

Article

Built Environment Determinants of Pedestrian Activities and Their Consideration in Urban Street Design

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Abstract: Pedestrian facilities have been regarded in urban street design as “leftover spaces” for years, but, currently, there is a growing interest in walking and improving the quality of street environments. Designing pedestrian facilities presents the challenge of simultaneously accommodating (1) pedestrians who want to move safely and comfortably from point A to B (movement function); as well as (2) users who wish to rest, communicate, shop, eat, and enjoy life in a pleasant environment (place function). The aims of this study are to provide an overview of how the task of designing pedestrian facilities is addressed in international guidance material for urban street design, to compare this with scientific evidence on determinants of pedestrian activities, and to finally develop recommendations for advancing provisions for pedestrians. The results show that urban street design guidance is well advanced in measuring space requirements for known volumes of moving pedestrians, but less in planning pleasant street environments that encourage pedestrian movement and place activities. A stronger linkage to scientific evidence could improve guidance materials and better support urban street designers in their ambition to provide safe, comfortable and attractive street spaces that invite people to walk and to stay.

Keywords: walking; pedestrians; urban street design; pedestrian facilities; link and place functions; sidewalk; walkability



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1. Introduction

For many years, spaces for pedestrians were treated as “leftover spaces” in urban street design. In regard to technical geometrical street design, motorised vehicle size was the main determinant for minimum lane widths. The provision of dedicated lanes for public transport depended on space availability and its level of prioritisation in local transport policy; defined target values for traffic quality for motorised vehicles, e.g., in terms of level of service for the forecasted traffic volumes, determined the number of lanes in street sections and at junctions. Additionally, the recent rise in the popularity of cycling has resulted in the increase in both the quality and quantity of cycling facilities. Yet the accommodation for pedestrian needs or place functions has fallen by the wayside, particularly in areas with limited street space availability. Furthermore, seen from an engineering perspective, with a width of about 0.75 m to 1.00 m, a “standard” pedestrian does not typically occupy much space, thus causing pedestrians to be perceived and treated as a more flexible user group compared to motorised vehicles and bicycles.

Two additional problems hamper the efforts of transport planners in providing for pedestrians: (1) Apart from the quality of the street environment, spatial structures and land use are also strong incentives for walking; thus, despite poor conditions, pedestrians will still walk if spatial structures and land use are supportive. (2) Planners rarely have reliable information about existing or expected pedestrian volumes. Even in the current era of digitalisation, pedestrians are still counted by hand in most cases, which is burdensome, time-consuming and rarely done.

Various combinations of the above-described issues have been the focus of many discussions concerning urban street design tasks, which has led to street layouts with overly narrow sidewalks. Those narrow sidewalks rarely accommodate pedestrians' movement functions and often do not encourage place activities such as resting, waiting, communicating, shopping, eating, and enjoying life in a pleasant environment.

At the same time, research interest in walking and in walkability has sharply increased, and new insights have surfaced about why people walk and about the various benefits of walking [1,2]. For example, the Health Economic Assessment Tool (HEAT-Tool, <https://www.heatwalkingcycling.org/> (accessed on 14 August 2021), provided by the WHO/Europe, allows cities to compute in advance the monetised health effects of anticipated behavioural change as well as increased walking and cycling levels. It is consensus that walking is a key ingredient of liveable cities, and contributes to a healthier population as well as to more environmentally friendly travel behaviours.

Cities and stakeholders are increasingly aware of these positive effects. Thus, there is increasing interest around the world in walking and in improving the quality of street environments to be more walkable. Cities such as New York are redesigning parts of their street networks and urban spaces with a primary focus on an increased quality of space for pedestrian and dense urban areas. The City of Malmö places pedestrians at the highest level of their street-user hierarchy [3]. In London, the healthy street approach takes highest priority in the Mayor's Transport Strategy [4], and also at the national level, more and more pedestrian strategies are being put in place (see e.g., [5]). The current COVID-19 pandemic and related physical distancing requirements bring new challenges and opportunities for efforts to provide for pedestrians [6].

Seeing the scientific evidence on the positive effects of pedestrian activities and the increasing interest in encouraging walking and lively streets, it becomes clear that spaces for pedestrians must not be treated as "leftover spaces". They should be the focus of attention.

This study focuses on the design of streets and pedestrian facilities as one important determinant of pedestrian activities, as well as one main field in policy-making for promoting walking. This study compiles standards for pedestrian facilities, including both movement and place functions, from international guidelines on urban street design from five European cities and six nationwide guides from European countries and the USA (NACTO). It compares these with empirical evidence from the scientific literature on infrastructure-based determinants of pedestrian activity in urban streets.

Two goals are pursued with this approach: Our comparison of standards can be used separately by researchers who analyse covariates of pedestrian activities. Our overview of scientific evidence provides a concise summary of infrastructure-based determinants of pedestrian activities. Our comparison of scientific evidence and standards highlights how the transfer from research to practice works, and simultaneously allows us to derive recommendations for advancing the guidelines based on insights gained in research. These insights should help address the above-described tensions and challenges, and give urban street designers optimal guidance for reliably providing for pedestrian movement and place activities, while at the same time leaving flexibility for finding tailor-made solutions that fit to the local context and that overall contribute to the final goal of advancing provision for pedestrians.

The remainder of this paper is organised as follows: Section 2 presents scientific evidence on determinants of pedestrian activities related to street characteristics and the

built environment. It is followed by the summary of guidance material on pedestrian facilities in Section 3. Section 4 compares scientific evidence and guidance material in order to show how the transfer between research and practice works. Recommendations on providing for pedestrians in future guidelines on urban street design are developed in Section 5. The final Section 6 summarises main findings and gives an outlook to further research.

2. Determinants of Walking and Place Activities

Research on determinants of walking and place activities is as interdisciplinary as the research topic itself [1,7]. Public health researchers focus on minutes of walking as one part of overall physical activity, and particularly include person-related variables such as socio-psychological variables, body mass index, or physical activity at work and for leisure purposes into their analyses [8]. Transport planners try to understand, above all, the influence of network and street characteristics on pedestrian volumes [9–11]. Urban planning literature also considers the characteristics of street networks, but takes a much broader view, including variables describing land use and other neighbourhood and city characteristics [12–14]. Three main groups of determinants of pedestrian movement and place activities related to street characteristics and the built environment could be identified in the analysis of the scientific literature:

1. Urban design and land use are of utmost importance for achieving high levels of pedestrian activities in the streets.
2. Streetscape design also matters.
3. The successful provision for pedestrian movement and place activities requires far more than pedestrian-focused urban and transport design.

In what follows, the main findings from the literature are summarised for each of these three groups of determinants.

