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## Article

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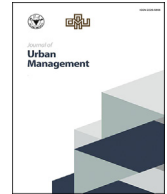
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## Research Article

# A methodology for the identification of significant factors for the improvement of pedestrian facilities in an urban area

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## ABSTRACT

In many developing countries, comprehensive and structured planning strategies for pedestrians compared to users of other modes are grossly absent. This poses a challenge for planning agencies and local government authorities in the proper utilization of the fund. The purpose of this paper is to develop a comprehensive list of factors that would help in the decision-making process for the improvement of pedestrian facilities in urban areas. A preliminary list of 57 factors that influence the improvement of pedestrian facilities in the urban area was discovered through a literature survey and expert intervention. The compilation was done based on the frequency of citations in previous studies. The factors were then grouped into five major categories that characterize the pedestrian facilities such as (1) Infrastructure; (2) Location (3) Ambience/Liveability, (4) Safety and Security, and (5) Mobility. A Delphi survey was conducted among 24 selected experts. After 4 rounds of the survey, 33 factors were identified as significant for the improvement of pedestrian facilities in an urban area. The study also identified some significant factors that failed to get attention in the past. The consolidated list would serve as a guide for planners, authorities, and government officials to adopt significant factors according to their requirements, and can be used as a reference for other developing countries.

## 1. Introduction

The concept of smart and sustainable cities is gaining momentum day by day. Sustainability is a relevant and widespread thought in many fields and is getting attention in the scientific communities of developing countries also. As the urbanization process continues worldwide, the idea of urban sustainability has progressively become a vital part of social development and has taken a central stage in the discussions of both science and policy development (Patra et al., 2018), (Soyinka et al., 2016). Since global warming and climate change are some of the widely discussed topics today, substantial consideration has to be given to the sustainable development of urban areas (Schwann, 2018), (Das & Das, 2019). The way forward for cities to better cope with the rising challenges of climate change and associated problems is to adopt the long-term approaches that focus on walkability and green transport (Shi, 2019), (Yang, 2013). The developed countries have already enforced countermeasures to face these challenges (Kawakubo et al., 2018). They have shifted their focus to promoting sustainable modes to cope with these challenges (Gonzalez-urango et al., 2020). Alternate modes of transportation have already emerged with maximum popularity (Cheshmehzangi & Thomas, 2016). They have identified the potential of walking mode in fighting the negative externalities of urban and vehicle growth (Southworth, 2005). Developing pedestrian-friendly areas has become an important goal for urban planners and designers in both academia and the professional world of developed nations (Jiao

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et al., 2017). Pedestrian oriented policies that address the requirements of distinct pedestrian groups, including young, old, differently-abled persons, pregnant women, etc. And their various travel purpose have come into reality (Moura et al., 2017). Pedestrian experiences and psychological wellbeing benefits of walking were also studied and addressed in the design process (Borniolia et al., 2019). But the case of developing countries is different (Girma et al., 2019).

Walking is one of the common modes of transportation (Weng et al., 2019), and it has a key role in urban areas across the world (Sangeeth & Lokre, 2019). Walking mode is not just simple; it is free, convenient, requires no equipment, and is encouraged as part of a healthy lifestyle and social interaction (Beiler et al., 2018). The walking mode is very common among the low-income commuters and low-mobility individuals (Siddiqui et al., 2013), whose trips are mostly carried out for their subsistence activities, specifically work or work-related purposes (Caspi et al., 2013). Studies have revealed that the average distance of more than 40 to 50 percent of the daily trips is less than 5 km in many of the Indian cities (Singh, 2005), and walking mode is the preferable mode of trips up to 1–2 km in length (Parida et al., 2014). As per the records, 22.6% of Indians prefer the walking mode of transportation for work commuting (Sabapathy et al., 2012). The walking mode has a superior role among the people living in cities (Zhang & Chang, 2014). Though this mode has much importance in society, it is often mistreated in the planning and research process (Marisamynathan & Lakshmi, 2018).

The governments in developing countries are also working towards the aim of sustainable and walkable cities (Bhattacharyya & Mitra, 2013). They have developed guidelines and declared various missions and schemes to improve infrastructure for pedestrians in the urban area (Venter et al., 2004). These missions have great vision and are forward-thinking in content, but the result achieved so far is not convincing (Nandi & Gamkhar, 2013). In the case of developing countries, the major issue is the availability of resources. The fund available for transport infrastructure development, specifically for the development of pedestrian infrastructure, is limited (Tiwari et al., 2016). Also, the local authorities and planning agencies do not possess a scientific method or tool for properly allocating the fund according to the priority it deserves (Kornas et al., 2017). Improvement schemes of pedestrian facilities in urban areas are often hindered by the absence of a proper tool for decision making, resulting in a lack of prioritizing the areas of intervention leading to the lapse of funds allocated for the purpose.

