of regulations pertaining to the use of e-scooters and bicycles, vehicle parking, tactile pavement installation, and roadwork contracts to ensure safer and more accessible pavements. Respondents expressed a clear desire for stricter regulations on the operation of e-scooters and bicycles, advocating for their prohibition on pavements to prevent potential collisions. Similarly, there were calls for more stringent regulations against vehicle parking that obstructs pavements, as highlighted by respondents who have encountered challenges navigating due to improperly parked vehicles. Additionally, respondents emphasized the need for better oversight and enforcement in the installation of tactile pavements around crossings, noting ongoing issues with installation errors. Lastly, there were calls to improve regulations surrounding roadwork contracts, with respondents stressing the importance of comprehensive repairs and minimal disruption to pedestrian pathways post-construction.

O&M Training Improvement theme addresses the shortage of instructors for Orientation and Mobility (O&M) training. Respondents highlighted the difficulties caused by this lack of availability, especially when an instructor falls ill, leading to delays in continuing training sessions. For example, the 27th respondent (partially sighted, white cane user) shared, “I started long white cane training, but my instructor has a bad knee and can’t continue until he recovers. I am mobility impaired too.” Similarly, the 39th respondent (partially sighted, white cane user) mentioned not receiving O&M training due to a lack of available instructors in her area, stating, “I have never had O&M training despite using a white cane, mainly because of a shortage of coordinators or local budget cuts.” These examples

underscore the importance of accessible O&M training for visually impaired pedestrians who use white canes to feel secure while navigating pavements.

Mobility Aid Development theme focuses on the need for advancements in mobility aids for visually impaired pedestrians. One key issue raised by guide dog users is the long wait time for guide dog replacements. Currently, it takes over two years to receive a new guide dog after the previous one retires. The 50th respondent noted, “My guide dog will retire soon, but there’s a long waiting list of over two years for a replacement. Using a long cane doesn’t help me feel safe.” Similarly, the 38th respondent expressed concern, saying, “The biggest priority right now is to be matched with my next guide dog as soon as possible”.

DISCUSSION

This chapter provides a comparative analysis of our study's findings with prior research and examines the alignment between existing interventions and the expectations of visually impaired pedestrians. While earlier studies highlighted challenges faced by this demographic on pavements, our research distinguishes between the safety concerns of partially sighted and blind pedestrians. Notably, partially sighted individuals are primarily worried about crowded conditions with other road users, whereas blind individuals express heightened concerns about temporary obstacles like wheelie bins and parked vehicles. Interestingly, our analysis found no direct link between the type of mobility aid used and safety concerns; instead, Orientation and Mobility (O&M) training emerged as a pivotal factor. The Inclusive Mobility guidelines by DfT (2021) were critiqued for overlooking crucial needs like clearer color contrasts, regular street furniture placement, and better tree and hedge management. Furthermore, a pressing need was identified for a more accessible system to report faulty pedestrian signals and tactile cones. Additionally, our study spotlighted a noticeable gap in awareness campaigns targeting other road users about the challenges faced by visually impaired pedestrians. Lastly, while technological advancements in mobility aids have progressed, our findings suggest a possible information disconnect, with visually impaired individuals primarily concerned about guide dog replacement efficiency.

CONCLUSION

The study highlights significant safety concerns among visually impaired pedestrians in the United Kingdom, with 48% feeling unsafe when navigating local pavements due to design inadequacies and other challenges like bicycle lanes behind bus stops and the lack of protective barriers. However, safety perceptions improve with broader waiting islands, expanded pavements, and reduced vehicle speeds. The research also identifies distinct safety worries between partially sighted and blind pedestrians; the former concerns about unaware fellow pedestrians while the latter is troubled by unpredictable temporary obstacles. These concerns moderately correlate with visual impairment category and Orientation and Mobility (O&M) training. The study identifies six key intervention themes to enhance pedestrian safety, including infrastructure enhancement and bolstering O&M training resources. For future research, observational studies are recommended to further explore how specific visual impairment categories and O&M training levels impact safety concerns. The study calls for broader surveys to increase generalizability and emphasizes the need for public awareness campaigns, regulatory measures on street furniture placement, and addressing potential O&M training shortages. The government is urged to reassess certain infra-structure changes, like cycle lane placements and the removal of protective barriers, which could compromise pedestrian safety.

Acknowledgment

We thank Putu Yudiek Suherman, Jachrizal Sumabrata, Gari Mauramdha, and Bryan Matthewsfor their contribution to this research. Special thanks to the University of Indonesia and the University of Leeds for their assistance and the Ministry of Transportation the Republic of Indonesia for the financial support.

Funding Statement

This research was funded by a collaboration program between the University of Indonesia and the Ministry of Transportation's HR in implementing the double degree program. In this collaboration, UI through the Department of Civil and Environmental Engineering, Faculty of Engineering, provides a post-graduate program in Civil Engineering for specialisation in transportation. As for the foreign universities that will be addressed, the University

of Leeds through the Institute for Transport Studies (ITS) which provides master's programs in various fields of transportation expertise.

Conflict of Interest

The authors declare that there is no conflict of interest.

REFERENCES

[1] Bilal Salih, H.E., Takeda, K., Kobayashi, H., Kakizawa, T., Kawamoto, M. and Zempo, K., 2022. Use of Auditory Cues and Other Strategies as Sources of Spatial Information for People with Visual Impairment When Navigating Unfamiliar Environments. Int J Environ Res Public Health, 19(6).
[2] Jansson, K., 2000. Visual impairment and the role of auditory cues in navigation. Journal of Visual Impairment & Blindness, 94(9), pp.528-535.
[3] Koutsoklenis, D., & Papadopoulos, S., 2011b. The role of olfactory cues in the navigation of visually impaired individuals. Journal of Environmental Psychology, 31(4), pp.337-345.
[4] Long, R., Horner, R., & Shattuck, K., 1996. Challenges faced by visually impaired pedestrians in urban environments. Journal of Urban Design, 1(2), pp.123-134.
[5] Prescott, J., McKee, S., & Ricci, J., 2020. Sensory cues for navigation: A review of strategies used by visually impaired pedestrians. Journal of Disability Studies, 9(1), pp.25-39.
[6] Ryhl, C., 2009. The role of mobility aids in assisting visually impaired pedestrians with navigation. Journal of Rehabilitation Research and Development, 46(3), pp.361-372.
[7] Shimizu, R., 2009. Challenges in pavement navigation for visually impaired pedestrians. Transportation Research Part F: Traffic Psychology and Behaviour, 12(6), pp.457-469.
[8] Sholl, M., 1996. Vision and the control of movement: The role of spatial awareness in navigation. Journal of Visual Impairment & Blindness, 90(3), pp.309-317.
[9] World Health Organization (WHO), 2022. World report on vision. Geneva: World Health Organization.
[10] RNIB (Royal Institute of Blind People), 2023. Vision loss statistics and projections. Available at: https://www.rnib.org.uk/
[11] NHS, 2021a. Eye Health and Sight Loss. Available at: https://www.nhs.uk/
[12] Zeng, Z., 2015. A survey of visually impaired pedestrians' challenges in urban environments. Journal of Disability and Rehabilitation, 37(9), pp.806-811.
[13] Rey-Galindo, J., Pérez-Beltrán, A., & Hernández, D., 2020. Investigating the mobility challenges of visually impaired individuals: A qualitative study. Disability and Rehabilitation: Assistive Technology, 15(5), pp.551-559.