2.1. Urban Design and Land Use

The “5 Ds” (Density, Diversity, Design, Distance to public transport, Destination accessibility) are consistently significant and influential for pedestrian activities in the researched literature [8,11,15–19]. Ewing et al. [9,20] demonstrate that Density is particularly important, measured in their example as floor area ratio and population density within a quarter mile of the investigated commercial streets. Diversity is often captured by entropy measures describing the number and variety of different land use types in a given area [15,19,21]. Ewing et al. found it to be statistically significant in one study [20], but not another study [9]. Shorter Distances, particularly to rail-based public transport, consistently and significantly increase pedestrian volumes [9,22]. Design-variables describe the characteristics, and more specifically the connectivity, of the street network, measured, e.g., as intersection density or as proportion of four-way intersections [15,23]. Mixed findings exist for these Design variables, which are significant in some studies, and not in others [9]. Destination accessibility describes the level to which relevant activities can be reached [15,24]. Destinations are operationalised, e.g., by the number of nearby stores and amenities weighted by their distance; these are hardly significant in Ewing et al. [9,20] and show an overlap with Diversity.

Some authors work with Cs instead of the Ds described above in order to investigate the influence of the built environment on pedestrian volumes: Connectivity, Convenience, Comfort, Conviviality, Conspicuousness, Coexistence, Commitment [25–28]. These Cs are a mixture of variables on the neighbourhood and street level; they show a substantial overlap with the Ds, and findings on their impacts on pedestrian activities are consistent with the findings summarised above.

2.2. Streetscape

The Ds also apply to the streetscape itself. This holds particularly for Design, but also for the other Ds. Ewing et al. [9] show the significant influence of floor area ratios along

the streets themselves (computed as the total building floor area for parcels abutting the street, divided by the total area of tax lots) and of the proportion of retail frontage along the block face on pedestrian volumes. In their pioneering work on the Design variable on the street level, Ewing and Handy [11] measured more than 100 features of selected streetscapes. Based on expert rankings as the dependent variable, the following five urban design qualities were identified as the most important:

- Imageability—quality of a place that makes it distinct, recognisable and memorable, measured, e.g., by the proportion of historic buildings, buildings with non-rectangular silhouettes and with identifiers, such as major landscape features;
- Enclosure—degree to which the streets are visually defined by buildings, walls, trees and other vertical elements, measured, e.g., by the proportion of street walls, of sky visible across and ahead, and by long sight lines;
- Human scale—size, texture, and articulation of physical elements that match the size and proportions of humans and correspond to the speed at which humans walk, measured, e.g., by long sight lines, street furniture, proportion of first floor with windows, building height, small planters;
- Transparency—degree to which people can see or perceive what lies beyond the edge of a street, measured, e.g., by the proportion of buildings with windows at street level and of active uses of adjacent buildings;
- Complexity—visual richness of a place, measured, e.g., by the number of buildings, dominant building colours, accent colours, pieces of public art, people in the street, and by the presence of outdoor dining.

These criteria have been validated against counted pedestrian volumes in subsequent studies [11,20]. Controlling for the D variables as introduced above, on the street level, only transparency was found to significantly influence pedestrian volumes. This is consistent with findings from other studies [29,30]. The only exemption is imageability, which was identified in one study as a variable that significantly increases pedestrian volumes [29]. Ewing et al. [9] refined the above concepts and analysed the influence of around 20 variables measuring the physical features of streetscapes on pedestrian volumes separately, resulting in three significant variables: proportion of windows, street furniture, and active uses. Overall, the three streetscape design features added significantly to the explanatory power of the statistical models on pedestrian volumes, compared to models with only the D variables on the neighbourhood and street levels. Street furniture was defined as a variety of signs, benches, parking meters, trash cans, newspaper boxes, bollards, and street lights, and includes anything at the human scale that increases the complexity of the street. Public seating was found to be of special importance. The proportion of active uses was defined as shops, restaurants, public parks, and other uses that generate significant pedestrian traffic. Inactive uses include blank walls, driveways, parking lots, vacant lots, abandoned buildings, and offices with no apparent activity.

Kang [31] and Kim et al. [22] focus on the street layout itself. They find significant positive impacts of sidewalk widths, crosswalks and trees, and negative impacts of slopes, on pedestrian volumes. The number of traffic lanes is positively associated with pedestrian volume, but highly correlated with the distance to public transport. Lai and Kontokosta [19] computed a composite variable called “streetscape” as the combination of sidewalk coverage, pavement quality, and street amenity. This variable significantly increases pedestrian volumes on weekends but not on workdays.

While a large number of studies analyse pedestrian volume, only few research groups and studies focus on place activities [13,14,32–34]. These are operationalised either by the number of people in a place [33,34], or by the liveliness index, as the product of people undertaking place activities times the duration of these activities (15 s to <1 min, 1 min to <5 min, 5 min to <10 min, 10 min to <15 min, ≥ 15 min) [13,14,32,35]. Mehta and Bosson [14] distinguish various activity types and the following physical human postures for their studies: standing, sitting, lying, sleeping. The determinants of place activities show substantial similarities with those of pedestrian volumes, and add further

valuable insights to how to achieve lively streets, including both pedestrian movement and place activities. The existence of community places, such as stores, that are places to meet neighbours, friends, strangers, etc., are most important for the liveliness index, followed by the provision of seating, both commercial and public. Personalisation is also statistically significant and describes how the interface of businesses with the street (building façade, entrances, shop windows) is embellished with personal touches, such as displays, decorations, signs, banners, planters, flowerboxes, and other wares. The variables permeability and variety of businesses are only significant in one study each [14,32]. Sidewalk widths are only significant in a study by Metha [32], and seem to be more of a mediating variable that is less relevant on its own but allows for facilities, such as seating, on the sidewalk that foster place activities. No significant influences on the liveliness index have been identified for shade provided, the existence of street furniture besides seating, the articulation of façades, and the degree of independence of the adjacent stores.

In addition to these empirical analyses of the influence of streetscape, urban design, and land use on pedestrian activities, various schemes for assessing walkability exist, e.g., the Pedestrian Environment Review System (PERS) [36], the Microscale Audit of Pedestrian Streetscapes (MAPS) [37] or the Healthy Street Checks applied by Transport for London [38]. These studies mainly rely on expert knowledge. They formulate recommendations for how to check the friendliness and suitability of street network elements for walking and place activities, and for how to improve walkability. The street characteristics included in these walkability assessments correspond well with the significant variables identified in the literature as described above, but go beyond this empirical evidence based on expert knowledge. Various street characteristics are investigated in walkability assessments, and these can be grouped along (1) destinations and land use, (2) street scape, and (3) aesthetics and social aspects [37].