A scientific decision-making tool is needed for making decisions on the improvement of sidewalks (Chan et al., 2003). A scientific decision-making tool is one that addresses the significant factors from all categories such as Infrastructure, Safety, Security, Liveability, Mobility, Location, Socio-Demographic, Aesthetics, Traffic, and Built Environment together. The planning agencies in India do not possess a proper tool for the purpose (Marisamynathan & Lakshmi, 2018). In order to develop such a scientific decision-making tool, it is required to consolidate all the significant factors together. A growing number of studies tried to identify factors that affect pedestrian activities, facilities, satisfaction, and walkability in urban areas (Wang & Yang, 2019). Studies also attempted to develop a strategy for prioritizing pedestrian infrastructure investments (Pradeep & Nair, 2013), (Frackelton, 2013), (Sousa et al., 2017), (Gonzalez et al., 2020), but they suffer from certain limitations. Most of the studies have considered quantitative factors only and not qualitative factors (Shaaban, 2019), (Frackelton, 2013). Some studies included factors according to the availability of data, and some are incorporating the influencing factors identified from studies on the developed countries (Pradeep & Nair, 2013), (Nag et al., 2020), which may not be applicable or appropriate in the context of developing countries (Bivina & Parida, 2020), (Jahan et al., 2020). The study conducted in the context of developed countries (Beiler & Phillips, 2016) had included all the factors from all these categories and developed a strategy to prioritize the pedestrian corridors for improvement. In India, some official studies attempted from the government side are the development of guidelines for pedestrian facilities in 2012 by the Indian Road Congress (IRC) and recently the development of Indian Highway Capacity Manual (Indo-HCM). The study by Hewawasam (2017) attempted to develop a model with three basic parameters: pedestrian demand, connectivity, and evaluation of existing pedestrian facilities. Marisamynathan and Lakshmi (2018) had made some advancements by incorporating traffic-related factors. Sneha Lakhotia (2019) had studied about the improvements in pedestrian infrastructure around bus stops. A recent study came in the same area is by Bivina and Manoranjan Parida (2020). But they have considered infrastructure, safety, security, and comfort related factors only. The factors related to socio-demographic, location, etc., were not considered in any of these studies. The studies that do not address sociodemographic and location-specific factors together with other related factors cannot provide an inclusive vision of improving the pedestrian facilities (Marisamynathan & Lakshmi, 2018). It was therefore inferred that there exists a research gap in developing a methodology to identify significant factors belonging to different categories such as Infrastructure, Safety, Security, Liveability, Mobility, Location, Socio-Demographic, Aesthetics, Traffic, and Built Environment.

There have been many methods, such as focus group discussion, traditional survey, Delphi technique, etc., widely used in research fields for factor identification purposes (Kamaruzzaman et al., 2018). Delphi technique has been widely employed in many research fields, including education, budgetary forecasting, business management, planning, healthcare, etc. (Vernon, 2009). The urban planning and transportation studies have also explored the applicability of the Delphi technique (Morgan et al., 2014), (Shefer et al., 1982). Delphi has been used as a technique for factor identification purposes also in many studies (Hanafin, 2004). In this context, the Delphi technique was found to be the ideal strategy for achieving the study's objective for many reasons. Delphi technique is a widely recognized approach in the research field (Hatcher & Colton, 2007), usually employed to gain consensus on any research issues (Hanafin, 2004). The technique was introduced in the 1950s by Dalkey and Helmer, and has been updated by various researchers over the years. In the Delphi survey, the consensus is achieved by subjecting a group of specialists to a series of questionnaires in-depth with controlled opinion feedback (Danladi et al., 2018). Delphi is a rigorous approach that allows the contribution of experts from varied places and areas of proficiency (Dalrymple, 2004). Furthermore, the Delphi approach permits the collection of anonymous feedback, which maintains unbiasedness in the process and avoids domination of certain groups to obtain final consensus (Weston & Davies, 2007). Also, the interaction among all panelists, who have a variety of skills, knowledge, and expertise on the topic from various viewpoints, may result in a better solution (Gharaibeh, 2014). As pedestrian facilities planning and its improvement are generally multi-dimensional, a consensus-based approach such as the Delphi technique is preferable (Dalkey & Helmer, 1963). The flexibility

offered in the Delphi survey is that it does not prescribe any formal or standard guidelines on the overall methodology, and there is no rule for the number of rounds and number of experts to be incorporated and criteria for selection of panelists, etc. (Nayyar et al., 2019). Though in some studies, a heterogeneous mix of 15–35 experts and 2–3 rounds are recommended as ideal for the Delphi survey (Zangenehmadar & Moselhi, 2016). Ranking type Delphi is a form of Delphi technique, which is very popular among researchers to reach group consensus on specific issues of factor identification (Strasser, 2019).

For the successful planning and development of pedestrian facilities, the planning agencies must be equipped with a scientific decision-making tool that can evaluate and prioritize sidewalks and pedestrian facilities, and distribute the fund according to the priority (Beiler & Phillips, 2016). Understanding the factors that have a significant influence on the improvement of pedestrian facilities and sidewalks enables planners and researchers to develop a scientific decision-making tool for prioritizing the improvement of pedestrian facilities (Jabbari & Fonseca, 2018). So, the preliminary requirement for developing the decision-making tool is the identification of significant factors that influence on the improvement of pedestrian facilities in urban areas. A study was thus initiated here to identify such significant factors in the Indian urban context.

The objective of this study is to identify the comprehensive list of factors belonging to different categories that have a significant influence on the improvement of pedestrian facilities in urban areas. There are 77 medium-sized cities in India, and nearly one-third of the urban population are living in these cities (Census of India, 2011). As these cities are crucial while doing researches on Indian urban conditions, this study was also focused on medium-sized cities in India. An extensive literature review was conducted to identify all factors that influence the improvement of pedestrian facilities in an urban area. It was followed by a ranking type Delphi survey to consolidate the categories and factors.

