IMPACT ON URBAN AMENITY IN PEDESTRIAN ENVIRONMENTS

A technical paper prepared for the Investment Decision-Making Framework Review

11 MARCH 2020

Waka Kotahi NZ Transport Agency is developing a new Monetised Benefits and Costs Manual (MBCM) to replace the existing Economic Evaluation Manual (EEM). Guidance and values have been developed for urban amenity from pedestrian and footpath improvements.

This interim guidance includes a procedure consistent with existing EEM guidance to value the benefits of quality improvements for users of footpaths and walking environments, and provides interim parameter values that can be used to value quality (including amenity) improvements. The values provided are interim until further work to confirm the parameter values in a New Zealand is complete.

The interim guidance is called ‘valuing improved pedestrian facilities’ rather than valuing urban amenity. Whilst conceptually this work has its origin in the Transport for London (TfL) tool ‘Valuing Urban Realm Tool (VURT)’, because of location-specific differences and the EEM already providing for some elements of VURT, for example safety, a framework that is conceptually and methodologically sound for New Zealand with defendable parameter values has been developed.

This report was commissioned by Waka Kotahi NZ Transport Agency and prepared by P Nunns and N Dodge.

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ABBREVIATIONS AND ACRONYMS

ATAP	Australian Transport Assessment and Planning
NZEEM	New Zealand Economic Evaluation Manual
OLS	Ordinary least squares
RP	Revealed preference
SP	Stated preference
TAG	Transport Appraisal Guidance
VOT	Value of time
WLS	Weighted least squares
WTP	Willingness to pay

EXECUTIVE SUMMARY

This report provides interim guidance on valuing quality improvements to footpaths and the pedestrian environment as a supplement to existing Economic Evaluation Manual (EEM) procedures. Previous EEM procedures have allowed for quantification of three types of benefits of pedestrian improvements: transport user benefits from faster or more direct routes, health and environmental benefits resulting from additional walking activity, and safety benefits from reduced crash risk. However, guidance has not captured benefits associated with improved quality of experience for pedestrians. Valuing quality improvements to pedestrian environments and footpaths will allow for a better understanding of the benefits of investing in different types of pedestrian improvements and prioritisation of projects that are most likely to deliver the best value for money.

This interim guidance:

- provides interim parameter values that can be used to value quality improvements to the pedestrian environment, based on a systematic review and meta-analysis of international research on how people value different aspects of the pedestrian realm, and
- outlines a procedure that can be used to value the benefits of quality improvements for users of footpaths and walking environments, consistent with existing EEM guidance for valuing transport user benefits.

This interim guidance focuses on benefits that accrue to transport users, ie people who are walking on pedestrian facilities, rather than benefits that accrue to non-transport users. This guidance may be particularly useful for understanding the benefits of certain types of pedestrian improvements, such as new footpaths on residential streets that currently lack them, footpath pavement upgrades, and street furniture investment.

A systematic review and meta-analysis of international research was undertaken to identify features of footpaths and pedestrian environments that may lead to increased or decreased quality of experience for users. These features relate to three aspects of the pedestrian environment: the quality of footpath links, intersections, and the adjacent traffic environment. The role of adjacent buildings and parks is also investigated.

A total of 25 studies met the criteria for inclusion in the meta-analysis, with studies conducted in 13 countries across four continents. Research on valuing the pedestrian environment has been accelerating in recent years, with over two thirds of included studies published in the past decade. With regard to research method, studies were relatively evenly split between stated preference and revealed preference approaches. A total of 31 attributes were observed across studies, with considerable variation in the specific attributes included in each study. The top five most commonly studied attributes were traffic volume, footpath width, traffic speed, carriageway width, presence of a footpath, and presence of plants or trees.

Key findings from the meta-analysis are:

- Surrounding land use: On average, both routes through parks and routes with active retail frontages are valued by pedestrians. However, some studies find negative values on these attributes, which suggests that context may be important.
- Traffic environment: On average, pedestrians are willing to walk out of their way to be in an environment with slower traffic speeds and lower traffic volumes. However, some studies find that higher traffic volumes are positively valued, which may be due to confounding with other desirable attributes (such as slower speeds or retail main streets). Results for other traffic attributes are mixed or based on a limited number of studies.
- Footpath links: The most highly valued attributes were the presence of a footpath (as opposed to walking on the side of the road) and a covered route (eg awnings or verandas on buildings). However, these values are highly influenced by results from individual studies.

- Improvements relative to a basic footpath are also valued. Pedestrianised or shared spaces are valued more highly than basic footpaths, and higher-quality or better-maintained paving is valued. Wider footpaths have a positive value, but this finding is not consistent across studies. People also place a value on street trees and plantings, the availability of seating, wayfinding signs, and lighting/CCTV.
- People prefer to walk on routes with a reasonable level of pedestrian activity (as opposed to no people around) but they also prefer to avoid routes that are crowded with pedestrians or where cyclists also occupy the footpath. This suggests that there is an 'inverted U' relationship between footpath use and user benefits: too few people are bad, too many people are bad, but there is a 'sweet spot' in the middle.
- Pedestrian crossings: People appear to place higher value on routes that allow them to avoid crossing the road. However, if they do have to cross, they value the presence of zebra crossings or median islands, pedestrian signals, or overbridges/underpasses. They also place a modest value on dropped kerbs at crosswalks.

The report then provides interim parameter values for valuing quality improvements to each of the relevant features of the pedestrian environment, along with a rating of the level of confidence in the underlying evidence and its applicability to the New Zealand context for each parameter. These values are drawn from the systematic review and meta-analysis of international research. For the most part, this is based on the weighted average parameters of studies included in the meta-analysis, but in some cases we have adjusted these values for methodological reasons or selected preferred values based on a specific study with a stronger methodology. We have excluded parameter values for some attributes if there is weak or no evidence of benefits or if the benefits of these attributes are already addressed through other EEM procedures, such as reduced noise and vehicle emissions. We have also added suggested parameter values for some attributes that were not explicitly included in the studies we reviewed but which can readily be valued based on attributes that are measured. Further research is required to confirm the parameter values in a New Zealand context, especially for attributes where limited or low quality international evidence is available.

Finally, a procedure is outlined that can be used to value quality improvements to pedestrian facilities and illustrates it with application to several case studies. User benefits are calculated using a conventional consumer surplus formula. The attributes of all links and intersections of a pedestrian facility are used to calculate the generalised cost of using the facility. 'Generalised cost' refers to the overall perceived cost of using facilities, including time, money, and inconvenience/ discomfort.

ABSTRACT

This report provides interim guidance on valuing quality improvements to the pedestrian environment, which will allow for a better understanding the benefits of investing in different types of pedestrian improvements and prioritisation of projects that are most likely to deliver the best value for money.

A systematic review and meta-analysis of international research was undertaken to identify features of the pedestrian environment that influence quality of experience for users. A total of 25 studies met the inclusion criteria, with 31 attributes observed across studies. Results showed that surrounding land use, adjacent traffic environment, and quality of footpaths all influenced quality of experience for users. The most highly valued attributes were the presence of a footpath and a covered route. Pedestrians also value routes through parks, active retail frontages, routes with less and slower traffic, and quality improvements. People prefer routes with fewer crossings, but value crossing aids if they do have to cross.

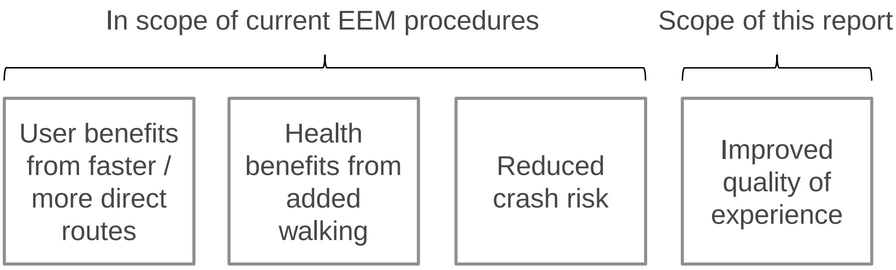
This report provides parameter values that can be used to value quality improvements and outlines a procedure that can be used to value these benefits. This guidance may be particularly useful for understanding the benefits of certain types of improvements, such as new footpaths on residential streets.

1. INTRODUCTION

This report provides interim guidance on valuing quality improvements to footpaths and the pedestrian environment as a supplement to existing *Economic Evaluation Manual* (EEM) procedures.

Appendix A20 to the EEM sets out current procedures for valuing walking improvements. As shown in Figure 1, quantifiable benefits of walking improvements may include transport user benefits from faster or more direct routes, health and environmental benefits resulting from additional walking activity, and safety benefits from reduced crash risk. However, it does not capture benefits associated with improved quality of experience for pedestrians. This is at odds with EEM procedures for valuing car, public transport, and cycling improvements that address the benefits of quality improvements such as reduced frustration in congested traffic (Appendix A4.4), public transport stop and vehicle attributes (Appendix A18.7), and separated cycling facilities (Appendix A20.2).

Figure 1: Scope of procedures for valuing improvements to footpaths and pedestrian facilities



Existing procedures are well suited for valuing some types of projects, such as new pedestrian links that enable more direct journeys or changes to intersections and signals to reduce pedestrian wait time. However, they are not well suited for valuing projects such as new footpaths on residential streets that currently lack them, footpath pavement upgrades, street furniture investment, etc. As a result, it can be difficult to understand whether these projects are likely to generate positive net benefits.

Valuing quality improvements to footpaths and pedestrian environments is an increasingly important topic for local authorities and Waka Kotahi, who are seeking to:

- better understand the benefits of investing in different types of improvements to footpaths and pedestrian environments
- prioritise investment to projects that are most likely to deliver the best value to transport users and society as a whole.

1.1 Scope of this guidance

This interim guidance:

- provides interim parameter values that can be used to value quality improvements to the pedestrian environment, based on a systematic review of international research on how people value different aspects of the pedestrian realm
- outlines a procedure that can be used to value the benefits of quality improvements for users of footpaths and pedestrian environments, consistent with existing EEM guidance for valuing transport user benefits.

A subsequent stage of research is aimed at developing New Zealand-specific parameter values. It is expected that this guidance will be updated with local parameter values when they are available.

This interim guidance does not address pedestrian modelling and demand estimation, although this is important for completing evaluations of walking projects. To value the benefits of improving a facility, it is necessary to know how many people currently use it and how many additional users may be attracted as a result of the improvement. However, pedestrian modelling and demand estimation is a different research question that entails different types of data collection and analysis.

Finally, this interim guidance focuses on benefits that accrue to transport users, ie people who are walking or using mobility devices on pedestrian facilities, rather than benefits that accrue to non-transport users. Some of the amenities that are considered in this interim guidance, such as street trees or uncluttered pavements, will also benefit surrounding residents and retailers, but this guidance does not attempt to provide parameter values for assessing those benefits.

1.2 Structure of this report

This report includes the following key sections:

- Section 2 identifies features of footpaths and pedestrian environments that may lead to increased or decreased quality of experience for users. These features relate to the quality of footpath links, intersections, and the traffic environment. The role of adjacent buildings and parks is also discussed. It then provides interim parameter values for valuing quality improvements to each of the relevant features, along with a rating of the level of confidence in the underlying evidence and its applicability to the New Zealand context for each parameter. These values are drawn from a systematic review of international research.
- Section 3 recommends a procedure that can be used to value quality improvements to pedestrian facilities and illustrates it with application to several case studies.
- Appendix A reviews international guidance on cost benefit analysis of transport investments to identify whether and how other countries address these benefits.
- Appendix B describes the systematic review of international research, including outlining how studies were selected, how values from different studies were standardised, and how findings from many studies were combined and statistically re-analysed.

2. VALUING QUALITY ASPECTS OF THE PEDESTRIAN ENVIRONMENT

This section provides interim parameter values for valuing user benefits associated with quality improvements to the footpath and pedestrian environment.

Many aspects of the footpath and pedestrian environment can affect users' quality of experience. It is necessary to ensure that values are ascribed to the specific elements that generate benefits for users, and to avoid double-counting between quality of experience benefits and safety and travel time related benefits that are captured in existing EEM procedures.

Some users may experience facilities differently, depending upon their capabilities and preferences and the circumstances under which they are using footpaths. For instance, cracked or uneven pavement may have a larger impact on people with disabilities, while availability of lighting will benefit people who are walking at night but not those who are walking during the day. It may be difficult to estimate and apply differentiated parameters without additional information on the characteristics of users, but this may be desirable for some projects.

Improved pedestrian facilities, like other transport facilities, can also have benefits for non-users, such as people who are indirectly affected by the presence of facilities in their neighbourhood or people who may value the existence of facilities or the option to use facilities in the future. The interim parameter values provided here focus on user benefits, rather than non-user benefits.

2.1 Relevant elements of the pedestrian environment

Relevant elements of the pedestrian environment were identified by:

- seeking feedback from practitioners from across the planning, funding, design, and engineering disciplines to understand applications for this guidance
- systematically reviewing international research to understand what aspects of the pedestrian environment have previously been assessed and valued
- considering whether these elements of the pedestrian environment are 'in scope' for transport investment, ie to avoid devoting effort to valuing outcomes that are not within Waka Kotahi control.

Elements of the pedestrian environment can be grouped into four broad categories, which are summarised in Table 1.

The first two elements – surrounding land use and traffic environment – relate to the context for pedestrian routes. In general, results from this meta-analysis indicates that people prefer to walk in places with attractive surroundings, including retail frontages and parks, and prefer to avoid walking in places with high traffic volumes and high speeds. Investment in improving the pedestrian environment may take these factors into account, eg when selecting where to develop a new pedestrian route, but it may not necessarily be able to directly affect surrounding land use. Traffic volumes and speeds can be influenced by transport investments such as traffic calming schemes, traffic versions, and speed limit changes.

The third and fourth elements – footpath links and pedestrian crossings – can be directly improved through transport investment. Footpath link improvements can be as varied as:

- providing footpaths where none are currently present
- improving the condition and quality of existing footpaths
- adding aesthetic elements, such as street trees or functional improvements, such as seating or wayfinding
- widening footpaths to alleviate crowding and clutter.

Pedestrian crossing improvements can include dropped kerbs at crossings as well as safe crossing aids like median islands, zebra crossings, pedestrian signals, and overbridges or underpasses. In most cases, these improvements are considered for safety reasons; however, they also appear to have some benefits for quality of experience.

Table 1: Elements of the pedestrian environment

Category	Examples of specific aspects	In scope for transport investment
Surrounding land use	• Active retail frontages • Street-facing buildings • Parks and open space	No, although pedestrian routes could be chosen to respond to land use
Traffic environment	• Street width/number of lanes • Traffic volumes • Traffic speed	Yes, although this has broader impacts on other road users
Footpath links	• Presence and width of footpaths • Footpath condition, quality, and clutter • Seating and street furniture • Street trees and plantings • Wayfinding and signage • Lighting and CCTV • Footpath activity/footpath crowding • Pedestrianisation/shared spaces • Conflict with cyclists on shared paths	Yes
Pedestrian crossings	• Dropped kerbs at crossings • Median islands • Zebra crossings • Signalised intersections • Overbridges/underpasses	Yes

2.2 Contexts for pedestrian improvements

Interventions to improve the quality of the pedestrian environment can apply anywhere where people are walking or using mobility devices.