Gehl [12] distinguished twelve quality criteria for high-quality street spaces for pedestrians. The criteria are grouped into the following categories:

- Protection—objective and subjective (perceived) safety against traffic and traffic crashes, as well as security against crime, are prerequisites and motivating factors for walking and for place activities. In addition, “protection against unpleasant sensory experiences” is to be considered;
- Comfort—after taking safety and security issues into account, the provision of comfortable public spaces must be ensured in order to invite people into different movement and place activities. For pedestrians, sidewalks should offer sufficient space void of obstacles (e.g., a dedicated footway clear zone) and good surface quality. Providing space for different place activities invites place users to spend time in public spaces;
- Delight—to ensure the well-being of pedestrians and place users, the human scale (in regard to adequate street width and building height) must be taken into account. The delight of design with respect to details and materials, as well as green structures, promote walking and the enjoyment of public spaces by place users.

Gehl [12] does not provide any quantitative validation for these twelve criteria, such as a comparison with empirically measured volumes of pedestrian movement or place activities. However, he lists various examples for the successful application of these criteria in projects for redesigning streets and public spaces all over the world [39].

2.3. Governance and Stakeholder Engagement

Studies in urban design, and particularly the projects published by the groups around Mehta et al. [13,14,32,35,40] and Gehl et al. [12,39], clearly show that successful provision for pedestrians needs more than tailor-made and pedestrian-focused designs. Designing and managing liveable streets is an interdisciplinary task that can only be achieved if far more stakeholders collaborate than only urban and transport designers.

Cities have a prominent role in initiating and coordinating such collaboration and in developing policies that support the various community-based stakeholders to engage in improving and actively using the streets in their neighbourhood. Incentive schemes

might be set up that create or strengthen small independent businesses, especially those that are perceived as community places. Longer and more flexible opening hours for local businesses might be considered and encouraged, contributing to active street usage over the whole day, week, and year. Cities might transfer some level of control to businesses and users so that these local stakeholders are enabled and feel invited to claim street space, e.g., by providing movable street furniture or by allowing businesses to use parts of the street for their activities and facilities. Incentives might also be given for the organisation of events such as street closures, festivals, open classroom projects, or other activities that strengthen the community. Temporary changes in the use of parts of the streets, e.g., by allowing parklets in summer, by closing lanes or taking out parking lots, e.g., on selected weekends, might also encourage pedestrian activities and give a different perspective on the potential of streets and possible perspectives.

Local building codes might support permeable and articulated façades at the street level. Nooks, alcoves, small setbacks, steps and ledges serve multiple purposes, e.g., people might seek shelter, get out of pedestrian flow, or stop and rearrange their belongings.

Streets are ecosystems; their users and usages constantly evolve. Streetscapes that are perfect for today might not be suitable in the near future. In addition, successful, liveable streets are well maintained streets; therefore, street management should be treated as equally important as the design. Regular evaluations of users and usages are needed in order to modify the street accordingly if change happens. Regular street management includes the operation of removing trash, sweeping and keeping the sidewalk clean, repairing and replacing furniture, maintaining trees and plants, etc. Local stakeholders might engage in some of these activities, and they might be supported by small and flexible funding schemes provided, e.g., on the city level.

3. Recommendations of Facilities for Walking and Place Activities in Guidance Material on Urban Street Design

3.1. Methodology for Collating and Synthesising Guidance Material

Data on guidance material for facilities for walking and place activities were gathered based on the MORE project (Multimodal Optimisation of Roadspace in Europe, <https://www.roadspace.eu/> (accessed on 14 August 2021), which brings together urban street designers from all over Europe. This project provides the unique opportunity to assemble guidance material on urban street design in local languages, to combine it into a standardized, approach as well as to gather background information about how this material is generated and used in daily planning practice. Guidelines and additional material in English—but also in various local languages—could therefore be synthesised for various European countries and, in particular detail, for the MORE city and corresponding country partners of Budapest, Constanta, Lisbon, London, and Malmö. Questionnaires with the following blocks of questions have been sent out to partners as the basis for collating relevant material: genesis and responsibilities for developing guidance, systems of road function classification, objectives and performance indicators for urban street design, specific recommendations for each street user group (pedestrians, cyclists, public transport, private motorised traffic, kerbside activities, etc.), and safety issues.

Partners from the MORE project filled in the questionnaires and provided relevant material. Intense discussions and feedback loops for translating materials and for compiling consistent information for all cities and countries followed and led to standardised comparisons for all street user groups. Further materials from other countries beyond the MORE partners have been included in order to get a broad picture of international practice in urban street design. Gerike et al. [6] have provided further information on this methodological approach.

The focus of this paper is on pedestrians and place activities. For these user groups, we analysed and summarised the following aspects in Table 1:

- Space requirements for moving pedestrians (movement function)—What width is assumed for “standard” pedestrians and for pedestrians with increased space require-

ments such as wheelchair users? Space requirements for two or more pedestrians are also provided in some references and included in Table 1. The reason for this is that sidewalks are never used in only one direction. Pedestrians are free to move in any direction on either side of the street and they extensively make use of this capability. This must be considered when designing pedestrian facilities;

- Space requirements for sidewalk equipment—What width is assumed in the guidelines for the various items that might be placed on sidewalks such as street furniture or greenery?
- Standard widths of sidewalks—How are the space requirements for movement and the place function translated into sidewalk widths? Which widths are recommended for sidewalks under differing conditions?
- Components/zones of sidewalks—Some references distinguish different zones of sidewalks;
- Recommendations on place functions—This part of the table summarises recommendations for supporting place functions of sidewalks;
- Crossing facilities—Besides the sidewalks, crossing facilities are very important for pedestrians as a vulnerable and highly detour-sensitive user group; recommendations on this topic are therefore also included in the table.

3.2. Summary of Recommendations Provided from Guidance Material

Table 1 combines the information taken from the researched guidance material on urban street design to provide an easily accessible comparative overview of the standards in the different countries and cities.

The combined research material shows that standards for space requirements of pedestrians are provided in most references and are comparable to one another. The width of a standard pedestrian varies between 0.55 m and 1.00 m. The main reason for this range seems to be the different definitions, as some references include (and others exclude) buffer space in the provided dimensions for standard pedestrians. Values for two pedestrians are given with few exceptions, and vary between 1.50 m and 2.00 m. Only the German guidelines on urban street design are clear and exacting, specifying that sidewalks should generally be scaled based on space requirements for two pedestrians. This specification is based on the fact that pedestrians walk in either direction on a sidewalk and that sidewalks should be generally designed in a way that allows two pedestrians walking in opposite directions to meet and pass each other.

Measurable differences were identified among buffer zones; these ranged from 0.00 m to 1.00 m. The criteria used for choosing buffer zone widths for each design task are consistent across locations. Buffers to the carriageway depend on speed and volume of motorised traffic. Buffers to the edge of the street depend on the type and size of adjacent buildings. However, the values themselves differ greatly.