## 2. Methodology

The Delphi method was used to select and comprehend the significant factors that influence the improvement of pedestrian facilities in an urban area. The following figure (Fig. 1) illustrates the overall methodology of the Delphi technique.

### 2.1. Identification of factors

In order to discover the factors influencing the improvement of pedestrian facilities in urban areas, a thorough and unbiased search of relevant studies was conducted using the appropriate keywords and criteria. The search methodology was designed in accordance with the aim of the study, and it covered journals, case studies, standard guides, and design codes related to pedestrian facility development in urban areas. The list was compiled based on the number of citations in past studies. The factors which were appeared in a minimum of 5 literature were incorporated. The factors that are closely linked and have identical functionality were also added to the list after assuring the journal support. Based on the review of previous studies (Clifton et al., 2007), (Beiler & Phillips, 2016), (Bivina &

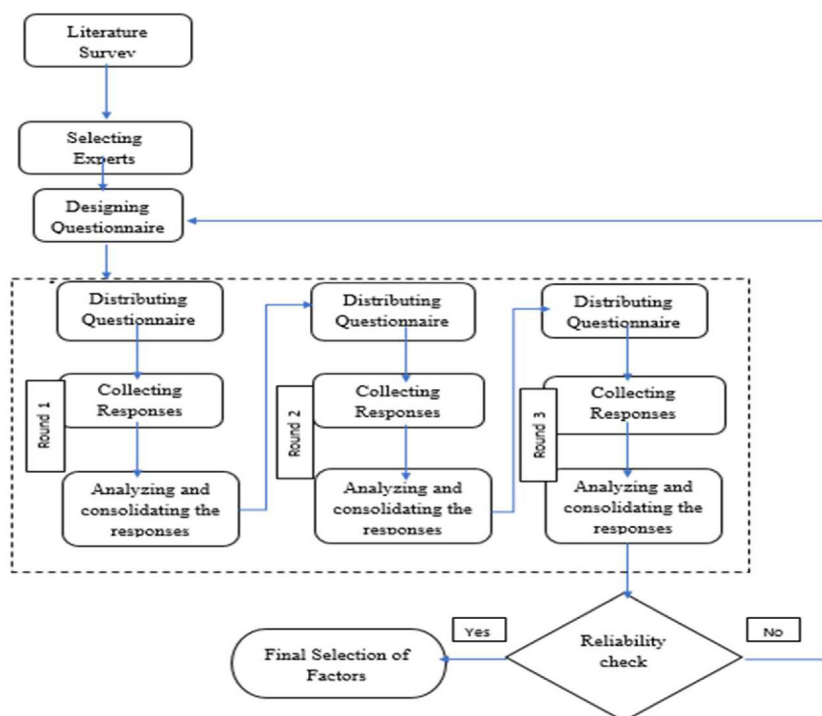


Fig. 1. Delphi methodology.

Parida, 2020), etc., and standard guidelines (IRC-Guidelines103, 2012), (UTTIPEC, 2009), (DULT Guidelines, 2014), 5 major categories and 11 subcategories were identified. Five major categories that characterize the pedestrian facilities were identified as (1) Infrastructure; (2) Location (3) Ambience/Liveability, (4) Safety and Security, and (5) Mobility. Various subcategories and factors that contribute to defining major categories were also identified. They are listed in Table 1.

## 2.2. Selection of panel of experts

The identification of relevant experts and their relative expertise in the concerned area are the critical aspect that decides the success of the Delphi technique (Hirschhorn, 2019). A snowball sampling method was employed in the selection process of panelists (Hanafin, 2004). A list of 35 experts was identified, and they were asked to fill the ‘qualification checklist’ to declare their expertise and professional background. After a thorough check by employing judgmental sampling (Merfeld et al., 2019), 24 panelists were selected for the survey. A heterogeneous mix of panelists from different categories such as Town Planners (Government Officials), Academicians, Engineers/Builders/Architects, and Scientists/Researchers were included in the list. All the selected members were having a minimum experience of 15 years in the urban planning field. All of the experts have previously worked on a variety of projects involving pedestrian facility planning and are capable of making sound judgments in the field. Fig. 2 shows the background profile of the panelists who participated in the survey process.

## 2.3. Questionnaire preparation

The first-round questionnaire was prepared in such a way as to generate a general idea about the context of the survey and to collect personal, professional, and academic details of the panelists. In the first-round questionnaire, all the 47 factors identified from the literature were presented, and the experts were asked to challenge the classification and factors identified. They were asked to list any missing factor in any category which they feel important in the context and list any factors which are irrelevant in the context. The questions were framed in such a way that experts were instructed to give their opinion separately and anonymously. The second-round questionnaire was prepared in a format in which the panelists were requested to rank the factors in each category separately based on their influence on the improvement of pedestrian facilities. The panelists were given the option to rank from 1 to n (n value varies in different categories according to the number of factors included in each category). The third-round questionnaire was prepared in a way that panelists were requested to re-rank the factors in each category after comprehending the result of the previous round. The consolidated list of factors with rank derived from the results of the second-round survey was included in the third-round questionnaire. This same questionnaire format with the results of the third-round survey was continued in the fourth round also.