Feedback from practitioners suggests that the following contexts are particularly relevant:

- city centre and town centre environments where there is a perceived need to improve the quality of existing pedestrian spaces
- suburban residential areas that lack footpath/pedestrian provision
- public transport station access, including provision of pedestrian routes and wayfinding
- school access, including provision of crossings and safe walking facilities.

Unless otherwise noted, the interim parameter values below are suitable for use in all of these contexts.

2.3 Interim parameter values

The interim parameter values summarised here are based on a systematic review of 25 international studies that valued aspects of the pedestrian environment. In most cases, they are based on a statistical summary of parameters from multiple studies; however, in some cases parameters from specific studies are preferred for methodological reasons.

All interim parameter values are stated in terms of how much additional time someone would be willing to spend walking to obtain the improvement. As explained in Section 3, this allows these parameter values to be easily incorporated into core EEM evaluation procedures without causing inconsistency with procedures for valuing travel time savings or crash cost reductions.

Each parameter value is assigned a high/medium/low quality score that reflects how much confidence users should have in the value. Higher scores reflect values that are drawn from a larger number of studies, while lower scores reflect values that are drawn from fewer studies or studies with weaker methodologies, or values that have a larger range across multiple studies.

Some parameter values will be updated with New Zealand-specific parameters after completion of survey research into New Zealanders' preferences for footpath quality improvements. Other parameter values may also be adjusted as a result.

Appendix B explains the underlying studies and the approached used for meta-analysis of values from those studies.

2.3.1 Surrounding land use and traffic environment

The following table provides parameter values for surrounding land uses and traffic environments. These values are stated in terms of the *percentage uplift* in walking time that an average user would be willing to incur to walk in a given environment. For instance, the parameter of 0.35 for retail frontages indicates that somebody might prefer a 13.5-minute route with active retail frontages to a 10-minute route with no active frontages.

These values apply to footpath links rather than crossings.

Table 2: Surrounding land use and traffic environment parameters

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Status
Surrounding land use			
Routes through parks	100% route through park, relative to routes in other areas	0.24	Medium confidence
Retail frontages	100% active retail frontage, relative to 0% active frontage	0.35	Medium confidence
Traffic environment			
Traffic volume	Reduce AADT by 1000 vehicles	0.05	Medium confidence
Traffic speed	Reduce average traffic speed by 1km/hr	0.03	Medium confidence, to be updated after local research

2.3.2 Footpath links

The following table provides parameter values for improvements to footpath link attributes. These values are stated in terms of the *percentage uplift* in walking time that an average user would be willing to incur to walk on a link with a given attribute. For instance, the parameter of 0.20 for street plantings and trees indicates that a typical user might prefer a 12-minute route on a footpath to a 10-minute route on the side of the road, while the parameter of 0.02 for signage and wayfinding indicates that a typical user might prefer a 10.2 minute route with wayfinding to a 10 minute route on a normal footpath.

These values apply to footpath links rather than crossings. They can be applied in a cumulative way to assess schemes that combine multiple improvements. For instance, the willingness to pay (WTP) value for a covered route with lighting and moderate levels of activity, relative to an uncovered route without lighting and with few other ‘eyes on the street’ would be equal to the sum of these attribute values (0.28 + 0.06 + 0.22 = 0.56).

No separate value is reported for the benefits of pedestrianised or shared spaces. That is because pedestrianised spaces can be described and valued as a combination of multiple attributes, in particular:

- reduced traffic volumes and/or reduced traffic speeds (from Table 2)
- increased footpath width and improved pavement quality (from Table 3)
- provision of seating and street trees (from Table 3).

Table 3: Footpath link attribute parameters

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Status
Facility availability			
Footpath presence	Basic 1.2m wide footpath available, relative to no footpath/ walking on the side of the road	1.59	Medium confidence
Footpath width: Crowded conditions	Increase width by 1 metre ‘Crowded conditions’ defined as a flow rate above 33 pedestrians per metre of usable width per minute	0.14 (capped at 0.56)	Medium confidence, to be updated after local research
Footpath width: Uncrowded conditions with narrow footpath	Increase width by 1 metre ‘Narrow footpath’ defined as two metres or less	0.07 (capped at 0.14)	Low confidence, to be updated after local research
Pavement condition	Smooth pavement without cracks, relative to cracked or uneven	0.03	Medium confidence
Pavement quality	Attractive/high quality paving relative to basic asphalt paving	0.08	Low confidence, to be updated after local research
Covered route	Awnings, verandas, or canopies are present	0.28	Low confidence, to be updated after local research
Dropped kerbs	Crossings are level with streets or offer dropped kerbs	0.02	Medium confidence

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Status
Footpath amenities			
Lighting or CCTV	Route is lit and/or monitored by CCTV	0.06	Medium confidence
Street trees or plantings	Trees or plantings are present on or adjacent to footpath	0.20	Low confidence, to be updated after local research
Seating	Seating is available on link	0.01	Medium confidence
Signage and wayfinding	Signs and wayfinding devices are available	0.02	Medium confidence
Activity and conflict			
Remove conflict with cyclists	No or few cyclists are present on the link, relative to a shared path with reasonable cycle volumes	0.10	Low confidence

2.3.3 Footpath crowding

Wider footpaths are likely to be valued differently in areas with high pedestrian volumes, such as busy city centre areas, relative to areas with low pedestrian volumes, such as residential areas or suburban town centres. The above table provides different values for use in different contexts.

People's quality of experience when using a footpath is influenced by the number of other people around them. The presence of some other people around makes a street feel welcoming and inviting. However, at a certain point, additional people on the footpath cause crowding and reduces pedestrian amenity. Crowding negatively impacts the pedestrian experience in three ways:

- personal space becomes invaded, reducing comfort and amenity
- opposing movements cause conflicts and become difficult
- people are unable to walk at their preferred speed, increasing their journey times.

The literature reviewed in Appendix B suggests that attributes such as footpath width, absence of clutter, and footpath activity level contribute to quality of experience. These attributes relate to both the quantity of available walking space and the amount of people trying to use that space.

Empirical research suggests that footpath crowding reduces average walking speeds (Fruin, J.J., 1971. Designing for pedestrians: A level-of-service concept (No. HS-011 999). https://trid.trb.org/view/116491; Pushkarev, B., and Zupan, J.M., 1975. Capacity of walkways. Transportation research record, 538, pp.1-15. https://trid.trb.org/view/35106; Lam, W.H. and Cheung, C.Y., 2000. Pedestrian speed/flow relationships for walking facilities in Hong Kong. Journal of transportation engineering, 126(4), pp.343-349.; Al-Azzawi, M. and Raeside, R. 2007. Modeling pedestrian walking speeds on sidewalks. Journal of Urban Planning and Development, 133(3), pp.211-219.[1])

[1] A limitation to using this research is that it does not arrive at a single standard function for predicting walking speeds based on the density of pedestrians on a footpath. Different studies indicate different quantitative relationships, all of which imply footpath widening benefits that are within the range of the parameter value suggested in Table 3.

Observed relationships between footpath crowding and pedestrian walking speed and comfort have been used to inform pedestrian Level of Service analysis in the US *Highway Capacity Manual* (Transportation Research Board, 2010) and Transport for London's (2019) *Pedestrian Comfort Level Guidance*.

This interim guidance recommends different parameters for valuing increased footpath width in crowded and uncrowded environments to reflect the fact that walking speeds and comfort decline beyond a certain level of footpath crowding.

There are three steps to this analysis, as outlined below.

Step 1: Calculate effective walking width

Effective walking width can be described as the space available for through movement on a footpath after reductions in space due to obstructions and shy distances from objects and people standing have been taken into account. It can be calculated by measuring total footpath width, subtracting the width of any fixed obstructions (such as bus shelters), and then subtracting shy distances from building edges, kerb edges, and fixed obstructions.

Recommended shy distances from footpath objects have been adapted from Transport for London (2019) and are summarised in Table 4.

Table 4: Shy distances from footpath objects

Object	Buffer
Building edge	0.2m
Kerb edge	0.2m
Seating	0.5m seating side 0.2m non-seating side
ATM	1.5m
Bus stop	0.2m from edge of queuing area (queuing area size will depend on passenger volumes at stop)
Individual street vendor	0.5m from stall edge
Market vendors/multiple adjacent street vendors	1.4m from stall edge
Other street furniture (trees, bollards, bike parking, etc.)	

Step 2: Calculate pedestrian flow rate

Pedestrian flow (P_{flow}) is measured in pedestrians per metre of effective walking width per minute. It can be calculated using data or estimates of peak hourly pedestrian flows as follows:

Equation 1: Calculation of pedestrian flow rates

$$P_{flow} = F/W/60$$

Where F = hourly pedestrian volumes (pedestrians/hour)

W = effective walking width, measured in metres.

Step 3: Identify whether footpath is crowded or uncrowded and identify appropriate benefit parameter value

Following Transportation Research Board (2010), a pedestrian flow rate above 33 people per metre per minute is considered to be the threshold for footpath crowding as this is the point where walking speeds start to be seriously affected by crowding.[2]

The following table summarises the parameter values that are recommended for use in different contexts. A higher value is suggested for crowded footpaths than for uncrowded footpaths. This reflects the fact that users of crowded footpaths will benefit from both improved comfort and increased walking speeds, while users of uncrowded footpaths will only benefit from improved comfort in cases where existing footpaths are narrow.

Moreover, benefit values are capped beyond a certain point to reflect the fact that these benefits are expected to diminish once a certain width or level of uncrowdedness is reached.[3]

Table 5: Parameter values for increasing footpath width in different contexts

Pedestrian flow rate (P_{flow})	Width of existing footpath	Willingness to pay for a 1 metre increase in footpath width (ratio increase in walk time)
Greater than or equal to 33 ped/m/min (crowded)	Any width	0.14 (capped at 0.56)
Less than 33 ped/m/min (uncrowded)	Less than or equal to 2 metres	0.07 (capped at 0.14)
Less than 33 ped/m/min (uncrowded)	Greater than 2 metres	0.0

2.3.4 Pedestrian crossings

No parameter values for quality of experience benefits from improved pedestrian crossings are recommended. In general, the empirical literature suggests that pedestrians place a negative value on routes that require them to cross the road. If it is necessary to cross, providing pedestrian crossing facilities can improve quality of experience for users. Benefits that users experience from crossing facilities may include changes in delay while waiting to cross, reduced exposure to crash risk, and perceived changes in comfort.

Few studies controlled for the safety record of intersections and/or traffic volumes and speeds at the crossing point (eg Ancianes, Jones, and Metcalfe, 2018; Hensher et al., 2011), and hence it is likely that parameters for user benefits from improved crossing facilities would double-count changes in crossing delay and crash risk. It is therefore more appropriate to assess the benefits of new pedestrian crossings, or provision of routes that allow pedestrians to avoid crossing the road, using existing EEM procedures or with the *Australasian Pedestrian Facility Selection Tool* (Abley, Smith, & Rendall, 2015).

The *Australasian Pedestrian Facility Selection Tool* consists of six distinct modules: delay calculation, safety modelling, sight distance calculation, pedestrian walkability component modelling, economic evaluation and pedestrian Level of Service modelling. The first module allows users to calculate expected average delay incurred by pedestrians when seeking to cross the road at:

- uncontrolled facilities where pedestrians do not have priority over vehicles, with or without median refuges

[2] This corresponds with LOS D/E/F in the *Highway Capacity Manual* or LOS E in TfL's (2019) *Pedestrian Comfort Level Guidance*. TfL suggests that pedestrian comfort begins to decline before this point and hence this is likely that this approach is conservative.
[3] Suggested caps are based on an indicative review of the degree to which walking speeds in crowded environments can be improved through further footpath widening.

- zebra crossings
- pedestrian signals
- grade separated facilities like underpasses or overbridges.

Similarly, the second module allows users to estimate potential safety benefits of intersection upgrades based on observed crash history and crash risk reduction factors.

These modules, which are implemented in an online assessment tool,[4] can be used to quantify travel time benefits and safety benefits from new or improved pedestrian crossings.

[4] https://austroads.com.au/network-operations/active-travel/pedestrian-facility-selection-tool

3. RECOMMENDED VALUATION METHODOLOGY

User benefits resulting from quality improvements to pedestrian facilities can be valued using a consumer surplus calculation that reflects both reductions in travel time from faster or more direct routes and willingness to pay for improved quality of facility. This is analogous to the approach used to value other direct transport user benefits and is consistent with the existing approach outlined in EEM Appendix A20.

3.1 Calculating user benefits

3.1.1 User benefits when induced demand cannot be modelled

In many cases, it is possible to observe or estimate the number of existing footpath users but not possible to predict induced demand resulting from improved facilities.

When this is the case, user benefits can be calculated using a modified version of the conventional consumer surplus formula:

Equation 2: Calculation of user benefits from an improved pedestrian facility when induced demand cannot be modelled

$$Benefits = VOT * D_{existing} * \left(T_{existing} - T_{new} + WTP_{new} * T_{new}\right)$$

Where: VOT is the value of travel time savings (in $/minutes) for facility users

$D_{existing}$ is the existing number of facility users, or the number that would be expected in the future regardless of intervention

T_{new} is the travel time to use the improved facility, in minutes

WTP_{new} is the willingness to pay for improved facility quality, which is multiplied by the time spent using the new facility to obtain total user benefits from improved quality

This formula adds together two distinct benefits that might arise from a new or improved pedestrian facility:

- faster or more direct journeys, which are estimated based on the reduction in travel time between the existing facility and the new facility $(T_{existing} - T_{new})$
- improved quality of experience, which is estimated based on willingness to pay for improved facilities, multiplied by the amount of time users spend on the facility $(WTP_{new} * T_{new})$.

Travel time on existing or new facilities can be estimated by dividing the length of the facility by average walking speed. In some cases, it may be appropriate to adjust walking travel times for slope, stairs, crossing delay, or other impedances. Walking times should not be adjusted to account for footpath crowding as benefits from reduced crowding are factored into parameter values for increased footpath width.

Total benefits also depend upon the number of existing users. The benefits of a given improvement will be higher in locations where more people are walking.

Willingness to pay for an improved facility can be calculated by summing together applicable benefit valuation parameters from Table 2 and Table 3:

Equation 3: Calculating willingness to pay for an improved pedestrian facility

$$WTP_{new} = \sum_{j \in J} WTP_j$$

Where: j identifies each distinct attribute improvement provided by the new facility

WTP_j is willingness to pay for improved facility attribute j, measured in terms of percentage increase in walk time that an average user would be willing to incur to access this improvement

This formula accounts for the additive impact of multiple improvements. Additional improvements always increase user benefits, and the results of assessment do not depend upon the order in which options are defined. In theory, it is possible that users experience diminishing marginal returns from multiple improvements, but in practice interim parameter values refer to distinct attributes that provide relatively distinct benefits. For instance, provision of seating is unlikely to substitute for a wider footpath, as these facility features serve different roles.[5]

3.1.2 User benefits when induced demand can be modelled

When it is possible to predict induced demand resulting from improved facilities, user benefits can be calculated using a modified version of the conventional consumer surplus formula:

Equation 4: Calculation of user benefits from an improved pedestrian facility when induced demand can be modelled

$$Benefits = VOT * (D_{existing} + D_{new}) * (T_{existing} - T_{new} + WTP_{new} * T_{new}) * 0.5$$

Where: VOT is the value of travel time savings (in $/minutes) for facility users

$D_{existing}$ is the existing number of facility users

D_{new} is predicted total number of users for the improved facility

$T_{existing}$ is the travel time to use the existing facility, in minutes

T_{new} is the travel time to use the improved facility, in minutes

WTP_{new} is the willingness to pay for improved facility quality, which is multiplied by the time spent using the new facility to obtain total user benefits from improved quality

This formula is similar to the previous formula, except that it also adds benefits for new users. A 'rule of half' adjustment is applied to benefits for new users to account for the fact that they would have otherwise derived some benefits from the alternative walking route, transport mode, or non-transport activity that they would have otherwise chosen.