The fairly similar space requirements for pedestrians summarised above translate within the researched guidance material into very different recommended sidewalk widths ranging from 1.00 m upwards. This wide range shows the difficulty of integrating adequate sidewalk widths into urban street layouts. A sidewalk of 1.00 m means that one standard pedestrian with an assumed width of 0.75 m can walk on this sidewalk with about 0.12 m buffer on both sides. One pedestrian needs to leave the sidewalk if two pedestrians walking in opposite directions meet each other. A wheelchair user with a width of 0.90 m can use this sidewalk with a 0.05 m buffer to each side. On the one hand, this is not very comfortable, and, on the other hand, it is also a safety issue when pedestrians use the carriageway when meeting each other. The authors of the guidance material are definitely aware of pedestrian space requirements and of the problems that might result from very narrow sidewalks. Nevertheless, they include these low values for sidewalk widths into their recommendations. The main reason for this is space scarcity. Particularly in historic city centres, it is rarely possible to accommodate all user requirements into the limited available street space. Low minimum values, e.g., for sidewalk widths, could help with

finding compromises for such challenging design tasks, and in the minds of the authors of the guidance material, these low values can be applied for pedestrians more easily than, e.g., for buses, which simply cannot pass a cross-section when lanes are too narrow.

Some references provide specific guidance for bottlenecks; these might help in such cases. For example, Transport for London [50] allows for a minimum width of the footway clear zone of 1.00 m, and for a maximum length of 6 m. Two pedestrians cannot meet each other here, but they might wait at a passing point until the bottleneck is cleared and can be passed. The Municipal Chamber of Lisbon [47] recommends coexistence streets (shared spaces) in situations of limited space availability; further references recommend taking out selected functions completely (such as parking), and thus allowing for regular widths for the remaining elements in the street [45].

The criteria for choosing sidewalk widths beyond minimum values are (1) the street type (Budapest/Hungary, Lisbon, London, Madrid, Malmö, Germany, Spain, The Netherlands), (2) speeds and volumes of motorised traffic (Austria, Germany, NACTO), (3) pedestrian volumes (Budapest/Hungary, Constanta, London, Switzerland), (4) the existence of parking or cycling facilities (Austria), (5) or proximity to specific destinations such as schools or retirement homes (Germany, Malmö).

The criteria for distinguishing street types for criterion (1) are based on road function classification, using mainly one-dimensional systems such as urban and district roads/local collector roads/local access roads in Madrid, or residential streets/major streets/commercial streets in Budapest. London's [70] approach to movement and place functions is a two-dimensional system for road function classification that disentangles user requirements in terms of pedestrian movement (walking) and place activities (staying). It is thus more detailed and better suitable for designing sidewalks that fit specific user needs in each of the two dimensions. Some references describe street types based on specific street characteristics, such as the location of the street section (e.g., inner versus outer city, proximity to specific destinations such as schools or retirement homes), characteristics and usage of adjacent buildings or traffic (e.g., volumes of motorised vehicles); these characteristics show an overlap with the more specific criteria (2) to (5).

The second criterion of speeds and volumes of motorised traffic focusses on safety and buffer zones. The third criterion (pedestrian volumes) seems to be very suitable for optimally matching sidewalk design and user needs. The disadvantage of this criterion is that it is based on the status quo and not on anticipated or desired pedestrian volumes. In addition, it is difficult to apply because of insufficient knowledge on pedestrian volumes. Discussions with city partners in the MORE project revealed that pedestrian volumes are hardly considered for sidewalk design, even when these are listed as criteria in the local or national guidance material, mainly because of a lack of data availability. Criterion (4) again focusses on safety and buffer zones, while criterion (5) is a suitable input for deciding on sidewalk width and is frequently applied.

More sophisticated references provide not only recommendations for the overall sidewalk width, but also give additional recommendations for different zones of the sidewalk [45,47,50,54,67]. This approach allows for a clear separation of movement and place functions. The footway clear zone (also called pedestrian through zone) is the part of the sidewalk that should be kept clear from any obstacles and that is dedicated to the movement function; it should allow pedestrians to move safely and comfortably. The recommended minimum width for footway clear zones is 1.20 m in Lisbon (on existing 4th or 5th level streets); 1.50 m in Budapest, Constanta (street category III), London (acceptable minimum) and the U.S.; 1.80 m in Germany, Madrid, Lisbon (for new streets), Spain and The Netherlands, and 2.00 m in Austria, London and Switzerland 2.00 m as the preferred minimum.

Table 1. Recommendations for Pedestrian Facilities in Guidance Material on Urban Street Design.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
Space Requirements (Width)													
Standard Pedestrian	1.00 m (including buffer on each side)	0.55 m + 0.10 m buffer on each side = 0.75 m	No rec.	0.80 m (value is given only in one figure where 2 pedestrians are shown)	0.655 m	0.75 m	0.55 m	0.70 m	No rec.	0.65 m	0.80 m/1.00 m	0.80–1.00 m (person with pram narrowest width 0.80 m, person with suitcases widest width 1.00 m)	0.55–1.00 m (with and without buffer space)
Two or More Pedestrians	2.00 m, min. 1.50 m	Adult + child: 1.30 m + 0.10 m buffer on each side = 1.50 m Family (2 adults + 2 children): 2.80 m + 0.10 m buffer on each side = 3.00 m	No rec.	Two standard pedestrians: 1.80 m (each pedestrian 0.80 m + 0.20 m buffer in between)	Two standard pedestrians: 1.50 m	Two standard pedestrians: 1.50 m Adult + child: 1.20 m	≥1.14 m (two persons holding each other tightly)	No rec.	No rec.	1.50 m two standard pedestrians 1.60 m standard pedestrian + wheelchair 1.80 m three standard pedestrians	2.00 m two standard pedestrians	2.10 m (two pedestrians with suitcases)	Adult + child: 1.20–1.50 m Two pedestrians: 1.14–2.10 m Family: 3.00 m
Increased Space Requirements (Width)													
Blind Person with Assistance	No rec.	No rec.	No rec.	1.20–1.30 m	No rec.	1.20 m	No rec.	1.20 m	No rec.	No rec.	1.25 m	No rec.	1.20–1.30 m
Person with Walking Cane	No rec.	0.80 m + 0.10 m buffer on each side = 1.00 m	0.95 m	0.85–1.20 m	No rec.	0.75 m	1.21 m	No rec.	No rec.	0.80 m	1.25 m	No rec.	0.75–1.25 m
Person with Crutches	1.00 m	0.80 m + 0.10 m buffer on each side = 1.00 m	0.90 m	1.00 m	No rec.	0.90 m	0.79 m	No rec.	No rec.	0.80 m	1.00 m	No rec.	0.79–1.00 m
References													
	[41]	[42]	[43,44]	[45,46]	[47]	[48–50]	[51]	[52,53]	[54]	[55]	[56]	[57,58]	

Table 1. Cont.