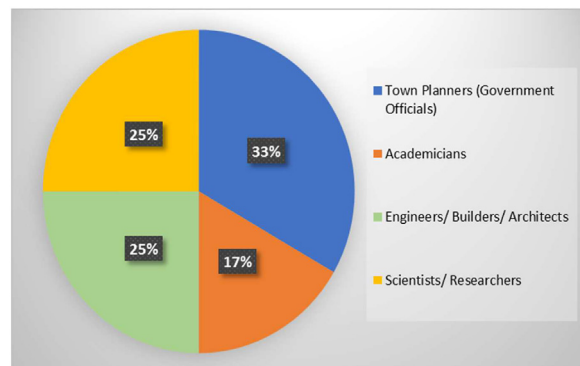
**Table 1**  
Factors identified from the literature.

Category	Factors	Source
Infrastructure	Physical Infrastructure	Effective walkway width, Surface Condition (Material/Texture Used and its condition), Cross falls for drainage, Guide blocks/Weigh blocks/Warning Blocks
	Accessibility Infrastructure	Kerb Height, Pedestrian Access points, Kerb Ramps/Ramp gradient, Slope, Tactile paving at ingress and egress of a footpath or median refuge
	Functional Infrastructure/Amenities	Bus Stops, Street Furniture (Seats, info Kiosks), Rain Shelter, Public Toilets/Washrooms
	Safety Infrastructure	Crossing Facilities, Guard rails/Lateral Separation from vehicle traffic, Refuge Islands/Median, Bollards, Traffic calming measure (Speed Humps, Speed Cushions, etc.), Traffic Control Devices/Signals
Safety and Security	Lighting/Clear visibility, No. of Traffic lanes/Crossing distance, Buffer width, Two-wheelers on the footpath, Passive Surveillance	(IRC-Guidelines103, 2012), (ITDP Guidelines, 2013), (Arslan et al., 2018), (Bahari et al., 2013)
Ambience/Liveability	Maintenance and Cleanliness, Shading/Tree Canopy, Air Quality, Space for Street vendors, Dust Bins	(IRC-Guidelines103, 2012), (ITDP Guidelines, 2013), (Bharucha, 2017), (López et al., 2017)
Mobility	Continuity/No of Kerb cuts, Obstructions, Wayfinding/Signage, Pedestrian travel speed, Pedestrian delay at the intersection	(Balsas, 2017), (Gorrini & Bertini, 2018), (Henderson, 2018), (Torres-ruiz et al., 2017)
Location-Based Factors	Socio-Demographic	Pedestrian Count, Population density, Employment density, Average pedestrian age
	Built Environment Factors	Building Setback, Building height, Building front/Windows Facing street/Facade
	Proximity Factors	School zone Proximity, Mixed land use, Proximity to civic bodies
	Hostility Factors	Ped-vehicle crash rate/Ped fatality rate, Crime rate, Vehicular speed in the adjacent lane

**Table 2**

Cumulative score achieved by each factor in round 2, 3 and 4.

Factors	Score in Rounds			Factors	Score in Rounds		
	2nd	3rd	4th		2nd	3rd	4th
Effective Walkway Width	87	88	88	Shading/Tree Canopy	90	86	86
Surface Condition	68	68	68	Space for Street vendors	43	31	31
Guide blocks/Weigh blocks	31	28	28	Dust Bins	45	46	46
Cross falls for drainage	41	40	40	Maintenance and Cleanliness	94	103	103
Block Size	13	15	15	Noise hindrance	37	32	32
Kerb Height	74	83	83	Air Quality	53	62	62
Kerb Ramps/Ramp gradient	50	50	50	Continuity	73	85	85
Slope	38	32	32	Pedestrian travel speed	30	25	25
Tactile paving	19	8	8	Pedestrian delay	28	19	19
Ped Access points	62	70	70	Obstructions	67	63	63
Bus Stops	101	114	114	Wayfinding/Signage	43	48	48
Street Furniture	75	78	78	Gender	41	31	31
Drinking Water Facilities	48	38	38	Average pedestrian age	58	51	51
Rain Shelter	72	61	61	Population density	80	78	78
Washrooms/Public Toilets	51	37	37	Employment density	71	69	69
Advertisement Hoardings	20	32	32	Pedestrian Count	86	102	102
Guard rails	90	92	92	Avg. Annual Income	34	31	31
Bollards	32	29	29	Mixed land use	43	43	43
Traffic calming measures	41	30	30	Proximity to Educational Institution	53	64	64
Crossing Facilities	88	94	94	safe distance from hazardous occupancy	16	7	7
Refuge Islands/Median	61	68	68	Proximity to Civic bodies	33	28	28
Traffic Control Devices/Signals	56	48	48	Building Height	29	28	28
Buffer width	72	71	71	Avg. Building to Building Gap	56	52	52
Two-wheelers on footpath	60	52	52	Building Setback	69	84	84
No. of Traffic lanes/Crossing distance	77	75	75	Building frontage/Windows Facing Street/Facade	27	9	9
Lighting/Clear visibility	84	98	98	Built up Density	62	67	67
Display of emergency contact	36	32	32	Crime rate	21	19	19
Passive Surveillance	39	31	31	Ped-vehicle crash/fatality rate	34	41	41
				Vehicular speed in adjacent lane	17	12	12