Travel time on existing or new facilities can be estimated by dividing the length of the facility by average walking speed. In some cases, it may be appropriate to adjust walking travel times for slope, stairs, crossing delay, or other impedances. Walking times should not be adjusted to account for footpath crowding as benefits from reduced crowding are factored into parameter values for increased footpath width.

3.2 Alternative base cases

This procedure should be implemented in slightly different ways depending upon the type of footpath improvement being assessed. There are two main types of improvement, each of which is assessed against a different base case.

Scenario 1: Providing a new footpath where one does not currently exist

In this scenario, the base case is no pedestrian facility, which means that people who are walking or using mobility devices must walk on the side of the road. The following improvements can be added to this:

- adding a basic footpath
- increasing the width of the basic footpath
- improving pavement quality relative to basic asphalt paving
- adding other amenities, if relevant.

As provision of a footpath is expected to reduce pedestrians' exposure to traffic, values related to improvements to the traffic environment should not be included in assessment as they may double-

[5] Based on interim parameter values, the maximum WTP for an improvement to an existing pedestrian facility is equal to around 3, indicating that users of the new facility experience the equivalent of 3 minutes of quality of experience benefits per minute walked on the facility.

count benefits. Similarly, values associated with activity and conflict on footpaths should not be included in assessment as new footpaths are likely to be implemented in suburban/residential areas with little conflict between footpath users.

Scenario 2: Improving pedestrian facilities where some facilities already exist

In this scenario, the base case is assumed to be the existing pedestrian facility, eg a footpath that is currently in place. The following improvements can be added to this:

- increased footpath width, improved pavement quality or condition, or provision of a covered route
- adding other footpath amenities, such as lighting or street trees
- improvements to activity and conflict on footpaths, noting that care should be taken to avoid double-counting benefits related to increased footpath width
- improvements to the traffic environment.

The parameter value associated with adding a basic footpath should not be included in assessment, as a footpath is assumed to be included in the base case.

3.3 Standard assumptions

In addition to demand estimates, facility characteristics, and valuation parameters, implementing this methodology requires:

- an estimate of average walking speed
- an estimate of value of travel time savings for people who are walking.

These parameters can be derived from the Household Travel Survey and value of travel time savings for different trip purposes from EEM Table A4.1(b).

The following table summarises estimated average walking speed and trip purposes for all national walking trips reported in the 2015-2017 Household Travel Survey. The national average walking speed is 4.5 kilometres per hour, which implies that the average person takes around 13.3 minutes to walk one kilometre. Most walking trips are taken for non-work purposes, principally shopping/personal services and sport/exercise. This breakdown of trip purposes implies an average value of travel time of $12.00/hour for walking trips in 2018 New Zealand dollars.[6]

However, average walking speeds and trip purposes vary between locations and hence it is desirable to check these parameters against local data, if available. For instance, average walking speeds appear to be higher in Wellington than in Auckland or Christchurch. Likewise, people walking in city centre environments may be more likely to be commuting or taking trips for work, leading to a higher average value of travel time.

[6] Based on 2002 value of travel time parameters from EEM Table A4.1(b) and 2018 benefit update factors from EEM Table A12.3.

Table 6: Average walking speed and trip purposes, 2015-2017

Variable	Value	Notes
Average walking speed (km/hr)	4.5km/hr	690.5km walked divided by 153.0 hours spent walking
Average walking pace (minute/m)	0.0133min/m	Converted from above
Walking trip purposes		
Work travel purpose	5%	Calculated based on average trip purpose split for distance, time, and trip legs, excluding walking trips to return home
Commuting to/from work or education	25%	
Other non-work travel purpose	70%	

4. APPLICATION TO CASE STUDIES

To illustrate the approach outlined in Section 3, user benefits are calculated for two hypothetical case studies. The first case study shows how this approach can be used to value improvements to links and the second shows how it can be used to evaluate projects that combine improvements to the directness of pedestrian links with improvements to the quality of facilities.

4.1 Case study 1: Providing a new footpath where one does not currently exist

This case study assesses an improvement to a 1.2km stretch of road that currently has no footpath. There are three options for upgrading this facility. Option 1 would provide a basic 1.2m footpath, Option 2 would provide a 2.4m footpath, and Option 3 would provide a 2.4m footpath with high quality paving. At present, 100 people per day walk on the road, and it is predicted that user volumes would rise by 20% if a footpath was available.

The following table shows how benefits can be calculated for this project. The amount of time users spend travelling on the facility does not change, as facility length remains the same under all options. However, all three options provide benefits from improved quality of experience. Total WTP parameters are larger for Options 2 and 3 than for Option 1, indicating that these options provide increased user benefits. Total user benefits are calculated by multiplying WTP for improved facilities by walking time on the facility and then multiplying by user numbers, with a rule of half adjustment for new users.

Total benefits are calculated using the consumer surplus formula in equation 2 and monetised using an average value of travel time of $12/hr, or $0.20/minute. Total daily user benefits are equal to $560 for Option 1, $619 for Option 2, and $673 for Option 3. This indicates that the benefits of providing a footpath in the first place are large relative to marginal improvements to that facility.

Table 7: Calculating user benefits for options to provide a new footpath on a road that currently lacks one

Option definition		Base case	Option 1	Option 2	Option 3
Description		Current state	Add a basic 1.2m footpath	Add a wider (2.4m) footpath	Add a wider (2.4m) footpath with high quality paving
Facility length (metres)		1200	1200	1200	1200
Facility characteristics					
Footpath presence (basic, 1.2m wide)	*1.59*		TRUE	TRUE	TRUE
Added footpath width (metres)	*0.14*		0	1.2	1.2
Pavement quality (high)	*0.08*		FALSE	FALSE	FALSE
User characteristics					
Daily user volumes		100	120	120	120

Option definition	Base case	Option 1	Option 2	Option 3
Share of link used by typical user	100%	100%	100%	100%
Model workings				
Walking time on facility (min)	16.0	16.0	16.0	16.0
Walking time saving (min)		0.0	0.0	0.0
WTP parameter (% increase in walk time)		1.59	1.76	1.84
Total WTP for improvements (min)		25.4	28.1	29.4
Total daily benefits (min)		**2798**	**3094**	**3235**
Total daily benefits ($)		**$560**	**$619**	**$647**

4.2 Case study 2: Improving existing pedestrian facilities

This case study assesses the option of upgrading an existing pedestrian link to both improve its quality and make it more direct. At present, the link is 1.2km long and offers a basic footpath. Under the investment option, the link would be shortened to 1km and upgraded to a higher-quality footpath. There are three options for doing so: Option 1 would widen the footpath by 2m and improve pavement condition and quality; Option 2 would also add lighting, seating, and wayfinding signs; and Option 3 would upgrade the facility to a shared street with further walking space, dropped kerbs, and a 20km/hr reduction in traffic speeds.

At present, 200 people per day use this facility, and it is predicted that user volumes would rise by 30% if a better and more direct facility was available.

The following table shows how benefits can be calculated for this project. There are two benefit streams. First, walking time is reduced by around 2.7 minutes, and second, users experience benefits from an improved quality facility. Total WTP parameters are larger for Option 3 than for Options 1 and 2, indicating that this option provides increased user benefits. Total user benefits are calculated by multiplying WTP for improved facilities by walking time on the facility, adding travel time savings, and then multiplying by user numbers, with a rule of half adjustment for new users.

Total benefits are calculated using the consumer surplus formula in equation 2 and monetised using an average value of travel time of $12/hr, or $0.20/minute. Total daily user benefits are equal to $362 for Option 1, $417 for Option 2, and $883 for Option 3. Quality of experience benefits are expected to be larger than direct travel time benefits for all options. Moreover, the per-user benefits from improving existing facilities appear to be smaller than the benefits of providing a facility where none currently exists.

Table 8: Calculation of benefits for a shorter and higher-quality pedestrian link

Option definition		Base case	Option 1	Option 2	Option 3
Description		Current state (basic footpath)	Widen footpath by 2m, improve condition and quality	Option 1 plus add lighting, seating and signage	Shared space with 20km/hr speed reduction
Facility length (metres)		1200	1000	1000	1000
Facility characteristics					
Added footpath width (metres)	*0.14*		2	2	2
Kerb treatments	*0.02*		FALSE	FALSE	TRUE
Pavement condition (improved)	*0.03*		TRUE	TRUE	TRUE
Pavement quality (high)	*0.08*		TRUE	TRUE	TRUE
Covered route	*0.28*		FALSE	FALSE	FALSE
Footpath amenities					
Lighting or CCTV	*0.06*		FALSE	TRUE	TRUE
Street trees or plantings	*0.2*		FALSE	FALSE	FALSE
Seating	*0.01*		FALSE	TRUE	TRUE
Signage and wayfinding	*0.02*		FALSE	TRUE	TRUE
Activity and conflict					
Absence of clutter	*0.2*		FALSE	FALSE	FALSE
Footpath activity level: Moderate activity	*0.22*		FALSE	FALSE	FALSE
Footpath activity level: Crowded	*-0.01*		FALSE	FALSE	FALSE
Remove conflict with cyclists	*0.31*		FALSE	FALSE	FALSE

Option definition	Base case	Option 1	Option 2	Option 3
Traffic environment				
Traffic volume (1000 AADT reduction)	*0.05*	0	0	0
Traffic speed (1km/hr reduction)	*0.03*	0	0	0
User characteristics				
Daily user volumes	200	260	260	260
Share or link used by typical user	100%	100%	100%	100%
Model workings				
Walking time on facility (min)	16.0	13.3	13.3	13.3
Walking time saving (min)		2.7	2.7	2.7
WTP parameter (% increase in walk time)		0.39	0.48	1.24
Total WTP for improvements (min)		5.2	6.4	16.5
Total daily benefits (min)		**1809**	**2085**	**4416**
Total daily benefits ($)		**$362**	**$417**	**$883**

5. APPENDIX A: REVIEW OF INTERNATIONAL APPRAISAL GUIDANCE

We review transport appraisal guidance on walking facility improvements in several other countries, including in-depth reviews of guidance from the United Kingdom, Australia, Ireland, the Netherlands, and Sweden, and high-level commentary on guidance from other OECD countries.

The United Kingdom, Ireland, and Sweden currently offer guidance or parameters for valuing quality improvements to the pedestrian environment. However, these parameters are selective: the UK provides parameters for quality improvements to existing footpaths, while Ireland and Sweden only provide parameters for valuing the presence or absence of footpaths. Australian guidance, like New Zealand guidance, gestures in the direction of valuing walking quality improvements but does not provide specific procedures. Dutch guidance does not provide procedures for valuing quality improvements to the pedestrian environment. Other OECD countries take a similar approach to Australia and the Netherlands.

5.1 United Kingdom guidance

The UK's Transport Appraisal Guidance (TAG) Unit A5.1 offers procedures for valuing improvements to journey quality for both walking and cycling users. It notes that:

> *Journey quality is an important consideration in scheme appraisal for cyclists and walkers. It includes fear of potential accidents and therefore the majority of concerns are about safety (e.g. segregated cycle tracks greatly improve journey quality over cycling on a road with traffic). Journey quality also includes infrastructure and environmental conditions on a route. […]*
>
> *The evidence in this area is fairly limited. Analysts should use judgment, or potentially a 'sliding scale' approach to value journey quality impacts depending on the perceived quality of an intervention, using published research figures as a guide to the maximum value for an improvement* (Department for Transport, 2018b).

The TAG Data Book provides parameters for valuing qualitative improvements to pedestrian facilities. Table 9 summarises these parameters, which are based on a 2005 stated preference study (Heuman, 2005) and updated to future years using GDP deflators. Because they are stated in per-kilometre terms, they can easily be applied to assess the value of improvements to specific pedestrian links.

These relate to qualitative improvements to existing pedestrian facilities – eg whether or not street lights are present, or whether or not the pavement is crowded or even. However, they assume that some facilities are present, ie that there is a footpath and that there are some crossing aids at intersections. As a result, they are not well suited for assessing the benefits of providing new facilities in locations that currently lack them.

To illustrate the magnitude of these benefits, we have compared them to the estimated cost of travel time incurred to walk one kilometre.[7] The benefits of individual facility features range from less than 1% to nearly 4% of the value of travel time.

Table 9: TAG Table A4.1.7: Values of aspects in pedestrian environment

Scheme type	2010 pence per kilometre	Relative to value of travel time
Street lighting	3.7	3.7%
Kerb level	2.6	2.6%

[7] Based on an average walking speed of 4.5km/hr and the 2010 TAG Data Book value for non-working, non-commuting travel time (£4.54/hour).

Scheme type	2010 pence per kilometre	Relative to value of travel time
Crowding	1.9	1.9%
Pavement evenness	0.9	0.9%
Information panels	0.9	0.9%
Benches	0.6	0.6%
Directional signage	0.6	0.6%

5.2 Australian guidance

Module M4 of the *Australian Transport Assessment and Planning (ATAP) Guidelines* offers procedures for valuing investment in walking and cycling facilities (ATAP Steering Committee, 2016a). Like existing New Zealand guidance, ATAP primarily focuses on assessing health benefits, travel time savings, savings in vehicle operating costs and parking costs, and crash cost reductions, as well as congestion reduction benefits from mode shift.

ATAP notes that quality improvements can in principle be accounted for as alongside changes to other 'generalised costs' faced by the user, such as travel time, vehicle operating costs, and parking costs. The guidance notes that where quality improvements are an important element of a project, an approach solely based on generalised cost may not provide a realistic estimate of benefits:

> *This approach to estimation of willingness to pay is less meaningful if there is an infrastructure initiative with an aesthetic element or an environmental element that has a positive influence on the decision to walk or cycle. An example would be a pedestrian cycle path along a river as an alternative to on-road or in-road access. Estimation of those benefits requires more sophisticated cross sectional or discrete choice studies that will be impracticable for most initiatives. Recent research for Sydney (see Table 24) suggests that cyclists place a value on the opportunity to shift from on-road cycling to an off-road pathway, but it is not clear whether cyclists are valuing amenity or the reduced crash risk associated with off-road cycle paths* (ATAP Steering Committee, 2016a).

Following this principle, ATAP provides guidance on valuing improvements to cycleway quality. This includes parameters that account for quality improvements by scaling the generalised cost of cycling on different types of facilities, relative to cycling in general traffic lanes.

Appendix C in the ATAP guidance provides a qualitative summary of the benefits of various walking and cycling facilities, ranging from implementation of pedestrian malls to footpath widening to provision of seating and water points on paths. Many of these facilities are expected to result in improvements to pedestrian amenity, in addition to benefits such as improved safety or reduced travel time. While ATAP guidance identifies these benefits, it does not provide parameters for valuing them.

Transport for New South Wales' *Principles and Guidance for Economic Appraisal of Transport Investment and Initiatives* (2016) provides additional guidance in the New South Wales context. It does not provide specific guidance on valuing active mode improvements, but it does provide parameters for valuing negative externalities from motor vehicle use, including costs associated with urban severance. Because severance principally affects pedestrians, these externality values could in principle be used to assess some of the impacts of schemes that reduce pedestrian exposure to traffic.