Increased Space Requirements (Width)													
	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
Person in a Wheelchair	0.90 m	0.80 m + 0.10 m buffer on each side = 1.00 m	0.80 m	0.90 m	0.90 m × 1.20 m, two persons with wheelchair ≥1.80 m	0.90 m	0.84 m	0.80 m	No rec.	0.90 m	1.25 m	0.85–0.90 m	0.80–1.25 m
Person with Luggage	1.00 m	0.80 m + 0.10 m buffer on each side = 1.00 m	No rec.	No rec.	No rec.	No rec.	1.24 m	No rec.	No rec.	0.90 m	1.25 m	1.00 m	0.90–1.25 m
Person with Pram	No rec.	0.55 m + 0.10 m buffer on each side = 0.75 m	No rec.	1.00 m	No rec.	Plus one adult beside: 1.50 m	1.62 m (with pram and child)	0.70 m	No rec.	0.80 m	1.00 m	0.80 m	0.75–1.50 m
Space Requirements for Street Furniture (Width)													
Benches	1.00 m	No rec.	No rec.	≥1.00 m	≥1.20 m	≥0.50 m (space to be kept clear in front of a bench)	≥0.60 m (space to be kept clear in front of a bench)	2.00 m	No rec.	≥1.20 m	≥1.50 m	≥1.20 m	1.00–2.00 m
Green Space without Trees	No rec.	No rec.	No rec.	≥1.00 m	No rec.	No rec.	No rec.	No rec.	No rec.	No rec.	≥1.50 m	No rec.	≥1.00 m
Green Space with Trees	No rec.	No rec.	0.75–1.00 m	2.00–2.50 m	≥1.20 m	No rec.	1.00 m, 1.50 m for bigger trees	> 2.50 m	No rec.	1.20 m	No rec.	Rec. to provide green at borough level	≥0.75 m
Waiting Area at PT Stops	1.50–4.25 m (depending on pass. volume)	≥1.50 m	≥2.00 m (≥2.80 m with cyclists)	≥1.50 m (excluding the shielded area)	≥2.60 m	Wide enough	≥1.50 m	2.30 m	1.83–3.05 m	1.50 m (including the shielded area)	≥1.50 m	≥1.80 m (bus stop, whole sidewalk width)	≥1.50 m
References													
	[41]	[42]	[43,44]	[45,46]	[47]	[48–50]	[51]	[52,53]	[54]	[55]	[56]	[57,58]	

Table 1. Cont.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
	Standard Width of Sidewalks												
Width and Conditions	Standard widths: 2.00 m (residential streets or SL ≤ 40 km/h or next to parallel parking or independent sidewalk off the carriageway), 2.30 m (next to cycle lane), 2.50 m (SL=50km/h or next to perpendicular parking), 3.00 m (SL ≥ 60 km/h) Increased width for higher ped. volumes Min. widths are provided in addition	Min. width 1.50 m, recommended width 3.00 m Useable width of sidewalk: 1.5 m + n \times 0.75 m (n = number of pedestrians) Width of sidewalk depends on street type, available space and pedestrian volume. Recommended width per street type: Living/residential street: 1.50–3.00 m Major street: ≥ 3.00 m Commercial street: ≥ 4.50 m PT stop area: ≥ 3.00 m	1.00 m–4.00 m depending on pedestrian volumes	Standard width: 2.50 m (1.80 m for two persons + buffer to adjacent buildings and carriageway) Wider sidewalks for AADT > 5000 v/24 h + higher density/height of adjacent buildings + commercial usage of adjacent buildings, high frequency PT Wider sidewalks also in the vicinity of specific destinations such as retirement homes, schools, shopping centres	Min. width: General (including trees, lighting, etc.): 3.00 m Usable width in new streets: 2.00 m Usable width in pre-existing streets: ≥ 1.20 m on 4th/5th level streets ≥ 1.50 m on 2nd/3rd level streets ≥ 1.50 m in every other situation Coexistence streets (shared space) in cases of space scarcity	Min. width: 2.00 m in lightly used streets (such as those with purely residential function) The width of the sidewalk varies depending on pedestrian volumes	Urban and district roads 6 m (4 m min.) Local collector roads (2 lanes) 6 m (3 m min.) Local collector roads (4 lanes): 6 m (4 m min.) Local access roads 3 m (2.50 m min.) Min. for bottlenecks 2.00 m Rec. for pedestrian main routes 6 m	Min. width: 2.00 m In inner city environment next to higher buildings the sidewalk should not be less than 2.50 m	Desired minimum clear zone of 2.13 m and an absolute minimum of 1.52 m Where a sidewalk is directly adjacent to moving traffic, the desired minimum is 2.44 m, providing a minimum 0.61 m buffer for street furniture and utilities	Urban and district roads 6 m (4 m min.) Local collector roads (2 lanes) 6 m (3 m min.) Local collector roads (4 lanes): 6 m (4 m min.) Local access roads 3 m (2.50 m min.) Min. for bottlenecks 2.00 m Rec. for pedestrian main routes 6 m	Standard width: 2.50 m (min. 2.00 m) Rec. widths: clear zone (2.00–3.00 m, depending on ped. volumes and proportion of persons with increased space requirements) plus buffer space	Standard 1.80 m (sufficient for two wheelchair users or wheelchair and pram to pass) Min. 1.20 m (max. 10 m length) Min. 0.9 m (bottlenecks, e.g., to pass a light pole) Shopping streets: ≥ 1.5 m (<100 p/h); ≥ 2.4 m (>100 p/h) ≥ 4.0 m free space in main shopping streets	Width: ≥ 1.00 m Dependencies: Land use and height of buildings Street type Available space Pedestrian volume Frequency of PT Existing vs. new streets
	References												
	[41]	[42]	[43]	[45,46]	[47]	[48–50,59]	[51]	[52,53,60]	[54]	[61]	[56,62]	[57,58,63]	