**Fig. 2.** Composition of panelists participated in the survey process.

#### 2.4. Survey process

The Delphi process was carried out with the help of a set of prepared questionnaires. Before distributing the questionnaire, it was pre-tested using the cognitive interview approach, including locally available experts and researchers. In the first round, all the panelists responded without commenting on any correction to the categorization, but 10 extra factors were added to the list. To check the reliability of the expert's recommendation, a literature study was done again and made sure that the factors recommended were relevant. The new factors added were Block size (Meeder & Weidmann, 2018), Drinking Water Facilities (ITDP Guidelines, 2011), Advertisement hoardings (Iveson, 2012), Display of emergency contact numbers (Vasudevan et al., 2016), Noise hindrance (Agyapong & Ojo, 2018), Gender (Ferenchak, 2016), Average Annual Income (Fitzsimons, 2013), Built-Up density (Lakhotia, Rao, & Tiwari, 2019), Avg. Building to building gap (Muthoni, 2008), Safe distance from hazardous occupancy (Ganguly et al., 2018).

The ranking process was started from the second round onwards. All the 57 factors were ranked according to the instructions of the second-round questionnaire. In the ranking process, the panelists have assigned ranks to all the factors in each category separately. The responses from all the experts were analyzed, and corresponding ranks for each factor were directly derived from the cumulative score



attained. The score was calculated using the formula given below.

$$\text{Cumulative score} = (M \times n) - \sum_{i=1}^n x_i$$

M is the total no of experts in the panel, n is the total no of factors in each category and.

$x_i$  is the rank given by the 'i'th expert.

In the third round, the panelists have re-ranked the factors according to the third-round questionnaire (see Table 2). The responses from all 24 experts were analyzed, and the cumulative score for each factor was calculated. This procedure was continued in the fourth round. All the panelists responded without any change from their previous responses. It was therefore considered that the panelists had reached a consensus, and it was declared as the end of the Delphi survey. The cumulative score achieved by each factor in all 4 rounds is shown in Table 3.

### 3. Data analysis

The panelists have assigned a rank between 1 to n (n value varies according to the number of factors in each category) to each factor based on its influence on the improvement of pedestrian facilities in the urban area. The final rank for each factor was derived by calculating the cumulative score using the above-mentioned formula. The cumulative score represents the order of influence of each factor. The factors with the higher cumulative scores represent the most significant factors, while those with the lower cumulative scores represent the lesser significant factors.

To develop a decision-making tool, it is required to integrate these factors with a suitable multi-criteria decision-making tool. For smooth integration, it is necessary to limit the number of factors. Therefore, three factors from each category with high scores were selected as significant factors. The final selected factors after all rounds are listed in Table 3.

Internal consistency was checked by calculating Cronbach's Alpha (Zangenehmadar & Moselhi, 2016) using SPSS 25.0 and found to be 0.920, 0.958, and 0.958 for the 2nd, 3rd, and 4th round, respectively. Cronbach's alpha values for all categories were also calculated separately and are shown in the form of a radar plot in Fig. 3. Round 3 and round 4 poses the same result, so it overlaps in the radar plot.

Since all the computed values of Cronbach's alpha in the final round were above 0.9, and it showed an increasing trend in the value as the survey proceeded from round 2 to 3 and 4. According to studies (Zangenehmadar & Moselhi, 2016), it can be concluded that the survey possessed high reliability.

Kendall's coefficient W is a statistical measure to check the level of concordance (Quarthey, 2016), and it was calculated using SPSS 25.0 and found as above 0.3 ( $P < 0.001$ ) with a level of significance 95%. It showed an increasing trend in the values as the survey proceeded from round 2 to 3 and 4. According to studies (Cafiso et al., 2013), it can be declared that a good or moderate agreement among the panelists was developed. The Kendall's coefficients value calculated for all categories separately in each round is graphically depicted on a radar plot in Fig. 4.

### 4. Results and discussion

The Delphi survey conducted in this study resulted in the identification of significant factors affecting the improvement of pedestrian facilities in the urban area. As mentioned in the previous sections, experts were asked to rank 57 factors in different categories, and finally, 33 factors were chosen as significant. Fig. 5 represents the workflow of the factor identification process.

All the experts could easily reach a consensus on the 12 infrastructure parameters because the sidewalk design must incorporate all these factors that provide better usability for pedestrians belonging to different groups and ages with different requirements (IRC-Guidelines103, 2012). Effective walkway width, Kerb height, Bus stop and Crossing facilities were identified as the top priority factors in four subcategories of Infrastructure factors. Other factors, such as Surface condition, Cross falls for drainage, Pedestrian access points, Kerb ramps/ramp gradient, Street furniture, Rain shelter, Guard rails and Refuge islands/median were also considered as significant by the experts. According to the value of Kendall's coefficient, the consensus rating of these factors was found to be increasing as the survey proceeded from rounds 2 to 3 and 4. Cities need crossing facilities to make it easier for people to cross highways safely. It decreases the