Table 10 summarises estimated unit costs for urban separation. The underlying source for these values is a 2003 Austroads report, which in turn references a 2000 study on the external costs of transport in Europe (Evans et al., 2014). An important caveat if using these values is that recent updates to the European *Handbook on External Costs of Transport* no longer include urban separation costs (European Commission, 2019). Similarly, while the 2003 Austroads report was updated in 2014 with updated urban separation costs, based on a 2011 study examining external costs of transport in Europe, these updates are not yet reflected in the New South Wales Guidance (Evans et al., 2014).

Table 10: TfNSW Table 58: Externality costs associated with urban separation due to motor vehicles

Vehicle type	2010 cents/kilometre travelled	Range
Passenger cars	0.73	0.43 to 1.02
Buses	2.35	1.47 to 3.23

5.3 Irish guidance

Unit 13.0 Pedestrian and Cyclist Facilities of the *Project Appraisal Guidelines (PAG) for National Roads* published by Transport Infrastructure Ireland offers procedures for valuing walking and cycling improvements (Transport Infrastructure Ireland, *Project Appraisal Guidelines (PAG) for National Roads*, 2016. https://www.tiipublications.ie/library/PE-PAG-02036-01.pdf). This guidance addresses health benefits, travel time savings, and crash cost reductions, as well as 'journey ambiance' benefits. The guidance describes 'journey ambiance' benefits as follows:

> *Journey ambience benefits are the users' perception of reduced danger (a reduced fear of potential collisions/incidents) and improved quality of journey as a result of the proposal being considered. Existing users will experience these improvements as well as any new users who are attracted to the facility. […]*
>
> *Assessing the journey ambience benefit is challenging as different users will have different sensitivities to danger and environmental quality. However, the benefit is potentially large, especially for cyclists, because surveys suggest that existing and potential users of this mode attach great importance to the perceived safety and quality benefits of improved facilities (in particular facilities segregated from motorised traffic).*

PAG provides per-minute and per-trip parameter values for improved cycle facilities, as well as a single parameter value for pedestrian footpaths shared with cyclists. The following table summarises this parameter value and compares it to the value of travel time used in PAG.[8]

The parameter value for benefits that pedestrians receive from shared paths is drawn from a 2010 study that elicited willingness to pay for pedestrian and cycling paths in rural Ireland, where pedestrian and cyclists typically share the road with motorised vehicles due to a lack of dedicated facilities (Laird, James & Page, Matthew & Shen, Shujie, 2013. "The value of dedicated cyclist and pedestrian infrastructure on rural roads", Transport Policy, Elsevier, vol.29(C), pages 86-96). It is unclear whether these values transfer to urban areas where traffic volume, traffic speed, and population density may differ. The PAG therefore suggest that judgment should be used when applying these parameter values.

Figure 2: PAG Table 13.4 Journey Ambience Values

Facility type	Value per minute walked (2011 Euro)	Value per trip (2011 Euro, assuming 29.8 min/trip)	Relative to value of travel time
Pedestrian footpath shared with cyclists	2.08 c/min	€0.62/trip	12%

[8] Table 3 in PAG Unit 6.11 National Parameters provides a value of €10.78/hr for non-working, non-commuting travel time.

5.4 Dutch guidance

General Guidance for Cost-Benefit Analysis published by the CPB Netherlands Bureau for Economic Policy Analysis sets out general appraisal procedures. Specific guidance for valuing transport projects is published in the transport application guide (Rijkswaterstaat Ministerie van Infastructuur en Milieu, 2018). Standard parameter values are also published online, but these are limited to values for travel time savings, reduced deaths and injuries in road crashes, and noise and emission reductions (Waterstaat, 2016).

The application guide does not provide guidance for assessing walking projects. This appears to be due to the fact that walking projects are typically fully funded by local governments, which prioritise provision of higher-quality facilities for reasons of safety, amenity, or community expectations.

The application guide provides principles for assessing cycling projects. These recommend capturing benefits related to improved access (encompassing travel time, reliability, and comfort/ quality of experience), improved health, external effects on emissions and road safety), as well as other social or economic effects.

5.5 Swedish guidance

The Swedish Traffic Administration publishes guidelines for transport cost benefit analysis that address walking and cycling projects as well as other transport modes (Trafikverket, Method of analysis and socio-economic calculation values for the transport sector: ASEK 6.1, 2018. Chapter 07, Section 7.6, Table 7.11 https://www.trafikverket.se/contentassets/4b1c1005597d47bda386d81dd3444b24/asek-6.1/07_restid_o_transporttid_a61.pdf). Section 7.6 in these guidelines provides guidance on valuing time spent travelling on different types of walking and cycling facilities. This guidance is in addition to guidance on the health benefits of additional walking and cycling facilities in Section 17.1.

This guidance recognises that users may value walking time differently depending upon whether they are walking in mixed traffic, on paths that are shared with cyclists, or on dedicated footpaths. This reflects improved convenience and comfort on dedicated facilities.

The following table summarises value of travel time parameters for people walking on different types of pedestrian facilities. Time spent walking on dedicated facilities is considered to be less 'costly' than time spent walking on shared paths or on the street. Moreover, time spent waiting, eg to cross the road, is considered to be more costly than time spent walking.

Swedish guidance also provides procedures for valuing other elements of the perceived urban environment. For instance, Section 17.3 provides guidance on perceived safety for people walking in enclosed or dark environments. As women are more sensitive to unsafe environments than men, it suggests applying multipliers to women's walking time in risky environments. These multipliers range from 1.35 for enclosed but well-lit walking paths to 1.85 for enclosed and dark walking paths (Table 17.2).

Table 11: Swedish parameters for valuing walking time (Trafikverket, Method of analysis and socio-economic calculation values for the transport sector: ASEK 6.1, 2018. Chapter 07, Section 7.6, Table 7.11)

Facility type	Value of walking time (SEK per hour)	Value of waiting time (SEK per hour)	% improvement relative to walking on street
Walking on the street next to motorised traffic	215	269	-
Shared path with cyclists	204	255	5%
Dedicated pedestrian facility	191	239	11%

5.6 Other international guidance

Mackie & Worsley (2013) reviewed transport appraisal practices in the United Kingdom, Germany, Netherlands, Sweden, United States, Australia, and New Zealand. Their key conclusion was that:

> *English practice has gone further than most in extending the use of appraisal beyond its core application to road and rail investment. Guidance now covers policy areas from walking and cycling to aviation and dimensions such as social and distributional impacts (p. 3).*

Many countries now include health benefits of increased walking and cycling in transport appraisal:

> *A significant development to appraisal guidance has been the inclusion in WebTAG from 2010 of specific guidance on health benefits and physical fitness impacts. […] Progress in this area is common, thus Sweden now follows the same WHO methodology, and Australia and NZ have extensive guidance relating to walking and cycling. In the US, funding for walking and cycling is from a different pot from other urban transport and is in competition with amenity and recreational projects, so assessment is handled differently and methods for benefit valuation are at the experimental stage (p. 9).*

The European Commission's *Guide to Cost-Benefit Analysis of Investment Projects* (European Commission, 2014) contains a brief summary of European practices for valuing transport investments. In line with Mackie and Worsley's findings, it notes that passenger travel time savings are typically the most significant benefit of transport projects. Valuation of travel time typically focuses on differences between different trip purposes, although quality of experience may be valued to some degree:

> *The comfort associated with travelling conditions, including the ability of the traveller to take advantage of the time spent travelling, also affects value of time. For example, VOT savings in congested car driving situations exhibit higher values than those in uncongested situations. This reflects both the value of reducing the variability of travel time and the unpleasantness of driving in congested conditions. In urban public transport, the availability of air conditioning, less crowded busses, etc. are very important to justify certain expenditures. Another critical aspect is the capacity to work during the trip, which is a key advantage of rail transport with regard to road and (short haul) air travel and explains the behaviour of many travellers.*

6. APPENDIX B: META-ANALYSIS OF INTERNATIONAL RESEARCH ON VALUING PEDESTRIAN ENVIRONMENTS

6.1 Introduction

Determinants of walking can be grouped into two broad categories: characteristics of surrounding land use and characteristics of the transport environment. Surrounding land use characteristics include job and residential density, land use mix, intersection density, destination accessibility, and distance to public transit (Ewing & Cervero 2010), as well as presence of amenities like parks. Surrounding land use affects walking behaviour through two causal mechanisms: first, by allowing origins and destinations to be within a viable walking distance of one another, and second, by influencing the amenity of the pedestrian environment.

Transport environment characteristics include footpath link characteristics, such as footpath width, pedestrian crossing characteristics, such as crossing seconds of delay at signalised crossings, and other traffic environment characteristics, such as traffic volumes and speeds on adjacent roads. These influence the safety and the amenity of the pedestrian environment. While many studies have investigated the factors that contribute to the quality of the pedestrian environment, there is disagreement on what factors contribute to pedestrian levels of service and the relative importance of these factors (Raad & Burke, 2018).

This paper systematically reviews the literature published from 2000 to 2019 to synthesize the empirical results on associations between attributes of footpath links, pedestrian crossings, and traffic environments, and the amenity value of walking in the context of walking for transport. Previous studies have summarised the impact of wider land use features on travel behaviour (Ewing & Cervero, 2010), summarised the literature on walking levels of service (Raad & Burke, 2018), and investigated the impact of the pedestrian environment on walking demand (Duncan, Spence, & Mummery, 2005). We do not attempt to repeat those efforts here, focusing instead on the valuation of transport environment characteristics. Specific objectives of this research are:

- to synthesize values of link, crossing, and traffic environment attributes, identifying the relative impact of different attributes and variability across studies
- to understand the methods used to value quality of experience in the pedestrian environment, investigating the impact of methodology and study location on results.

Synthesizing the values of pedestrian links and crossings can assist in:

- quantifying quality of experience benefits associated with pedestrian improvements, as is standard practice for cycling, public transport, and road improvements (Department for Transport, 2016; New Zealand Transport Agency, 2018; Transport for NSW, 2016)
- evaluating the relative quality of experience impacts of alternative project options and the relative contribution of project elements to overall benefits.

6.2 Methods

6.2.1 Systematic review protocol

A systematic literature review of the valuation of pedestrian facility attributes was undertaken using the Preferred Reporting Items for Systematic Review Recommendations (PRISMA) protocol (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). The systematic review protocol is outlined in Table 12. Research papers were identified through three methods: electronic database search, personal communication with practitioners from across the planning, funding, design, and engineering disciplines, and a full forward and backward citation search of studies that met the inclusion criteria. We sought original research papers published in English with the search conducted from September to November 2019. Each paper that passed the initial screening criteria was read to check if it met the eligibility criteria for inclusion in the review.

Three inclusion criteria had a large impact on the number of studies that met the criteria for inclusion in the review. The first was that all publication types, including conference papers, PhD or Master's thesis, or technical working papers, were included in the review. A substantial share of research in this area has been completed by the private sector for the purposes of valuing pedestrian improvements, and it was desirable to include these studies in the research.

The second was that at least one value reported in the study was an attribute of a pedestrian link or crossing. There is a large body of literature that investigates the impact of the built environment on walking, and a large number of studies that only reported built environment variables were excluded. The rationale for this was while investments in improving the pedestrian environment may take these factors into account, they may not necessarily be able to directly affect them.

The third was that studies either (a) reported a willingness to pay value for pedestrian environment elements or (b) reported econometric model coefficients that could be used to calculate willingness to pay. For instance, a study that reported coefficients from a discrete choice model of route choice that included user price, walking distance, or travel time as a route attribute would meet inclusion criteria. We did not limit to studies that reported a standard error or confidence interval for willingness to pay.

Data was extracted from studies and recorded in Excel at each of the screening stages. Content assessment against eligibility criteria and data extraction was independently conducted by the two investigators and cross-checked to ensure accuracy. Zotero was used to organise references and identify duplicates.

It was hypothesized that valuation type, model specification, sample size, and publication type could potentially introduce bias and substantial variation in values. For example, (De Gruyter, Currie, Truong, & Naznin, 2018) found that stated preference studies tend to produce higher values than other study types when valuing public transport amenities. It was also hypothesized that study location could influence values due variation in factors such as climate, air quality, and perceptions of safety. Each of these variables was recorded for each study for inclusion in meta-regression.

Table 12: Systematic review protocol

Review step	Information collected
Search terms used in electronic databases	("pedestrian" or "walking" OR "traffic calming" OR "severance" OR "urban realm" OR "amenity" OR "walkability") AND ("route choice" OR "stated choice" OR "stated preference" or "hedonic" OR "path choice" OR "revealed preference" OR "property values")
Electronic databases searched	Google Scholar, TRID
Initial screening strategy	• Published in English • Published in the year 2000 or later • Stated or revealed preference study • Published as journal article, conference paper, book, PhD or Master's thesis, or technical working paper • Reports at least one footpath or pedestrian crossing attribute in clearly defined terms. Studies with only built environment variables and studies that only analysed composite indices of walking quality were excluded.

Review step	Information collected
Content assessment and eligibility criteria	• All attributes and levels are articulated and have units • A willingness to pay value or econometric model coefficient is stated for attributes • If a coefficient is provided, user price, walking distance, or travel time is included as an attribute in econometric analysis
Data collection process	**Basic data on paper** Paper title, author, publisher, year of publication, study location **Methodological information** Attributes included in study, valuation method, recruitment method, model specification, number of observations, number of models reported **Results** Attribute value, attribute units, dependent variable, dependent variable units

6.2.2 Standardising and synthesising results

Different studies reported outputs in a variety of ways. Some studies reported willingness to pay for pedestrian facility improvements in local currency units, while others reported discrete choice model coefficients that could be used to estimate willingness to pay. However, both numerator and denominator units for willingness to pay values differed between studies.

For instance, Ancianes, Jones and Metcalfe (2018) report willingness to pay for reduced street width in terms of pounds per walking trip for a one-lane reduction. On the other hand, Weber (2017) report coefficients that could be used to calculate willingness to walk additional distance to a crosswalk to reduce the width of the street that must be crossed by one metre. Standardising these values entailed converting both the numerator and denominator into common terms.

A further issue was that the 'base level' for pedestrian environment attributes varied between studies. For instance, Sheldon et al (2006) report a value for the benefits pedestrians receive from lower traffic volumes, while Kelly et al (2006) report values for the disbenefits they receive from medium or heavy traffic, relative to low traffic volumes.

We therefore standardised values using a four-step process.

Step 1: Categorise values

Studies reported values for a wide range of pedestrian environment attributes. To allow us to analyse and summarise values across multiple studies, we grouped them into four broad categories, each of which had a number of sub-categories:

- Surrounding land use: Sub-categories include retail frontages/active street frontages and routes through parks.
- Footpath link attributes: Sub-categories include presence of a footpath, pedestrian/shared space treatments, footpath width, pavement condition and quality, covered routes, street trees/plants, seating, wayfinding and signs, and other attributes such as presence of pedestrian activity, pedestrian crowding, footpath clutter, and conflict with cyclists.
- Pedestrian crossing attributes: Sub-categories include presence of crossings on routes, and (conditional on a crossing existing), availability of crossing facilities like zebra crossings, median refuges, pedestrian signals, and overbridges/underpasses.
- Traffic environment: Sub-categories include traffic speed, traffic volumes, street width, and other disamenities like noise and air pollution.