Table 1. Cont.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
Components/Zones of Sidewalks													
Clear Zone	2.00 m, min. 1.50/1.20 m (max.1 m length) and 0.90 m at one point	≥1.50 m	Street category I: 2.00 m Street category II: 1.50 m Street category III: 1.00–1.50m	1.80 m	Min. 1.80 m in new streets Min. 1.50 m on 2nd/3rd level streets Min. 1.20 m on 4th/5th level streets	≥2.00 m (preferred minimum, unobstructed width)	1.80 m	Should be provided, but no information on width	1.52–2.13 m in residential settings 2.44–3.66 m in downtown/commercial areas	Min. ≥ 1.50 mm Rec. 1.80 m	See sidewalk widths above	See sidewalk widths above	≥1.00 m
Buffer to Adjacent Buildings	No rec.	0.50 m	≥1.00 m	0.20 m (0.00 m in case of no buildings or low fences)	≤0.60 m	0.30 m	0.45 m	Should be provided, but no information on width	No rec.	0.50 m	≥0.20 m	No rec.	0.00–1.00 m
Buffer to Carriageway/Kerb Zone	No buffer (SL ≤ 40 km/h) 0.50 m (SL = 50 km/h) 1.00 m (SL ≥ 60 km/h)	0–30 km/h: 0.00 m 31–50 km/h: 0.25 m 51–70 km/h: 0.50 m 71–100 km/h: 1.00 m	0.25 m	0.50 m in standard busy streets 0.30 m in case of low goods traffic and residential streets	0.30 m	0.45–0.60 m	0.40 m	Should be provided, but no information on width	0.61 m Otherwise enhancement zone with bike lanes, parklets or kerb extensions	0.50 m	0.20–0.50 m for SL ≥ 50 km/h ≥0.20 m to parallel parking ≥0.50 m to perpendicular parking	No horizontal space requirements, but required bicycle paths or lanes along distributor roads (SL ≥ 50 km/h) located between the carriageway and the sidewalk No buffer between bicycling path and pedestrian area	0.00–1.00 m
References													
	[41]	[42]	[43,44]	[45,46]	[47]	[48–50]	[64]	[52,53,60,65]	[54]	[61]	[56]	[58,63]	

Table 1. Cont.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
Components/Zones of Sidewalks													
Furniture Zone	No rec.	1.00 m	No rec.	≥1.00 m Reference values for width for specific place functions, higher widths for specific street types, next to specific POIs	Parklets: 2.00–2.50 m; Terrace/gastronomy: ≥2.00 m if terrace is provided, clear zone ≥2.00 m	0.50–2.00 m with detailed information on space requirements of different types of street furniture	Kiosks 1.20 m	Should be provided, but no information on width	Yes, but no information on width For parklets: 1.68 m	Min 1.00 m, kiosks 2.50 m, light poles 0.70–1.00 m, trash cans 0.90 m, terrace 2.10–2.50 m, water fountains 1.50 m Min. 0.40 m between furniture and kerb to carriageway	See frontage zone	General recommendation for place advertisement, information panels, traffic sign, light poles and the like, outside of walking routes	0.50–2.00 m
Frontage Zone	1.00 m	1.00–1.50 m	No rec.	≥1.00 m	Shop displays and showcases: 1.00 m	Yes, but no information on width	0.90 m	Should be provided, but no information on width	Yes, but no information on width	1.50 m	≥1.20 m for vitrines/sales booths, ≥0.50 m for street café, ≥0.20 m for advertisement/info panels/parking meter	0.90 m clear from obstacles such as parked bicycles so that facades and fences can offer guidance to visually impaired pedestrians	≥1.00 m
References													
	[41]	[42]	[43,44]	[45,46]	[47]	[48–50]	[64]	[52,53,60,65]	[54]	[61]	[56]	[58,63]	

Table 1. Cont.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
	Recommendations on Place Function												
Place Function	No rec.	<p>Staying, waiting, leaning against the wall: 0.70–1.00 m</p> <p>Two to three persons chatting/sitting: 1.50–2.00 m</p> <p>Places to stay (e.g., gastronomy, benches) or to play: 2.50–3.00 m</p> <p>Spacious places to stay or to play: ≥ 4.00 m</p>	No rec.	<p>Installation of benches at appropriate intervals</p> <p>Public spaces should primarily be created by widening a section of sidewalk in addition to the area provided for moving along This also includes the creation of play spaces.</p>	<p>Installation of benches at appropriate intervals: 50–150 m</p>	<p>Seating on key pedestrian routes should be considered every 100 m to provide rest points and to encourage street activity, max. recommended spacing interval on high streets and city places 50 m</p> <p>Places to stay/chat: ≥ 2.50 m</p> <p>Places to play: ≥ 4.00 m</p>	<p>Benches: One every 30 m on sidewalks</p> <p>Playgrounds areas: 20 m² for every 100 m² of green spaces, parks or boulevards</p>	<p>Installation of benches every 25 m in pedestrian zones otherwise every 50 m</p> <p>Next to benches, garbage bins should be installed</p>	<p>Street space can be reused for different purposes, such as parklets, bike share, and traffic calming</p>	<p>Benches every 50 m in pedestrians routes</p>	No rec.	<p>Benches at intervals of about 100 m in city centres and near retirement homes, 200 m outside city centres, ≥ 1.20 m in front of a bench</p> <p>Further qualitative recommendations: Create car-free city centres, provide sufficient resting areas, provide green facilities at the level of boroughs, e.g., parks, dog walking areas, and playground</p> <p>Improve the attractiveness at street level with interesting architecture, green spaces such as planting, or rows of trees along a road, and water such as a pond or ditch</p>	<p>Benches: 25–150 m</p> <p>Places to stay/chat: 1.50–2.50 m</p> <p>Places to play: ≥ 4.00 m</p>
	[41]	[42]		[45,46]	[47]	[48–50]	[64]	[52,53,60]	[54]	[66]		[58,63]	

Table 1. Cont.