**Table 3**  
Significant factors identified.

Final selected factors		
Effective walkway width	Refuge islands/median	Population density
Surface condition (material/texture used and its condition)	Lighting/clear visibility	Employment density
Cross falls for drainage	No. of traffic lanes/crossing distance	Building setback
Kerb height	Buffer width	Built-up density
Ped access points	Maintenance and cleanliness	Building front/windows facing street/facade
Kerb ramps/ramp gradient	Shading/tree canopy	School zone proximity
Bus stops	Air quality	Mixed land use
Street furniture	Continuity	Proximity to civic bodies
Rain shelter	Obstructions	Ped-vehicle crash rate/ped fatality rate
Crossing facilities	Wayfinding/signage	Crime rate
Guard rails	Pedestrian count	Vehicle speed in the adjacent lane

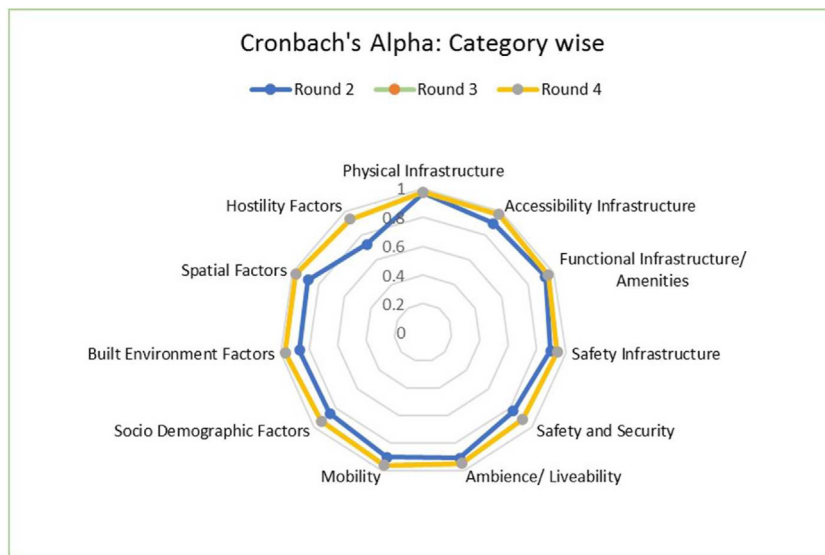


Fig. 3. Category wise value of Cronbach's Alpha in round 2, 3 and 4.

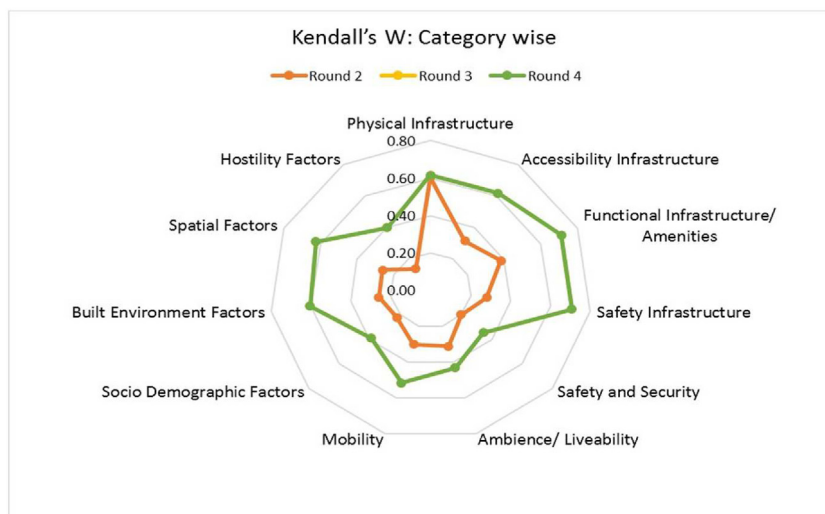


Fig. 4. Category wise value of Kendall's coefficient in round 2, 3 and 4.

dangers to pedestrians and, as a result, prevents pedestrian fatalities (Anciaes & Jones, 2018). The experts have given the least priority to Guide blocks/weigh blocks and tactile paving in the ranking process. The consensus on these factors was unanimous. Surface condition (material or texture used and its condition) was one factor selected as significant by the experts. So, while addressing the execution of the parameter 'surface condition' in the field, the installation of tactile pavers or warning blocks can be insisted along with it. Perhaps that's why experts omitted weigh-blocks/guide-blocks and tactile pavers as separate factors. Though many studies identified the importance of Washrooms/Public Toilets in urban areas, it did not qualify for the final list in the ranking process. In Indian cities, the construction of these facilities is usually carried out separately, and the pedestrian facilities improvement projects do not often deal with these factors. That might be the reason why experts did not consider Washrooms/Public Toilets as a significant factor in the pedestrian facility improvement. Though the advertisement hoardings can generate revenue, the panellists haven't rated it as significant. The findings of the recent studies that advertisement hoardings are the potential sources of distraction and a partial cause of the accident, might have lead the panelists to assign the least rank to the factor (Oviedo-Trespalcacios et al., 2019). Traffic calming measures, Traffic control devices/Signals were also eliminated from the final list during the ranking process.