Step 2: Convert all study results to willingness to pay values

The following table summarises the methodologies used in the 25 studies included in the final dataset, and how outcomes were reported. Six studies reported willingness to pay values, while 19 studies reported econometric model coefficients that could be used to derive willingness to pay values.

Figure 3: Study methodologies and outcome reporting

Study type	Willingness to pay values reported	Model coefficients reported	Total
Revealed preference – hedonic price	0	2	**2**
Revealed preference – walking path choice	0	10	**10**
Stated preference	6	7	**13**
Total	**6**	**19**	**25**

We converted model coefficients to willingness to pay values as follows:

- For revealed preference – hedonic price studies, the outcome variable was the natural logarithm of house sale prices. We therefore estimated average willingness to pay for an improvement to the local pedestrian environment by multiplying model coefficients by average house sale prices. This provides an estimate of the present value of expected future benefits resulting from neighbourhood amenities.
- Revealed preference – walking path choice and stated preference studies estimated discrete choice models that relate walking route characteristics with respondents' choice of routes. Willingness to pay for a specific attribute can be calculated by dividing the coefficient on the attribute by the coefficient on cost, time walked, or distance walked.

After this step, willingness to pay values were available for all studies, albeit stated in different units.

Step 3: Standardise willingness to pay numerator units

After Step 2, willingness to pay values were stated using various numerator units, ranging from:

- local currency units (LCU, in GBP, AUD, USD, EUR) per month or year
- local currency units per trip
- added house value that people were willing to pay for facilities, stated in local currency units
- added distance (in kilometres, metres, miles, or feet) that people were willing to walk per trip or per facility use
- added minutes that people were willing to walk per trip or per facility use.

We standardised all numerator units to either:

- added minutes that people were willing to walk per facility, for improved facilities
- percentage increase in walking time that people were willing to incur for improved facilities.

To do so, it was necessary to:

- convert house prices into annual willingness to pay by applying a discount rate parameter
- convert money into time using country-specific value of travel time savings parameters, adjusted from their base year using GDP deflators published by the World Bank (2019)

- convert annual and monthly values into per-trip and per-minute values, based on estimates of average monthly walking trips per person and average walking trip length and speed
- convert distance walked into time spent walking based on average walking speed and unit conversions from feet/miles to metres/kilometres.

The following table summarises the key parameters and assumptions that we used.

Table 13: Parameters used to standardise willingness to pay numerators

Parameter	Value	Source/notes
Converting money to time		
Discount rate	6%	Waka Kotahi EEM
Value of travel time savings (LCU/hr)		
Australia (2013)	$14.99	Private travel time VOT, Section 3.1.1 in ATAP guidance (ATAP Steering Committee, 2016b)
United Kingdom (2010)	£9.95	Commuting travel time, TAG data book Table A1.3.1 (Department for Transport, 2018a)
United States (2013)	$12.50	Table 4 in US Department of Transportation (2015)
Spain (2002)	€8.52	Table 6.3, short-term car commuter VOT (Centro de Estudios y Experimentatión de Obras Públicas (CEDEX), 2010
Converting annual/monthly values to per-trip values		
Average walking trips per person per month	15	Based on New Zealand Household Travel Survey data. Travel survey data from 8 of the 12 countries covered in the literature review indicates a similar median value, but a higher mean value of around 21 walking trips per month. As there are 12 months in a year, this implies 180 walking trips per person per year.
Average people/household	2.6	Average household size is 2.6 in the US and 2.4 in the UK (Office for National Statistics, 2016)
Average length of walking trip (km)	0.8km	Based on New Zealand Household Travel Survey data. Travel survey data from 6 of the 12 countries covered in the literature review indicates a similar median value, but a higher mean value of 1km per trip.
Converting distance walked to time spent walking		
Average walking speed (km/hr)	4.5km/hr	Based on New Zealand Household Travel Survey data. Travel survey data from 2 of the 12 countries covered in the literature review indicates a similar average walking speed.
Average trip time (minutes)	10.67 min	Obtained by dividing average walk trip length by average speed and multiplying by 60.

Step 4: Standardise willingness to pay denominator units

After the previous steps, willingness to pay denominators were stated in various units. We standardised denominator units within each category defined in Step 1. This entailed:

- Standardising all values against a common 'base level'. For instance, for crossings, we standardised WTP values for pedestrian crossing facilities relative to the base level of jaywalking across moving traffic.
- Standardising all values into common units. For instance, values for traffic volumes were all restated in terms of WTP for a 1000 vehicle reduction in average annual daily traffic, while values for footpath availability were stated in terms of the value of a footpath being available for an entire pedestrian link.
- Standardising all values to relate to improved pedestrian amenity, rather than deteriorated conditions. For instance, values for footpath cleanliness or clutter were stated in terms of an improvement from unclean or cluttered conditions to clean or uncluttered conditions.

As some studies used discrete variables (eg high/medium/low traffic volumes) and others used continuous variables (eg annual average daily traffic volumes) this entailed making judgments about the level that discrete variables were set at. Where possible, these judgments were informed by variable description from the underlying studies; however, in some cases it was necessary to estimate conversion values based on outside data.

6.2.3 Meta-analysis methodology

Meta-analysis is commonly used in transport economics and other disciplines to summarise values from many studies, to derive value transfer functions, and to understand the impact of study context and methodology on outcomes. To inform our meta-analysis methodology, we reviewed previous meta-analysis studies that used different statistical methodologies, depending upon the type of outcome being studied and the data that could be gathered from underlying studies.

Broadly speaking, there are two types of models that can be used for meta-analysis:

- Fixed-effect model: This assumes that all studies included in the dataset are estimating the same underlying parameter. Differences between studies are assumed to arise purely due to random sampling error. In the fixed-effect model, greater weight should be given to studies that report more precise estimates of the effect (ie a lower standard error).
- Random-effects model: This assumes that each study is estimating a study-specific true parameter. Differences between studies are assumed to arise from both between-study heterogeneity in true parameters and within-study sampling error. The aim of meta-analysis is to estimate the mean and variance of true parameters across the population of potential studies. To do so, it is necessary to incorporate information on coefficient point estimates and standard errors from underlying studies (Pigott, 2012).

Ideally, choice of modelling approach should be informed by statistical testing of heterogeneity in the underlying true parameters estimated by studies, which could reflect heterogeneity in the populations or the types of effects being studied. For instance, Mohammad et al., (2013) test for between-study heterogeneity and use a random-effects model in their review of property value uplift effects of rail projects. Melo, Graham, and Noland (2009) compare pooled ordinary least squares (OLS) models and models with study-specific random-effects in their review of urban agglomeration elasticities, finding that a pooled OLS model is appropriate.[9] Both studies included covariates to account for study context and study methodology.

Many meta-analyses focus on the fixed-effect model, implementing it through ordinary least squares (OLS) regression. Some studies incorporate study-level fixed effects or give a larger weight to studies with larger sample sizes or lower standard errors on parameter estimates. They also typically include covariates to account for study context and study methodology. Holmgren (2007) and Hensher (2008) use this approach in their reviews of public transport demand

[9] Melo, Graham, & Noland (2009) include study-specific random effects to control for the fact that some studies reported multiple estimates of agglomeration elasticities for different sectors or estimates that were based on different econometric models. Their approach appears to differ from the random-effects model described above.

elasticities. Wardman, Chintakayala, & de Jong (2016) apply it to a review of value of travel time savings in Europe, and De Gruyter et al., (2018) apply it to synthesise valuations of public transport customer amenities.

A third approach is multilevel mixed-effects linear regression, which can account for systematic variation between different groups, such as studies from different regions. This approach is used in reviews of non-market values for cultural heritage (Wright & Eppink, 2016) and open space (Brander & Koetse, 2011).

The above approaches can be used to estimate an average effect across studies, controlling for context and study methodology. Sometimes, this is not possible as values are reported in incompatible terms. For instance, Elburz, Nijkamp, & Pels (2017) reviewed the impact of public infrastructure investment on regional growth. As outcome variables varied between studies and could not easily be standardised, they used an ordered probit model to identify factors that increased the likelihood of finding a positive and statistically significant effect, as opposed to a negative and statistically significant effect or an effect that was not significantly different from zero.

Finally, some meta-analyses are not able to undertake a formal econometric analysis of study outcomes due to the fact that the studied outcomes were highly heterogeneous or otherwise unable to be standardised. Ewing & Cervero (2010) faced this issue in their review of the impact of built environment features on travel behaviour. Instead of a formal meta-regression, they therefore reported weighted average values for elasticity of travel demand with respect to various built environment features. Mazumdar et al. (2018) faced a similar challenge in their review of the impact of built environment features on social capital and addressed it by creating summary statistics for the sign and statistical significance of study results.

We are unable to implement a random-effects model due to the fact that we lack data on standard errors for most willingness to pay estimates.[10] As a result, we focus on a three-pronged approach:

- First, we calculate weighted average values for each individual attribute we analysed.
- Second, we estimate fixed-effects linear regression models to understand the impact of study context and methodology on parameter values. This modelling approach assumes that we can capture any differences in true effects between studies using covariates for context and study design.
- Third, we estimate a discrete outcome model to understand what factors tend to lead to positive or negative valuations on pedestrian environment elements.

We also undertook some informal tests for publication bias. First, we include publication type as an explanatory variable in regression and probit models to understand whether values sourced from these studies are systematically higher or lower. Second, we create funnel plot that compare willingness to pay values against studies' sample size. Asymmetry in funnel plots can indicate publication bias.

6.3 Results

6.3.1 Summary of studies included in meta-analysis

A total of 25 studies met the criteria for inclusion in the meta-analysis, as shown in Figure 4. The final set of research papers included in the meta-analysis is shown in Table 14. Although the meta-analysis captured studies conducted in 13 countries across four continents, a large proportion of the studies were from the United Kingdom (12; 36%) and the USA (10; 30%). As shown in Figure 5, research on valuing walking has been accelerating in recent years, with 17 papers (68%) published in the second decade of the 20-year analysis period.

[10] A number of studies report WTP values without standard errors or confidence intervals, while studies that report model coefficients provide standard errors for individual coefficients but do not provide enough information to calculate a standard error for a ratio of coefficients.

Figure 4: Study inclusion diagram

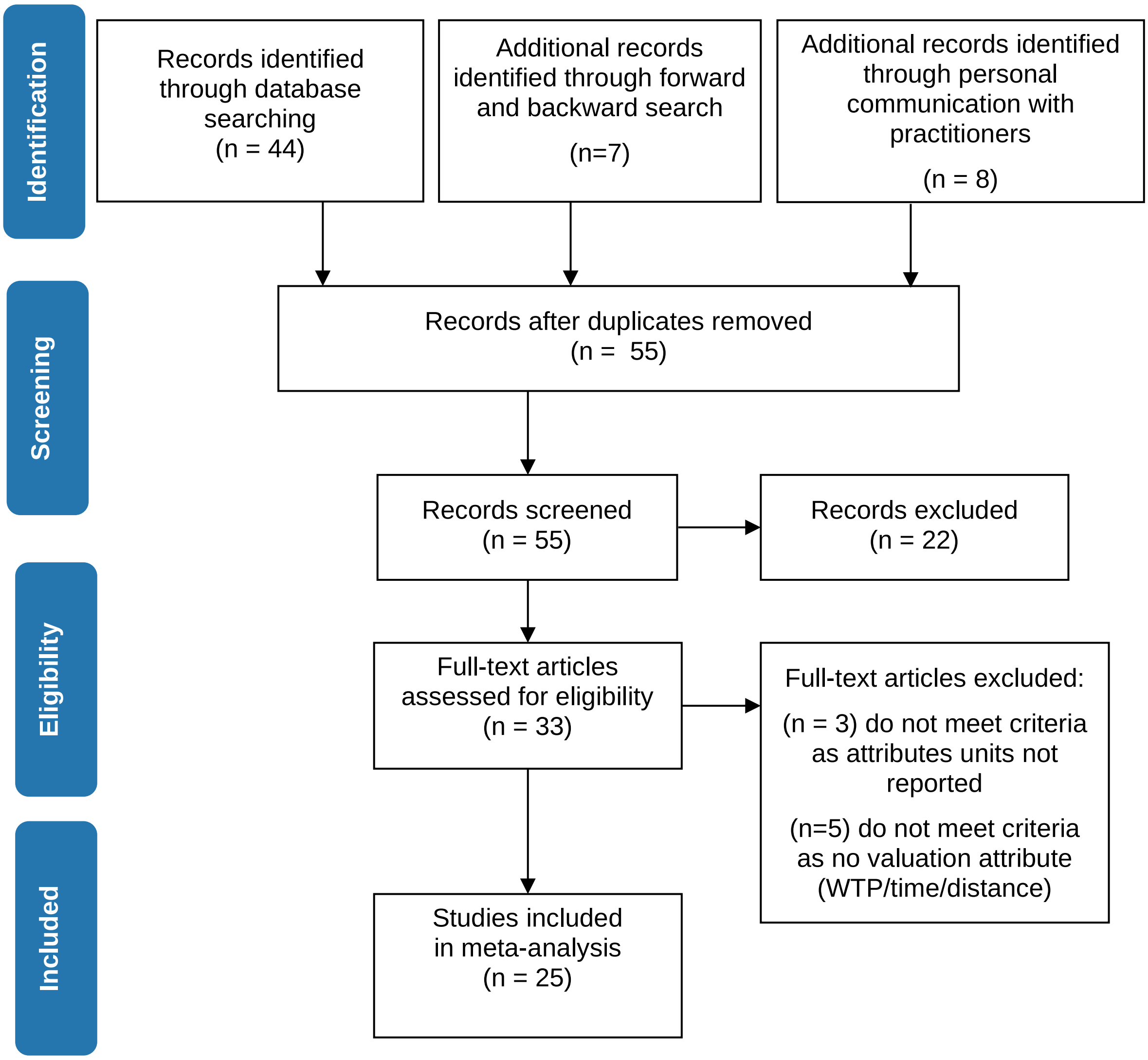


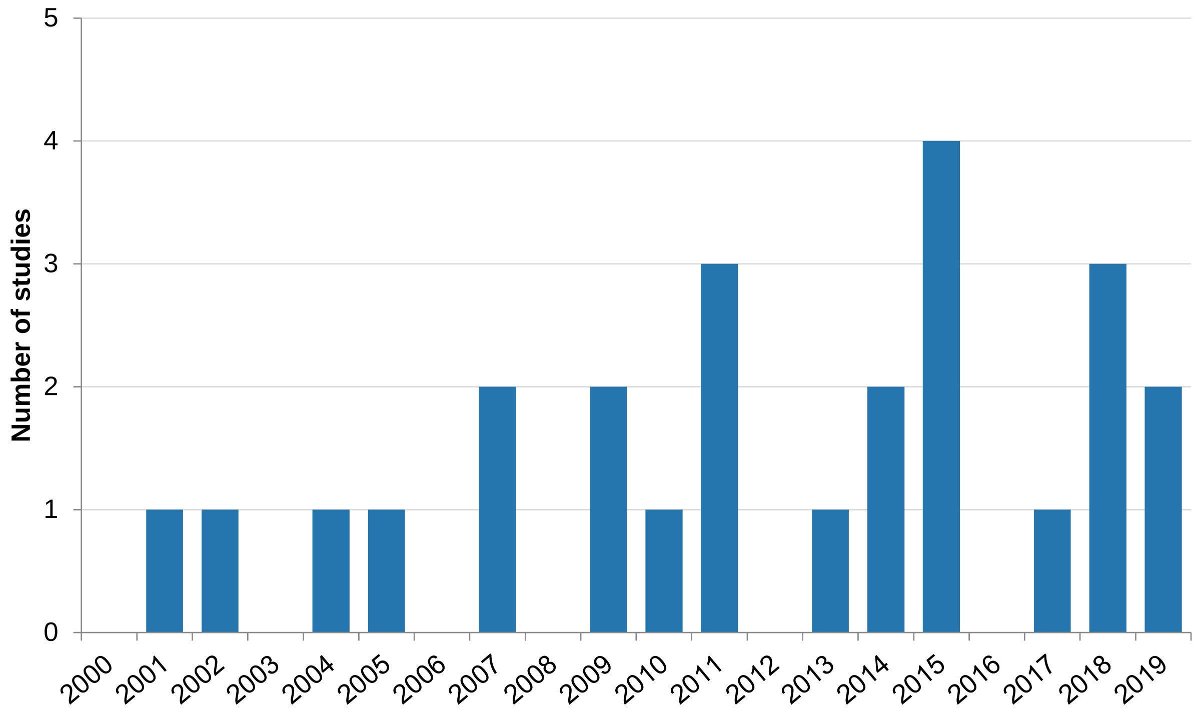
Table 14: Studies included in meta-analysis