	Austria	Budapest	Constanta	Germany	Lisbon	London	Madrid	Malmö	NACTO	Spain	Switzerland	The Netherlands	Summary
	Recommended Crossing Designs												
Crossing Designs	Pedestrian crossing (Zebra Crossing) Traffic signal central median Under-/overpass (exemption)	Central median Physical without priority (plateau/raised block-paved area) Pedestrian crossing (Zebra Crossing) Pedestrian crossing with physical measures Traffic signal Under-/overpass	No rec.	Central median Physical without priority (plateau/raised block-paved area) Pedestrian crossing (Zebra Crossing) Pedestrian crossing with physical measures Traffic signal Under-/overpass	Central median Pedestrian crossing (Zebra Crossing) Traffic signal	Central median Physical without priority (plateau/raised block-paved area) Pedestrian crossing (Zebra Crossing) Pedestrian crossing with physical measures Traffic signal Under-/overpass	Central median Pedestrian crossing (Zebra Crossing) Traffic signal Safety islands in big roads Under-/overpass	Central median Physical without priority (plateau/raised block-paved area) Pedestrian crossing (Zebra Crossing) Pedestrian crossing with physical measures Traffic signal	Central median or central island Pedestrian crossing (e.g., Zebra Crossing) Traffic signal	Pedestrian crossing Central median Traffic signal	Pedestrian crossing (Zebra Crossing) Traffic Signal Central Median, refuge Under-/overpass (exemption) Pedestrian zone, shared space	Pedestrian crossing: Zebra Crossing Signal controlled crossing Under-/overpass The first two types of crossings may be combined with a median island Speeds should be reduced to 30 km/h at zebra crossings	Central median Physical without priority (plateau/raised block-paved area) Pedestrian crossing (Zebra Crossing) Pedestrian crossing with physical measures Traffic signal Under-/overpass
	Criteria for Selecting Types of Crossing Facilities												
Criteria	Criteria: ped. and veh. volumes No need for crossing facility: veh. volumes < 100 v/h Crossing facility recommended: 100–300 v/h (depending on ped. volumes) Crossing facility mandatory: higher veh. volumes	Crossing facilities are necessary if there is a distinct crossing need; Traffic volume > 1000 v/h, speed limit 50 km/h; or Traffic volume > 500 v/h and speed limit > 50 km/h.	No rec.	Crossing facilities are necessary if there is a distinct crossing need; Traffic volume > 1000 mot. veh. per hour, SL = 50 km/h; or Traffic volume > 500 v/h, SLt > 50 km/h.	Zebra Crossings should be used whenever no traffic lights could be provided, To reduce speed and to avoid accidents	Zebra Crossings are only recommended for low-speed environments, 35 mph or less Underpass only under exceptional circumstances with high pedestrian demand	3 main criteria: Veh./ped. volumes, road hierarchy, land use Pedestrian crossings when >1000 v/h and >100 ped/h Local roads: Zebra Crossings Collector roads zebra or traffic signal crossings Urban and district roads, traffic signal crossings or underpass	Crossing design depends on: Traffic safety Whether a carriage-way or a cycle path should be crossed	On streets with higher volume (> 3000 AADT), higher speeds (> 20 mph), or more lanes (2+), crosswalks should be provided At places with high ped. demand marked crossings may be beneficial regardless of traffic conditions	No rec.	Criteria: Local or linear crossing needs, widths of carriageway, vehicle volumes, speed limit, pedestrian volumes, proportion of pedestrians with special requirements (proximity to destinations such as schools)	Road category (distributor or access road) Location at crossing or road section (and local situation such as nearby a school)	Typical criteria: Crossing need for pedestrians High traffic volume High speed High pedestrian demand
	[41]	[67]		[45,46]	[47]	[50]	[64]	[68]	[54]	[66]	[62,69]	[63]	

No rec. = no recommendation; PT = public transport; Veh = vehicles; Min = minimum; AADT = annual average daily traffic; rec. = recommendation; SL = speed limit; p/h = persons per hour; Ped. = pedestrians.

The frontage zones, furniture zones, and kerb zones are spaces that are dedicated to place functions or that serve as buffer zones, as described above. Recommendations for place functions are very technical in the researched guidance material, and include mainly space requirements for street furniture such as benches, parklets, terraces, gastronomy tables/seating, waiting areas at public transport stops, or parking facilities for bicycles. Malmö is the most advanced in providing space requirements for greenery. Transport for London [50,59] lists possible place activities for different widths of the furniture zone. Some references work with pictograms to visualise possible sidewalk usages for specific sidewalk widths; for example, they provide a pictogram showing a group of pedestrians who chat and give the necessary sidewalk width for this scenario [6]. Provision for place functions is additionally included in the increased sidewalk width for specific street types, as described above.

Overall, the focus of the researched guidance material is clearly on the movement function for pedestrians; rarely is any information given about how to design pleasant spaces for place users that fit to the human dimension and that encourage users to stay, sit, chat, etc.

4. Comparison of Empirical Evidence and Guidance Material in Urban Street Design

Empirical evidence in the researched literature consistently shows the dominance of the D variables for pedestrian volumes, including pedestrian movement and place activities. Density, Diversity of land uses and Distance to public transport are significant determinants of walking and, with less comprehensive empirical evidence, also for place activities in all the studies identified in the literature research. Streetscape also matters, but with less importance compared to the D variables at the neighbourhood level. Floor area ratios, the proportion of retail frontage or other active uses of the adjacent buildings, as well as façade design, are the most important variables at the street level. Transparency at the ground floor level is of particular relevance; people like to see what happens inside the buildings next to the street. These street characteristics, as well as the D variables on the neighbourhood level, are shaped by urban planning rather than by transport engineering.

Sidewalk width, street furniture and amenities are the relevant variables related to actual street design. Sidewalk width shows ambiguous causality: wider sidewalks are implemented in locations with observed or anticipated high pedestrian volumes, and they allow the placing of (more) street furniture and amenities, thus inviting pedestrian activities. Empirical evidence clearly shows that street furniture and particularly seating increase pedestrian volumes, and the relationship between sidewalk width (other things being equal) and pedestrian volumes is thus clear.

The comparison of this empirical evidence in the scientific literature with the compiled guidance material shows that they are not well linked. Guidance material for pedestrian facilities focusses on space requirements for specific furniture and usages of sidewalks. Recommendations on which sidewalk design to choose in a specific location are based on criteria that focus on safety and buffer zones (e.g., existence of parking), pedestrian volume (a criterion that is hardly measured and only represents the current situation), or street types, without good support from scientific evidence. The street type approach as such, in combination with the proximity to relevant destinations, seems to be the most suitable criterion for deciding on sidewalk width and design. However, it should make use of the determinants for pedestrian movement and place activities, as these have been identified in the literature. These are the D variables, particularly Density, Diversity and Distance to public transport. In terms of classification, the characteristics of adjacent buildings, particularly at street level, should be considered as one criterion for defining the street type. Based on street type classification, recommendations should be given for sidewalk widths, design and equipment. These should cover both the movement function for pedestrians (walking) and place activities.

5. Recommendations for Advancing Guidance on Urban Street Design

Based on the findings so far, this section develops recommendations for pedestrian facilities in future guidelines on urban street design.

Movement Function:

- In a supply-oriented approach, an adequate standard width for sidewalks should be provided in the guidance material as a basic standard value, independent of expected pedestrian volumes. These should include a footway clear zone that allows two pedestrians to meet/pass each other and buffer zones to adjacent usages;
- For the footway clear zone that should be kept free of any obstacles, a minimum value of 1.80 m seems to be suitable. This is the width that allows two standard pedestrians to pass each other (0.80 m + 0.20 m + 0.80 m). This value would be 1.90 m if the goal were to allow one standard pedestrian and one wheelchair user to pass each other (0.80 m + 0.20 m + 0.90 m). The chosen standard width for a pedestrian of 0.80 m is in the upper range of values identified in the guidance material, but seems to be suitable given the ageing population in many countries all over the world, which is related to a growing number of pedestrians with increased space needs;
- Buffer zones to buildings and the carriageway should be scaled depending on the height of the buildings and the usage of the carriageway. For residential streets with low traffic volumes and speed, small buffer values are sufficient. For busy streets with higher speeds and volumes of motorised vehicles, bigger buffer zones between the pedestrians and the moving motorised traffic are necessary (≥ 0.30 m). Guidelines should also provide recommendations for the adequate separation of pedestrians from cyclists, scooters, and other micromobility vehicles. Guidelines might not only provide guidance on the dimensions of buffer spaces, but also on their design, with possible reference to the design-for-all principles, water treatment, and the provision for place functions;
- For street sections with higher observed or expected pedestrian volumes, greater widths for the footway clear zones should be recommended, following again a supply-oriented approach. These street sections can be identified based on the street type approach, as described above. Alternatively, pedestrian volumes can be counted. Automated counting facilities for pedestrians are increasingly available, and allow for counting at more locations and for longer time periods. Future expected or envisaged changes in pedestrian volumes need to be considered in this case;
- Guidelines should also provide recommendations for types and locations of crossing facilities. These are paramount for achieving high levels of subjectively perceived and objective safety.