The most significant factor identified in the Safety and security category was Lighting, followed by No. of traffic lanes/crossing distance and Buffer width. Improving sidewalks by installing proper lighting along their length can improve walking by giving pedestrians a sense of security (Bivina & Parida, 2020). In India, inadequate lighting in urban areas has already been recognized as a



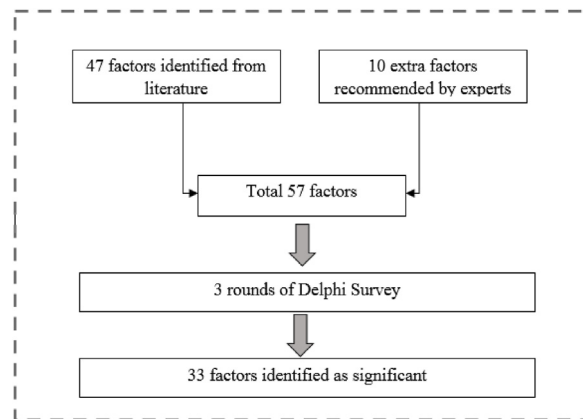


Fig. 5. Overall workflow.

challenge that causes dangerous pedestrian crashes (Mukherjee & Mitra, 2020). For smooth and safe walking, lighting is necessary on the sidewalk for pedestrians, particularly women, the elderly, and differently-abled people (Johansson et al., 2011). The ranks of security parameters assigned by academicians and researchers differed moderately from experts of other fields. Academicians and researchers considered Passive surveillance as a key factor in the security aspect, whereas other experts gave the least priority to Passive surveillance. The increase in the crime rate against pedestrians could be a reason why academicians and researchers think about the need for surveillance in an urban area. The installation and maintenance cost of these surveillance cameras and other accessories would create an extra load on the budget, which is perhaps the reason for other experts, especially government officials, to avoid surveillance from the final list and include another factor.

Maintenance and cleanliness, Shading/tree canopy and Air quality were three factors identified as significant in the Aesthetics/Liveability category. Previous studies have emphasised the relevance of cleanliness in establishing a pleasant atmosphere for pedestrians walking in urban areas (Bivina & Parida, 2020), (Cook et al., 2014). Only a well maintained and cleaned sidewalk can attract people to choose walking as a mode of transport over other motorized modes. Tree canopies along the walkway provide a liveable environment, aesthetic beauty, and a space for social interaction and recreational activities (McMillen et al., 1999). The transport sector is one of the largest contributors to air pollution, which in turn is responsible for the deterioration of pedestrian spaces in urban areas (Jahan et al., 2020). So, while improving the sidewalks, it is essential to consider air quality as a factor. Vendors can also use the space under trees because they prefer spots that are visible to passers-by. In the category of liveability and aesthetics, the experts with architecture backgrounds assigned better ranks to Space for vendors, but other experts gave lesser priority to this factor. The provision of space for vendors on the sidewalk would obstruct the free movement, which is perhaps the reason for other experts to avoid this factor from their consideration. The availability of dust bins in urban areas can be insisted under the criterion of Maintenance and cleanliness, which may explain why experts did not include the Dust bin as a separate factor in the final list.

Continuity, Obstructions and Signages were identified as the three significant factors in the Mobility category that influence smooth movement of pedestrians on footpaths. The major issue regarding the improvement of pedestrian facilities in Indian cities is the non-existence of footpaths in most areas. The footpaths available are often discontinuous or damaged (Bivina & Parida, 2020). The obstructions on the sidewalks are also a major hindrance to free mobility. The obstructions include electric poles, garbage bins, trees, informal commercial activities, illegal vendors, the presence of manholes, service covers, signposts, etc. So, while improving the pedestrian facilities, it is mandatory to get rid of these obstructions from the sidewalk. Pedestrian travel speed and Pedestrian delay were the other two factors discovered in the literature, but they did not gain a score for getting selected to the final list. The score achieved by these factors was very less compared to the other 3 factors selected as significant. The increasing trend of Kendall's coefficient value also indicates consensus among experts on these factors.

The importance of the 12 factors identified in the location category was very rarely discussed in previous studies. No studies in the context of developing countries could club these location factors together with other categories and develop a strategy for decision-making. According to studies conducted in developed countries (Iamtrakul & Zhang, 2015), (Beiler & Phillips, 2016), a location with a high pedestrian count, population density, and employment density should be given higher priority in improvement. The sidewalks near the school zone and civic bodies have to be considered separately in the planning process (Iamtrakul & Zhang, 2015). Pedestrian safety near schools and civic bodies is a concern for transportation agencies, municipal governments, and the general public (Heydari et al., 2020). It is important to take extra care in the design of sidewalks near school zones, and the same must be addressed in planning practises as well (Loukaitou-Sideris, 2006). In order to encourage higher levels of pedestrian mobility, it was recommended to consider mixed land use as an influential factor in the planning process (Evans-cowley, 2006, pp. 71–75). The sidewalks in mixed land uses could provide more walking pleasure than vacant gaps between the buildings (Xitong Li, 2015). Building set-back, Built-up density, and Building facade are three important factors to be considered in selecting a sidewalk in a specific location for improvement (Beiler & Phillips, 2016). The amount of open space between the footpath and the buildings, the exterior of the buildings and the activities taking place inside the buildings; all have an impact on pedestrian movement in that location. Building height and Avg. Building to building gap were the two factors that did not qualify to the final list in the ranking process. According to Frank et al. (2019), surveillance from