Author	Date	Publication type	Study type	Reporting type	Sample size	Year data collected	Country of study	Recruitment method	Completion method	Model specification
Sheldon et al.	2006	Consultancy report	SP - Contingent valuation	WTP	600	2006	United Kingdom	Street intercept	Personal interview	Not stated
Anciaes, Jones, & Metcalfe	2018	Journal article	SP - Choice experiment	WTP	423	2016	United Kingdom	Street intercept	Not stated	Mixed logit
Atkins Consultants & ITS Leeds	2011	Consultancy report	SP - Choice experiment & priority ranking	WTP	758	2010	United Kingdom	Street intercept	Self-completion with interviewer present	Logit
Boeri et al.	2014	Journal article	SP - Choice experiment	Coefficient	407	Not stated	United Kingdom	Not stated	Personal interview	Logit
Broach & Dill	2015	Conference paper	RP - route choice	Coefficient	283	2010-2013	United States	Not stated	GPS log	Expanded path-size logit
Buchanan & Gay	2009	Journal article	SP - Not defined	WTP	600	2002	United Kingdom	Not stated	Not stated	Not stated
Bunds et al.	2019	Journal article	SP - Choice experiment	Coefficient	501	Not stated	United States	Not stated	Online self-completion	Hierarchical Bayes analysis
Cervero	2001	Journal article	RP - route choice	Coefficient	177	1994	United States	Other	Paper self-completion	Logit
Garrod et al.	2000	Consultancy report	SP - Choice experiment	Coefficient	414	Not stated	United Kingdom	Not stated	Personal interview	Logit
Diao and Ferreira	2010	Journal article	RP - hedonic pricing	Coefficient	92,774	2004-2006	United States	Property sales records	Not applicable	Spatial dependence model and OLS
Millard, Nellthorp, & Ojeda-Cabral	2018	Conference paper	RP - hedonic pricing	Coefficient	56,000	2015	United Kingdom	Property sales records	Not applicable	OLS
Guo & Loo	2013	Journal article	RP - route choice	Coefficient	101	2010	United States	Street intercept	Personal interview	Probit
Guo	2009	Journal article	RP - route choice	Coefficient	2,748	1994	United States	PT intercept	Personal interview	Logit

Author	Date	Publication type	Study type	Reporting type	Sample size	Year data collected	Country of study	Recruitment method	Completion method	Model specification
Weber	2017	Academic thesis	RP - route choice	Coefficient	166	2017	Switzerland	Street intercept	Online self-completion	Logit
Rodriguez & Joo	2004	Journal article	RP - route choice	Coefficient	509	Not stated	United States	Convenience survey	Paper self-completion	Logit
Muraleetharan & Hagiwara	2007	Journal article	RP - route choice and SP - priority ranking	Coefficient	531	Not stated	Japan	Street intercept	Paper self-completion	Mixed methods approach
Kawada et al.	2014	Journal article	SP - Choice experiment	Coefficient	70	2012	Japan	Street intercept	Personal interview	Logit
Grisolia et al.	2015	Journal article	SP - Choice experiment	Coefficient	74	Not stated	Spain	Not stated	Personal interview	WTP space logit
Cantillo, Arellana & Rolong	2015	Journal article	SP - Choice experiment	Coefficient	120	Not stated	Colombia	Street intercept	Personal interview	Integrated choice and latent variable
Lue & Miller	2019	Journal article	RP - route choice	Coefficient	71	2014	Canada	Multiple methods	GPS log	Path size logit
Kelly et al.	2011	Journal article	SP - Choice experiment	WTP	100	2007 or earlier	United Kingdom	Other	Online self-completion	Not stated
Hensher et al.	2011	Journal article	SP - Choice experiment	Coefficient	99	2007	Australia	Survey firm	Personal interview	Mixed logit
Heuman et al.	2005	Consultancy report	SP - Contingent valuation	WTP	700	Not stated	United Kingdom	Street intercept	Telephone interview	Not stated
Ghiasi Ghorveh	2017	Academic thesis	RP - route choice	Coefficient	51	2015	United States	PT intercept	Personal interview	Logit
Hoffer	2015	Academic thesis	SP - Choice experiment	Coefficient	400	Not stated	United States, Singapore and India	Other	Online self-completion	Logit

With regard to research method, studies were relatively evenly split between stated preference (14 studies; 56%) and revealed preference (10; 40%) approaches, with one study (4%) using a combination of stated preference and revealed preference approaches. The predominant stated preference methodology was a stated choice experiment (10 studies; 40%) and the predominant revealed preference methodology was a walking path choice approach (8; 32%). Logit models and their variants were by far the most common approach to analysing data and were used by 60% of studies.

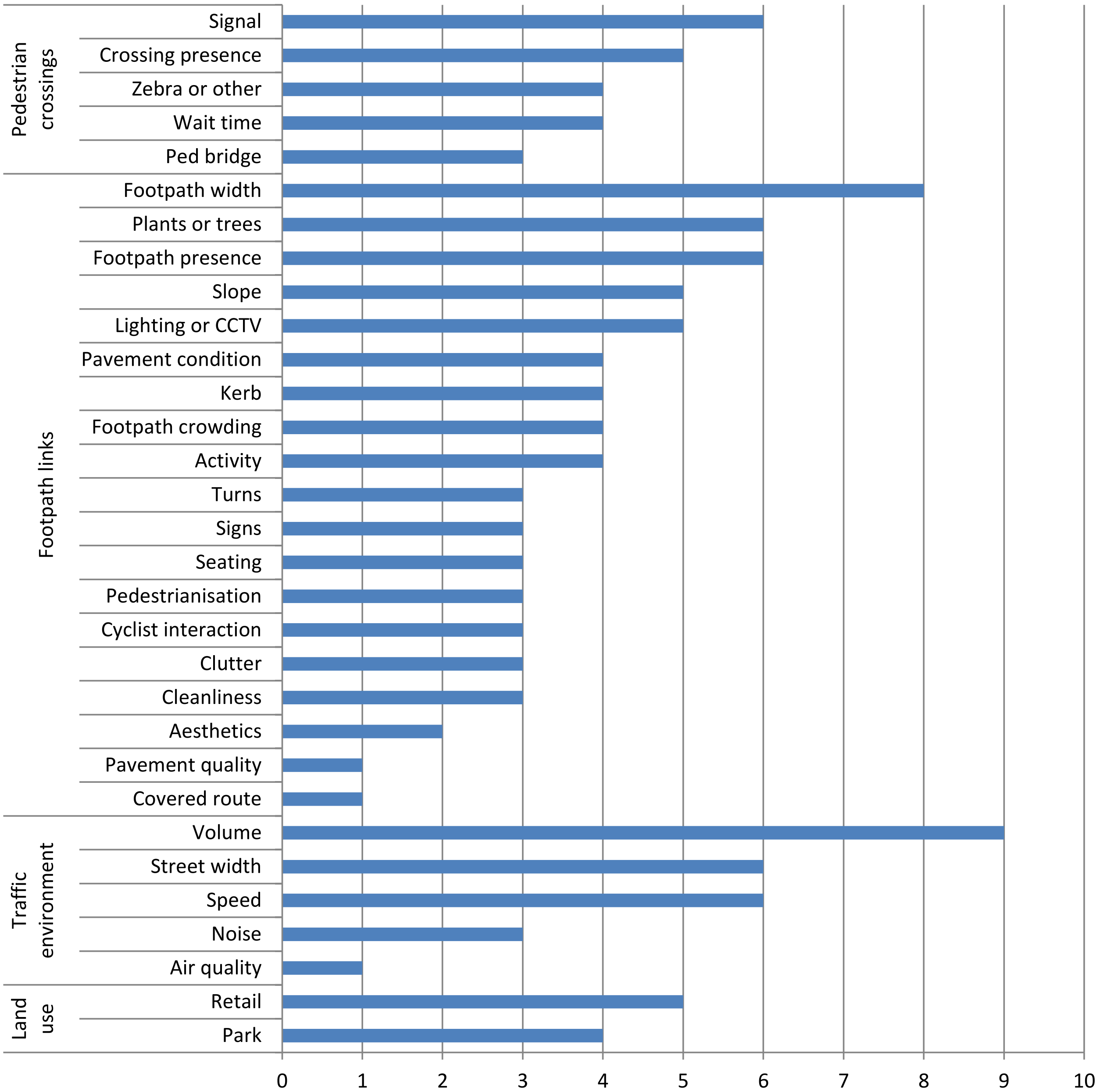
Figure 5: Number of studies by publication year



6.3.2 Attributes used to value pedestrian facilities

We grouped the factors used in the studies to value pedestrian facilities into four categories: surrounding land use, traffic environment, footpath link attributes, and crossing link attributes. A total of 31 attributes were observed across the four categories Figure 6. There was considerable variation in both the specific attributes and total number of attributes included in each study. The top five most common attributes were traffic volume (9), footpath width (8), traffic speed (6), carriageway width (6), presence of a footpath (6), and presence of plants or trees (6).

Figure 6: Number of studies that assess each attribute



6.3.3 Summary of willingness to pay values

The following charts illustrate the variation in different willingness to pay values for each individual attribute. Each WTP value is shown as a single point, with larger points indicating values that received a higher weight in analysis due to the fact that they had larger sample sizes. The largest points are all drawn from hedonic studies that drew upon a large number of property sales.

These charts highlight the degree of variation between different estimates. Almost all valuations of link attributes fell within the -1 to +2.5 range, although there were outliers on both sides. Valuations of crossing attributes generally fell within the -0.5 to +10 range, with some outliers.

Figure 7: Summary of willingness to pay values for footpath link, land use, and traffic environment attributes

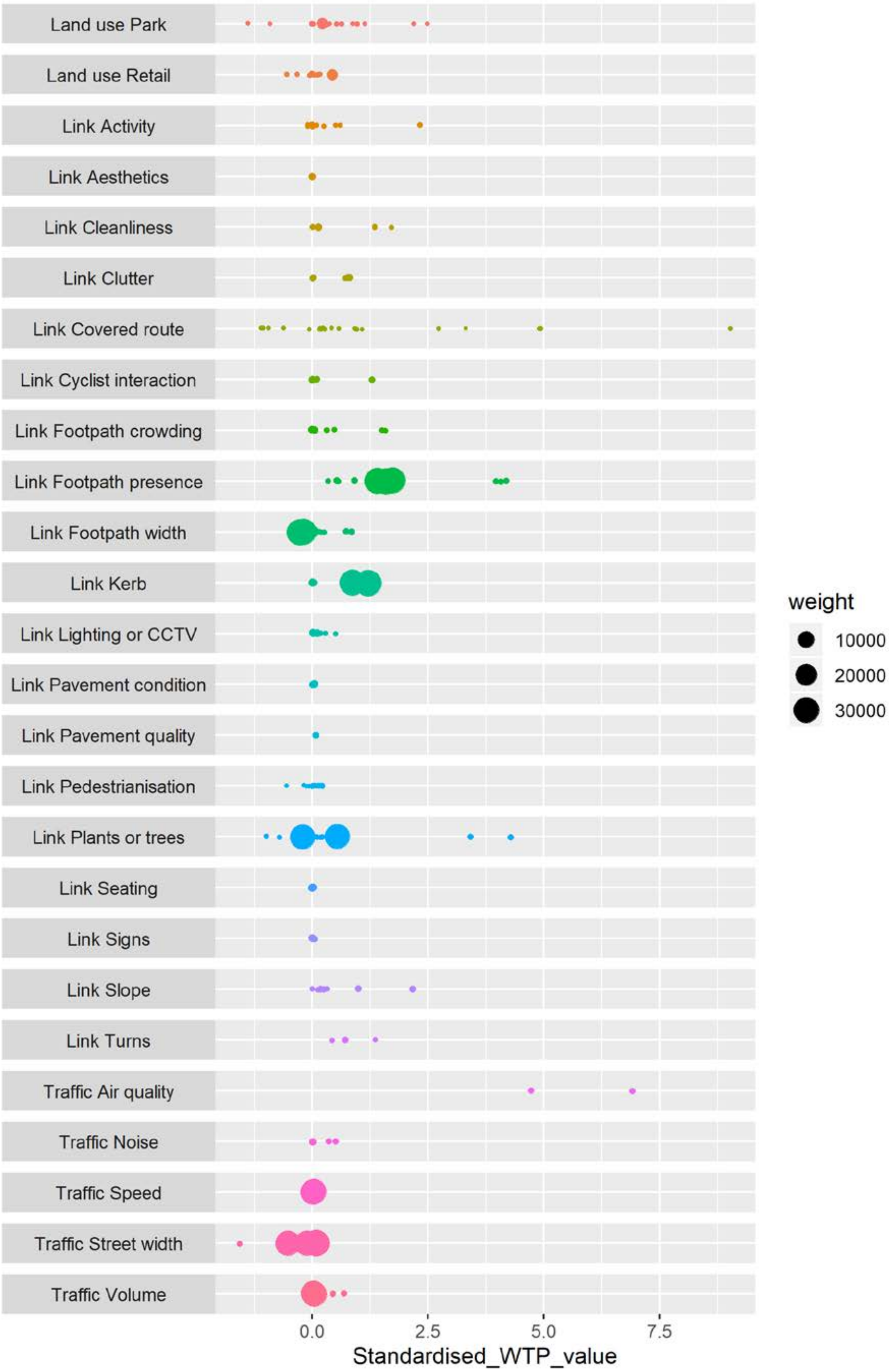
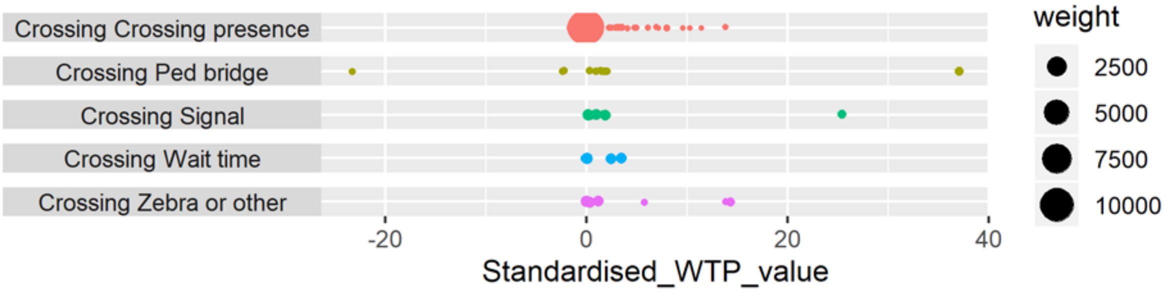


Figure 8: Summary of willingness to pay values for pedestrian crossing attributes



6.3.4 Weighted average parameter values

We calculate weighted average values for each individual parameter value that averaged out multiple values from the same study and assigned a higher weight to studies with a larger sample size. The following formula explains this weighting procedure.