Place Function:

- The street type approach also seems to be a suitable basis for providing recommendations for place functions. It allows for implicitly considering differences in place functions resulting from different types and usages of the buildings next to the street and in the neighbourhood (the D variables), as well as resulting from the vicinity to public transport stops or further specific destinations;
- Recommendations should be given for the amount of space to be provided for place functions (quantity), and also for how to design and equip this space (quality). The qualitative descriptions of requirements for benches, characteristics of attractive spaces, etc., in [57,58] might be a suitable starting point for this;
- Guidance on seating should be provided, as this variable was found to increase pedestrian activities significantly in all the researched scientific references. Seating should be preferably located near activity-supporting businesses or facilities, and it should also allow groups of people to sit together and to engage in any kind of social activity;

- Shade and shelter, street furniture, and greenery are further significant determinants of pedestrian activities and should also be included in future guidelines on urban street design in terms of location, quality, and quantity;
- Road function classification is also of great importance for pedestrians. A strategic concept for pedestrian networks, including a hierarchy of main and secondary pedestrian facilities, is the basis for deciding on extra space beyond standard values and on the equipment of sidewalks (e.g., benches or public toilets). The concept of main pedestrian arteries in Madrid is a good example of such strategic development of pedestrian networks and facilities [51].

Bottlenecks:

Bottlenecks are a major problem in planning for pedestrians. Guidance should be provided about how to deal with bottlenecks. Examples of such guidance are given above in Section 3. For example, selected functions such as parking might be taken out completely in narrow parts of a street in order to gain space for pedestrians. Shared space concepts might be a solution, as proposed for Lisbon. Low speeds and volumes of motorised traffic are necessary for successfully implementing such concepts. Gehl [12] concludes from his practical work and research that these shared space concepts only work if, firstly, priority is legally given to pedestrians. Narrow sidewalks for limited and clearly defined distances, as suggested in London and in the Netherlands, are another opportunity for dealing with bottlenecks. Narrow values such as 1.00 m should be limited in their application, as otherwise, there is the risk that these become the standard values commonly used. These standard values for sidewalk width should instead be values that allow pedestrians to at least move safely and comfortably in both directions and to meet each other.

Streets as ecosystems:

Streets are vital parts of urban ecosystems. They are places where man-made infrastructure interferes with natural systems. Street design is a significant determinant for various aspects of environmental quality at the street level itself, as well as beyond. It influences the micro-climate, as well as the exposure of street users and residents in the adjacent properties to noise and air pollution, and it is one core component of water management at the city level. Designing for streets as ecosystems is an interdisciplinary task that requires collaboration between urban, transport and environmental planning, including, e.g., public works and water departments. These aspects regarding how to provide for ecosystem services and how to maximise synergies between all the different street functions are hardly covered at all in the researched guidance material on urban street design. They should be included in future guidelines with the final goal of designing streets and cities that are resilient, efficient in moving people and goods, sustainable, and enjoyable.

The NACTO guides can be seen as a best practice example for including environmental aspects into guidance on urban street design. The Urban Street Design Guide [54] stresses the importance of planning for streets as ecosystems, and gives brief guidance on important design elements, such as stormwater management, bioswales or flow-through planters. The Urban Street Stormwater Guide [71] details these aspects with a particular focus on the important aspect of stormwater management.

6. Conclusions, Summary and Outlook for Further Research

Planning for pedestrians is an interdisciplinary task that requires contributions from (1) transport planning, (2) urban planning, and (3) environmental planning, as well as (4) commitment from the city, local businesses and communities, and from other local stakeholders. Our review of scientific literature has shown that all four of these aspects are important, and that no clear priorities can be identified. Some level of trade-off seems to be possible between the four criteria. For example, one weak element, e.g., in transport planning/street design, might be compensated by strong urban design and stakeholder

engagement. However, none of these four aspects can fail entirely when the goal of lively streets must be achieved.

The review of guidance material on urban street design shows that urban street designers are well advanced in measuring space requirements for pedestrians and for pedestrian facilities, but less in planning pleasant urban environments that fit the human dimension and invite pedestrian movement and place activities.

It will be neither possible nor meaningful to integrate all relevant aspects of successfully providing for pedestrian activities as identified in the scientific literature into guidelines on urban street design. However, a better linkage with scientific evidence can greatly improve the guidance material. The recommendations given in guidelines on urban street design could be far more focused on the significant aspects as identified in scientific literature, with two types of possible positive effects: In a supply-oriented approach, sidewalk width and design match with pedestrian needs and activities at each specific location. In a demand-oriented approach, wider and more attractive sidewalks including space for pedestrian movement and place activities can be provided at the most suitable locations based on scientific evidence, thus inviting people to come and stay in the streets and to support lively cities and streets, with various positive side effects.

The suggestions of more targeted recommendations for pedestrian facilities, and particularly for place functions, in future guidelines on urban street design hopefully contribute beneficially to the discussion on how to promote walking and lively streets. This could contribute to various positive side effects in overall travel behaviour, the economy and the environment. Planning for walking and place activities will only be successful if this is done in the context of all street functions and user needs. The challenge is to find the right balance between movement and place functions for all the different user groups anew for each design task.

The current COVID-19 pandemic brings new challenges, but also opportunities. Walking is one essential aspect of resilient transport systems, and has substantially increased in importance in the last few months. Insights into behavioural changes due to COVID-19 restrictions, and also into the effects of policy measures implemented in various cities all over the world for supporting social distancing and for generally promoting walking and place activities (see e.g., [6]), should feed into future guidelines.

Sufficient evidence exists in the literature that can reliably be translated into recommendations for planners and urban street designers. Further research on the determinants of walking and pedestrian place activities would help to additionally validate the findings from the studies published so far, and to elaborate on issues that have not been addressed in detail in the existing studies.

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