adjacent buildings, their height and setback influences healthy behavior and mental well-being of pedestrians by signifying a sense of safety. According to [Bereitschaft \(2017\)](#), the gap or unused spaces between buildings may create a sense of discontinuity and vulnerability among pedestrians. Though these factors have considerable influence on the pedestrians walking in urban areas, the experts assigned lower ranks to these factors. As the consensus on these factors was unanimous, the same was accepted. The factors such as the pedestrian-vehicle crash rate, crime rate, and vehicle speed in the adjacent lane have considerable influence on the safety and satisfaction level of pedestrians walking in urban areas ([Marisamynathan & Lakshmi, 2018](#)), ([Bharucha, 2017](#)). Pedestrians are the most vulnerable road users, and they are highly exposed to traffic accidents, particularly in nations where traffic laws are not strictly enforced ([Zegeer & Bushell, 2012](#)). So, while improving the pedestrian facilities in urban areas, it is important to consider areas where pedestrian crashes are recorded high. Urban areas are always prone to different types of crimes such as theft, snatching, vandalism, violence, sexual harassment, etc. The fear of crime in people has always discouraged people from walking in urban areas ([Seedat et al., 2006](#)). So, it is essential to identify locations where more crimes are recorded and improve the facilities in that location. Effective planning of facilities can help to prevent crimes and improve traffic safety in urban areas ([Day et al., 2007](#)). The speed of vehicle in the lines adjacent to the sidewalk is a key factor while selecting a sidewalk for improvement. The pedestrians walking in urban areas are always under the risk of vehicles moving in the adjacent line. So, the sidewalks in the locations where traffic speed is high must be provided considerable attention in the pedestrian facility improvement process.

The requirements of pedestrians are different among different groups ([Moura et al., 2017](#)). The inclusion of Surface condition, Continuity and obstruction-free footpath in the final list will ensure smooth movement for visually impaired persons. Kerb ramp ensures the movement of wheelchairs of aged persons and persons with disabilities. Pregnant women and elderly people can use street furniture for taking rest during their walk.

This study provides various novel contributions to the urban planning field, especially to the planning of pedestrian facilities. First, this study assisted in unifying the literature on pedestrian activities and facilities in urban areas. Second, the study provides a methodical and inclusive categorization of identified factors related to the improvement of pedestrian facilities. Third, this paper proposes a comprehensive list of significant factors that need to be incorporated in the planning and design of a better pedestrian environment in the urban area including some new factors which are missing in previous studies. Forth, this study represents a consensual starting point towards the development of a decision-making tool to prioritize the improvement and investment decisions for pedestrian facilities.

The results of the study fill the gap existing in the development of a comprehensive list of factors and set in a valuable reference for urban planners and government officials to implement the obligatory steps towards the development of a scientific decision-making tool for prioritizing the improvement and resource allocation. It can thus be concluded that the improvement of pedestrian facilities in urban areas should consider important factors such as socio-demographic, traffic, proximity, location, etc., that were not considered in the standard guidelines followed in India.

Though the study has achieved the aims, there are certain limitations as well. The consensus arrived was fully dependent on attitudes of experts towards the importance of pedestrian facilities in the urban area, which is a general limitation of the Delphi study, that is expert-driven and often overlooks the perceptions of real end-users. Since it is required to integrate these factors with a suitable multi-criteria decision-making method in the later phases of the study, the number of factors in each category had to be limited. Some factors were left off the list in the process. This is another limitation of this study. Future studies may look into expanding the list, which allows more factors to be included, especially some of the accessibility factors which are currently missing in the final list. Future studies should also consider including psychological aspects in the study, which the developed countries have already included in the design. To improve the study, it is also recommended to seek public opinion while taking policy decisions as it allows constant feedback from real end-users. Since the study was dealing with jargon in Urban Planning, it was difficult to get health professionals who could understand these terms. Due to the non-availability, they were not included in the expert panel. The exclusion of health professionals from the expert panel is one of the major limitations of this study. Their feedback would have given a better dimension to the result. Future studies may consider including health professionals in the expert panel since their knowledge can improve the outcome.

## 5. Conclusion

This is high time for the development of a decision-making tool to prioritize the improvement of pedestrian facilities in the urban area. This paper has presented a methodology for identifying the significant factors to be considered for the development of a decision-making tool for the improvement of pedestrian facilities in an urban area. A Delphi survey was adopted to develop a comprehensive list of factors that are significant for the purpose. 47 factors enumerated from the literature and 10 factors recommended by the experts were subjected to the Delphi survey. After four rounds of Delphi survey conducted among 24 preselected experts, 33 factors were identified as significant. The result showed good internal consistency and a moderate level of concordance among the experts. The result established the rationality of the initial assumption that ‘most of the previous studies in this area choose factors based on their availability, not importance,’ and additional factors were also recommended. The study also identified some significant factors that not gained attention during many of the past studies. This study offers a dependable set of factors towards the development of a decision-making tool, which will help future studies to identify the significant factors on which the researches have to focus on creating a pedestrian-friendly atmosphere in the urban area. The list is comprehensive and adaptable to similar situations in other developing countries also. The methodology highlights the worth of espousing the Delphi technique for key-factors identification purposes.

## Declaration of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant

financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from. We confirm the corresponding authors email address as [aromalmv@gmail.com](mailto:aromalmv@gmail.com).

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