Equation 5: Calculating weighted average parameter values

Step 1: Calculate weights: $w_{i,j} = n_j/m_{i,j}$

Step 2: Calculate weighted average values: $V_i^{avg} = \frac{\sum_{j,k} V_{i,j,k} * w_{i,j}}{\sum_{j,k} w_{i,j}}$

Where V_i^{avg} is the weighted average parameter value for attribute i; $V_{i,j,k}$ is the kth parameter value observation from study j for attribute i; $w_{i,j}$ is the weight for values of attribute i derived from study j; n_j is the sample size for study j; and $m_{i,j}$ is the number of parameter values for attribute i that are reported in study j. For instance, Sheldon et al (2006) report two values for the benefits of street lighting based on a sample size of 600 people, while Heuman et al (2005) report a single value for street lighting based on a sample size of 700. As a result, the value from Heuman et al is given a weight of 700, while each of the two values from Sheldon et al are given a weight of 300.[11]

This approach places a very high weight on a small number of values from hedonic price studies, which include a large number of property sales records. As a result, we also report weighted averages (in parentheses) that exclude hedonic price studies. In some cases, this results in significantly different parameter estimates.

Table 15: Weighted average parameter values

Facility attribute	Number of studies (ex hedonic)	Number of values (ex hedonic)	Weighted average WTP (ex hedonic)	Share positive values	Share negative values
Surrounding land use					
Park	4	15	0.24	80%	20%
Retail	5	13	0.35	77%	23%
Traffic environment					
Air quality	1	2	5.82	100%	0%
Noise	3	5	0.17	100%	0%
Traffic speed	6 (5)	8 (6)	0.03 (0.01)	100%	0%

[11] This weighting scheme is a mix of the approaches used by Ewing & Cervero (2010), who weighted by sample size, Wardman, Chintakayala, & de Jong (2016) and Elburz, Nijkamp, & Pels (2017), who weighted according to the inverse of number of observations from each group.

Facility attribute	Number of studies (ex hedonic)	Number of values (ex hedonic)	Weighted average WTP (ex hedonic)	Share positive values	Share negative values
Street width	6 (4)	11 (6)	-0.06 (-0.02)	64%	36%
Traffic volume	9 (8)	20 (18)	0.05 (0.14)	60%	40%
Footpath links					
Activity	4	11	0.22	64%	36%
Aesthetics	2	3	0.00	100%	0%
Cleanliness	3	7	0.18	100%	0%
Clutter	3	7	0.39	100%	0%
Covered route	1	23	1.10	78%	22%
Cyclist interaction	3	4	0.31	100%	0%
Footpath crowding	4	7	0.23	100%	0%
Footpath presence	6 (5)	10 (7)	1.59 (1.91)	100%	0%
Footpath width	8 (7)	13 (10)	-0.19 (0.14)	62%	38%
Kerb	4 (3)	8 (5)	1.07 (0.02)	100%	0%
Lighting or CCTV	5	9	0.06	100%	0%
Pavement condition	4	5	0.03	100%	0%
Pavement quality	1	8	0.08	100%	0%
Pedestrianisation	3	23	0.10	78%	22%
Plants or trees	6 (5)	17 (15)	0.20 (1.27)	71%	29%
Seating	3	3	0.01	100%	0%
Signs	3	6	0.02	100%	0%
Slope	5	8	0.93	100%	0%
Turns	3	3	0.75	100%	0%
Pedestrian crossings					
Crossing presence	5 (4)	41 (32)	-0.04 (0.26)	78%	22%
Ped bridge	3	12	8.28	75%	25%

Facility attribute	Number of studies (ex hedonic)	Number of values (ex hedonic)	Weighted average WTP (ex hedonic)	Share positive values	Share negative values
Signal	6	12	2.19	100%	0%
Wait time	4	13	1.08	69%	31%
Zebra or other	4	6	2.10	100%	0%

*Notes: * WTP for pedestrian crossing improvements and reductions in the number of turns are stated in terms of minutes per facility. All other WTP values are stated in terms of % increase in walk time that an average user would be willing to incur to obtain this improvement for their entire trip.*

6.3.5 Linear regression models

Linear regression models of the following general form are estimated:

Equation 6: Linear regression models

$$V_{i,j,k} = \beta' X_{i,k} + \gamma' S_{j,k} + \delta' C_{j,k} + e_{i,j,k}$$

Where $V_{i,j,k}$ is the kth parameter value for attribute i derived from study j; $X_{i,k}$ is a vector of indicator variables that identify each distinct attribute i; $S_{j,k}$ is a vector of methodological characteristics related to the k^{th} parameter value derived from study i (e.g. study design, publication type, sample size); $C_{j,k}$ is a set of context-specific variables (i.e. region and GDP per capita); $e_{i,j,k}$ is an error term; and the Greek letters are constants to be estimated in the regression.

Inspection of the data suggests that it was more appropriate to estimate separate models for pedestrian crossings (which are generally valued in terms of added minutes per facility) and footpath links, surrounding land use, and traffic environment (which are generally valued in terms of percent increase in walking time).

For each subset of the data, we estimated two models: A pooled ordinary least squares (pooled OLS) model that 'weighted' each individual observation equally, and a weighted least squares (WLS) model that weighted observations based on sample size and number of values reported per study (analogous to the weighting scheme described in Equation 5). Because multiple values are derived from each study, errors are not necessarily independent across observations. We address this by calculating heteroscedasticity-robust standard errors.[12]

The following table summarises results from four linear regression models estimated on these two subgroups. These models include constants for 31 individual types of pedestrian environment attributes, as well as parameters for whether the study was published in a journal, whether it reported a WTP value or simply model coefficients, what methodology the study used, what region the study was conducted in, and GDP per capita in the study country (constant 2011 PPP dollars). Coefficient estimates are reported

We highlight the following findings, noting that most model coefficients are not statistically significant even at the 10% level:

- Studies that were published in a journal, as opposed to published as conference papers, student theses, or consultancy reports, appeared to produce slightly higher values for links but not for crossings. This suggests the potential presence of publication bias.
- There are some signs that study methodology affects parameter values. Hedonic price studies appear to produce the lowest values, on average. Values from choice experiment studies and priority ranking studies were higher than values from hedonic price studies, and this difference was statistically significant across most models.
- Values appear to be slightly higher in the Americas and Australia than in Asia or Europe.

[12] Residual plots for both models indicate substantial remaining heteroscedasticity. This suggests that further investigation of model specification or weighting scheme may be desirable.

- Higher GDP per capita is associated with higher parameter values, although this effect is not statistically significant.

Constants for different attributes of the pedestrian environment are, for the most part, statistically insignificant. However, we find that:

- In the WLS model for footpath links, a variety of attributes, including routes with retail land uses, routes with moderate levels of pedestrian activity, clean and uncluttered footpaths, routes that were not subject to pedestrian crowding, covered routes, routes with footpaths, routes with plants or trees, lower traffic speeds or traffic volumes, etc., were more highly valued than the base level (routes through parks).
- In the models for pedestrian crossings, there were few statistically significant differences in attribute values relative to the base level (one fewer crossing along the route).

Table 16: Linear regression models

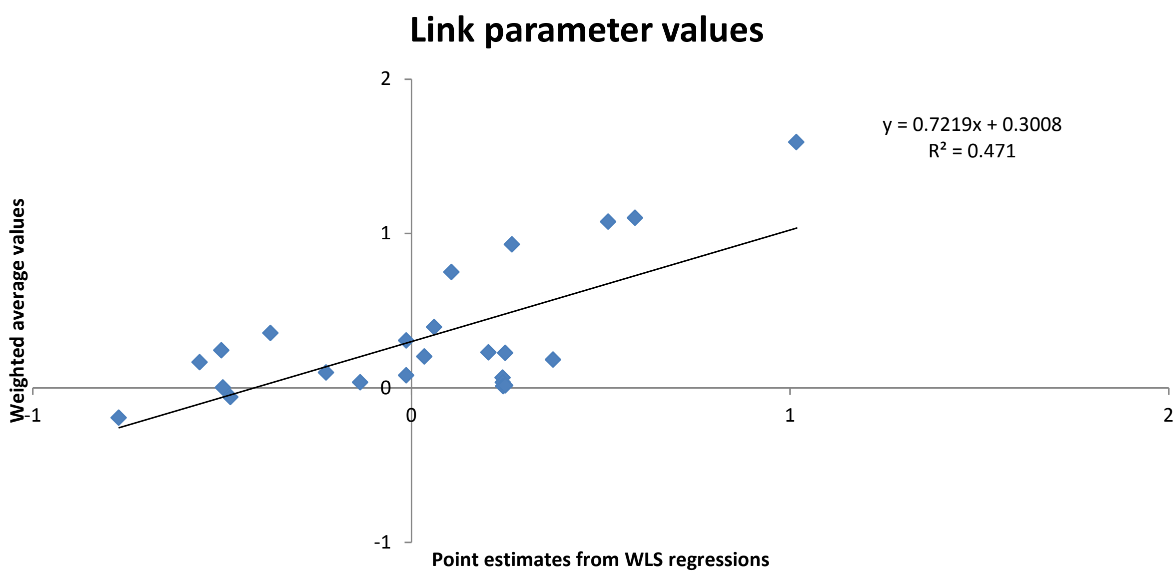
Dependent variable	Standardised WTP value			
Subgroup	Footpath links, surrounding land use, traffic environment		Pedestrian crossings	
Econometric model type	Pooled OLS	WLS	Pooled OLS	WLS
Land use Park	**(base level)**	**(base level)**		
Land use Retail	-0.409	0.129^{*}		
	(0.280)	(0.068)		
Link Activity	0.112	0.750^{***}		
	(0.312)	(0.231)		
Link Aesthetics	-0.485	0.004		
	(0.297)	(0.308)		
Link Cleanliness	0.500^{*}	0.876^{***}		
	(0.298)	(0.192)		
Link Clutter	0.068	0.562^{***}		
	(0.256)	(0.196)		
Link Covered route	0.726	1.092^{**}		
	(0.549)	(0.513)		
Link Cyclist interaction	-0.163	0.488^{*}		
	(0.315)	(0.285)		
Link Footpath crowding	0.078	0.705^{***}		
	(0.277)	(0.199)		
Link Footpath presence	1.351^{***}	1.519^{***}		
	(0.493)	(0.160)		
Link Footpath width	-0.400^{*}	-0.271^{*}		
	(0.243)	(0.140)		
Link Lighting or CCTV	0.194	1.021^{***}		
	(0.247)	(0.170)		
	-0.114	0.743^{***}		
	(0.236)	(0.185)		
Link Pavement condition	-0.027	0.744^{***}		
	(0.249)	(0.188)		
Link Pavement quality	0.009	0.488		
	(0.264)	(0.316)		
Link Pedestrianisation	-0.117	0.277		
	(0.259)	(0.218)		
Link Plants or trees	0.072	0.536^{*}		
	(0.391)	(0.303)		
Link Seating	0.030	0.745^{***}		
	(0.242)	(0.191)		
Link Signs	0.015	0.750^{***}		
	(0.239)	(0.191)		
Link Slope	0.047	0.768^{*}		

Dependent variable	Standardised WTP value			
Subgroup	Footpath links, surrounding land use, traffic environment		Pedestrian crossings	
Econometric model type	Pooled OLS	WLS	Pooled OLS	WLS
	(0.361)	(0.417)		
Link Turns	0.395	0.608***		
	(0.385)	(0.186)		
Traffic Air quality	4.875***	5.224***		
	(0.823)	(0.817)		
Traffic Noise	-0.495*	-0.057		
	(0.262)	(0.266)		
Traffic Speed	-0.417	0.367**		
	(0.254)	(0.186)		
Traffic Street width	-0.572**	0.024		
	(0.258)	(0.144)		
Traffic Volume	-0.353	0.375**		
	(0.248)	(0.183)		
Crossing Presence			**(base level)**	**(base level)**
Crossing Ped bridge			-3.121	5.189
			(3.227)	(7.111)
Crossing Signal			-0.703	2.453
			(3.267)	(3.449)
Crossing Wait time			-4.912*	1.903
			(2.531)	(2.986)
Crossing Zebra or other			1.583	0.863
			(3.464)	(3.281)
Journal	0.321***	0.193	-0.655	-2.411
	(0.116)	(0.169)	(1.999)	(2.955)
Outcome reporting: WTP	-0.311**	-0.576***	-6.912*	-0.652
	(0.124)	(0.190)	(3.885)	(3.542)
Valuation method: revealed preference hedonic pricing	**(base level)**	**(base level)**	**(base level)**	**(base level)**
Valuation method: choice experiment	0.307***	0.517*	7.127**	7.436**
	(0.104)	(0.265)	(2.787)	(3.587)
Valuation method: contingent valuation	0.164*	0.188	4.037	0.889
	(0.097)	(0.136)	(5.521)	(3.613)
Valuation method: priority ranking	0.452***	0.611**	6.388	10.590
	(0.122)	(0.273)	(4.029)	(9.802)
Valuation method: revealed preference route choice	0.030	0.230	1.906	0.595
	(0.146)	(0.147)	(2.262)	(0.538)
Region: Americas and Australia	**(base level)**	**(base level)**	**(base level)**	**(base level)**
Region: Asia	-0.179	-0.427**	-5.808*	-10.036
	(0.200)	(0.207)	(2.979)	(7.407)
Region: Europe	-0.180	-0.193	-0.640	-5.639**
	(0.178)	(0.190)	(2.085)	(2.602)
log(GDP per capita)	0.163	0.104	1.448	3.061
	(0.138)	(0.152)	(0.960)	(1.891)
Constant	-1.459	-1.249	-13.895	-30.706
	(1.499)	(1.684)	(11.280)	(20.138)
Observations	249	249	84	84
R^2	0.383	0.912	0.178	0.341
Adjusted R^2	0.285	0.898	0.026	0.219
Note:	*$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$*			

We used coefficient point estimates from WLS models to predict 'best guess' values for each of these attributes in the New Zealand context.[13] The following charts show how these values compare with the weighted average values in Table 15. The first chart excludes the parameter value for air quality, which is an influential outlier that has a very similar, high value using either method.

There is a reasonably strong positive correlation for both link and crossing parameter values, which suggests that weighted average values are unlikely to be significantly biased due to methodological differences between studies.

Figure 9: Comparison of OLS model point estimates with weighted average values



6.3.6 Binary outcome regression

Finally, we estimate a binary outcome regression model to understand what study- and context-related factors contribute to a higher probability of finding a positive parameter value. We estimate a probit regression that takes on the following form:

Equation 7: Probit regression model

$$\mathbf{Pr}\ (\boldsymbol{V_{i,j,k}} \geq \mathbf{0}|\boldsymbol{X_{i,k}}, \boldsymbol{S_{j,k}}, \boldsymbol{C_{j,k}}) = \boldsymbol{\Phi}(\boldsymbol{\beta}'\boldsymbol{X_{i,k}} + \boldsymbol{\gamma}'\boldsymbol{S_{j,k}} + \boldsymbol{\delta}'\boldsymbol{C_{j,k}} + \boldsymbol{e_{i,j,k}})$$

Where Pr denotes probability; Φ is the cumulative distribution function of the standard normal distribution; and other variables are defined as in Equation 6. We weight observations based on inverse of values reported per study, following Elburz, Nijkamp and Pels (2017).

As shown in Table 15, we only observe positive parameter values for many pedestrian environment attributes. We therefore replace the 31 attribute-specific coefficients used above with four coefficients for broad attribute categories (surrounding land use, traffic environment, footpath link, pedestrian crossing). The following table summarises outputs from this model. Parameter estimates do not have an intuitive interpretation, but their sign and statistical significance indicates whether attributes increase the probability of finding a positive WTP value.

Key findings from this analysis are as follows:

- There are no statistically significant differences in the probability of finding a positive impact for studies that use different valuation methods.

[13] We set the other explanatory variables as follows: Journal=FALSE; Outcome reporting=WTP; Valuation method=revealed preference route choice; Region=Americas and Australia; GDP per capita=PPP$36,354.

- On average, studies published in a journal have a higher probability of finding a positive impact, although this impact is not statistically significant. Again, this indicates the potential presence of publication bias.
- Studies from Asian and European countries had a lower probability of finding positive impacts than studies from the Americas and Australia. This difference was statistically significant for Asian studies. GDP per capita had a negative but statistically insignificant effect on the probability of finding positive values.
- The probability of finding a positive impact is higher for surrounding land use attributes and footpath link attributes, relative to pedestrian crossing attributes, but these effects were not statistically significant.

Table 17: Weighted probit model

Dependent variable	Pr(Standardised WTP ≥ 0)
Model type	Weighted probit
Pedestrian crossing	**(base level)**
Surrounding land use	0.719
	(0.740)
Footpath link	0.548
	(0.480)
Traffic environment	0.157
	(0.510)
Journal	0.283
	(0.392)
Outcome reporting: WTP	0.263
	(0.655)
Valuation method: revealed preference hedonic pricing	**(base level)**
Valuation method: choice experiment	0.258
	(0.491)
Valuation method: contingent valuation	0.786
	(0.817)
Valuation method: priority ranking	1.549
	(1.243)
Valuation method: revealed preference route choice	0.118
	(0.513)
Region: Americas and Australia	**(base level)**
Region: Asia	-1.009**
	(0.509)
Region: Europe	-0.382
	(0.486)
log(GDP per capita)	-0.385
	(0.528)
Constant	4.879
	(5.664)
Observations	333
Log Likelihood	-7.146
Akaike Inf. Crit.	40.292
Note:	**p<0.1; **p<0.05; ***p<0.01*

We used point estimates from this probit model to predict the likelihood of finding positive parameter values in New Zealand for each of the four broad types of attributes.[14] These probabilities are summarised in the following table. Without over-interpreting these values, they support the idea that many pedestrian environment improvements are likely to be positively valued in New Zealand.

[14] As above, we set the other explanatory variables as follows: Journal=FALSE; Outcome reporting=WTP; Valuation method=revealed preference route choice; Region=Americas and Australia; GDP per capita=PPP$36,354.

Table 18: Predicted probability of finding positive parameter values in New Zealand

Broad attribute type	Predicted probability of positive impacts
Surrounding land use	97%
Traffic environment	92%
Footpath links	96%
Pedestrian crossings	89%

6.3.7 Analysis of publication bias

The following charts are funnel plots that compare WTP values with the natural logarithm of studies' sample size.[15] Blue points show values from studies that were published in journals, while red points show values from consultancy reports, student theses, and conference papers.

Asymmetry in funnel plots can indicate the presence of publication bias. Under the fixed-effect model, which assumes that all studies included in the dataset estimate the same underlying parameter but obtain different estimates due to random sampling error, studies with larger sample sizes should obtain more precise estimates of the true parameter, while studies with smaller sample sizes should exhibit a wider spread around the true parameter. In the absence of publication bias, funnel plots should be symmetric – there should be a scatter of points on either side of the average, and no sudden drop off in observations to the left of the y axis.

In this case, funnel plots suggest that there may be asymmetry in the values published in journals, compared with values from studies that were not published in journals. In particular, journal articles provide very few negative observations of WTP values, even when sample sizes are small. This is consistent with the presence of publication bias.

However, as noted above, it is unclear whether the fixed-effect model is valid for this population of studies. At minimum, we would expect WTP values to differ for different types of pedestrian environment attributes. Results from meta-regressions in Table 16 and Table 17 show that, after controlling for observable characteristics that may cause true parameters to differ between studies, publication in journals has a (generally) positive but statistically insignificant effect on WTP values and on the probability of finding a positive impact.

In short, this analysis does not conclusively demonstrate publication bias but nor does it allow us to conclude that it is not present.

[15] Sample size is an imperfect proxy for the precision of the study. Ideally, funnel plots should be constructed with standard error on the y axis, rather than sample size, as this offers a much clearer interpretation of publication bias. We are unable to do this due to a lack of information on standard errors in the underlying studies.

Figure 10: Funnel plot for footpath link, land use, and traffic environment attributes

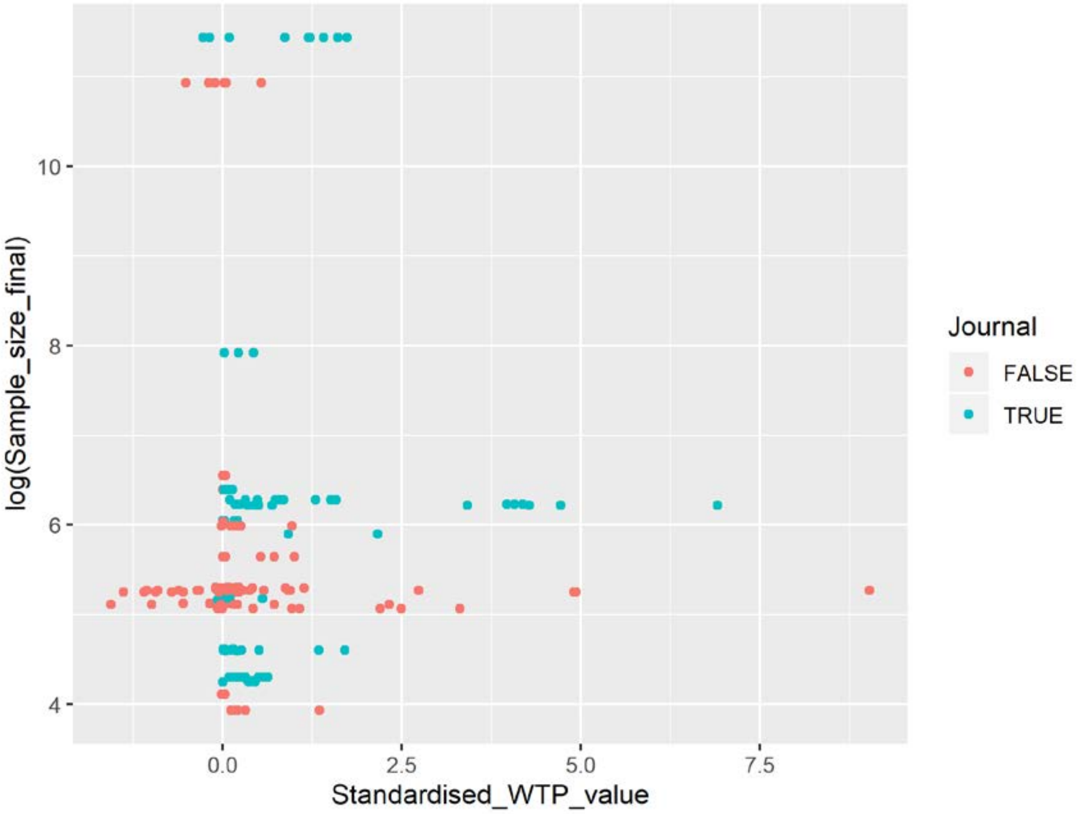
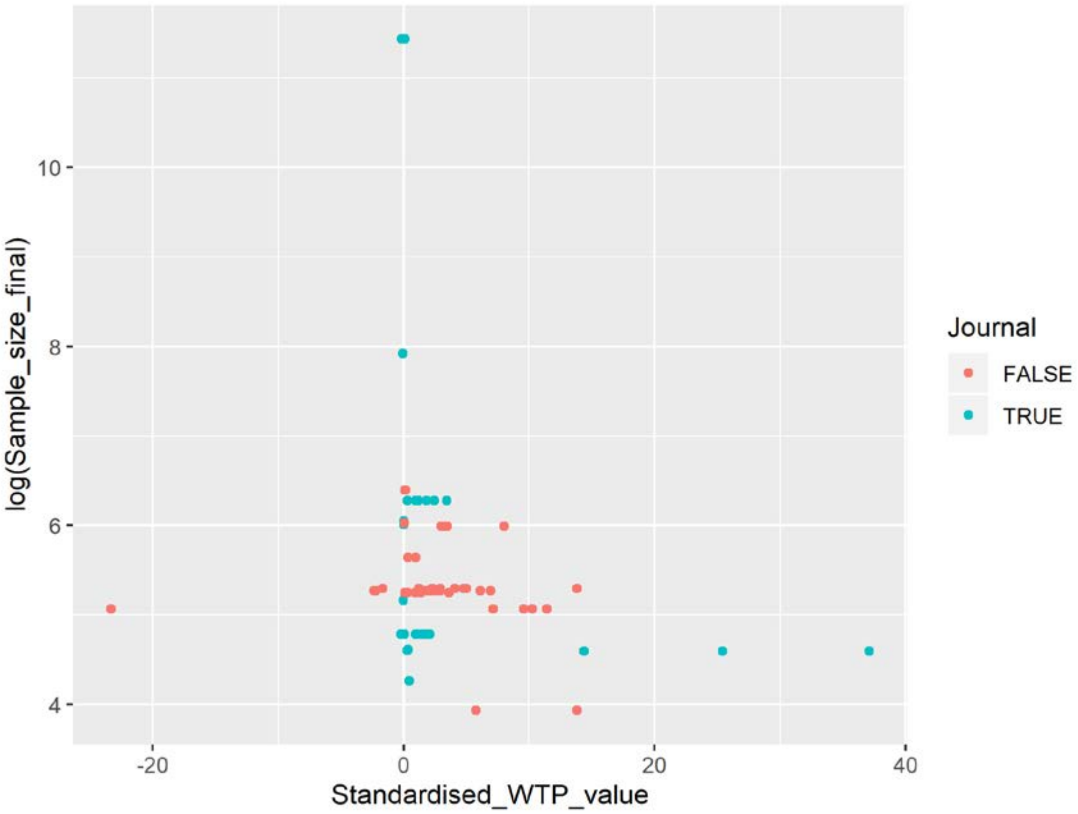


Figure 11: Funnel plot for pedestrian crossing attributes



6.4 Discussion

The growth in the number of studies valuing attributes of the pedestrian environment is indicative of the increased interest in improving the pedestrian experience. Despite growing interest in the area, research conducted across 13 countries shows substantial heterogeneity with regard to both the attributes of the pedestrian environment studied and the methodological approach applied. Even the most common attribute was observed in only about a third (36%) of studies, showing that there is a lack of consensus among researchers regarding the most important factors that contribute to the pedestrian experience. This review also demonstrated that there is a range of research methods used to value attributes of the pedestrian environment. While there was a degree of consistency across studies with regard to the sign of values observed, valuation method appeared to have an impact on both the magnitude of values reported and on the likelihood of values having a positive impact.

Our key findings from the meta-analysis and meta-regression are as follows.

Surrounding land use: On average, both routes through parks and routes with active retail frontages are valued by pedestrians. However, some studies find negative values on these attributes, which suggests that context may be important.

Traffic environment: On average, pedestrians are willing to walk out of their way to be in an environment with slower traffic speeds and lower traffic volumes. However, some studies find that higher traffic volumes are positively valued, which may be due to confounding with other desirable attributes (such as slower speeds or retail main streets). Results for other traffic attributes are mixed or based on a limited number of studies.

Footpath links: The most highly valued attributes were the presence of a footpath (as opposed to walking on the side of the road) and a covered route (eg awnings or verandas on buildings). However, these values are highly influenced by results from individual studies and so bear further consideration.

Improvements relative to a basic footpath are also valued. Pedestrianised or shared spaces are valued more highly than basic footpaths, and higher-quality or better-maintained paving is valued. Wider footpaths have a positive value, but only if hedonic studies are excluded. People also place a value on street trees and plantings, the availability of seating, wayfinding signs, and lighting/ CCTV.

People prefer to walk on routes with a reasonable level of pedestrian activity (as opposed to no people around) but they also prefer to avoid routes that are crowded with pedestrians or where cyclists also occupy the footpath. This suggests that there is an ‘inverted U’ relationship between footpath use and user benefits: too few people are bad, too many people are bad, but there is a ‘sweet spot’ in the middle.

Pedestrian crossings: People appear to place higher value on routes that allow them to avoid crossing the road, at least if hedonic studies are excluded.[16] However, if they do have to cross, they value the presence of zebra crossings or median islands, pedestrian signals, or overbridges/ underpasses. They also place a modest value on dropped kerbs at crosswalks, again excluding hedonic studies.

6.4.1 Recommended interim parameter values

Based on the above analysis, we recommend a set of interim parameter values for footpath links, traffic environment, and surrounding land use. Unless otherwise noted, these parameters are based on the weighted average parameters in Table 15. In some cases, we have adjusted these values for methodological reasons or selected preferred values based on a specific study with a stronger methodology.

We have excluded parameter values for some attributes if there is weak or no evidence of benefits or if the benefits of these attributes are already addressed through other EEM procedures, such as reduced noise and vehicle emissions. We have also added suggested parameter values for some

[16] There is a strong case to exclude hedonic studies when valuing the presence of crossings, as the variable used is crossing density per square kilometre in the neighbourhood around each house. This measures the connectivity of the local street network, which might benefit pedestrians.

attributes that were not explicitly included in the studies we reviewed but which can readily be valued based on attributes that are measured.

At this stage, there is not sufficient evidence to justify the inclusion of quality of experience factors for pedestrian crossings. In general, pedestrians place a negative value on routes that require them to cross the road. However, if it is necessary to cross, providing pedestrian crossing facilities can improve quality of experience for users. Benefits that users experience from crossing facilities may include changes in delay while waiting to cross, reduced exposure to crash risk, and perceived changes in comfort.

Few studies controlled for the safety record of intersections and/or traffic volumes and speeds at the crossing point (eg Ancianes, Jones, and Metcalfe, 2018; Hensher et al, 2011), and hence it is likely that the weighted average parameter values in Table 15 double-count changes in crossing delay and crash risk. We therefore suggest that it would be more appropriate to assess the benefits of new pedestrian crossings (or routes that allow pedestrians to avoid crossing the road) using existing EEM procedures or with the *Australasian Pedestrian Facility Selection Tool* (Abley, Smith, and Rendall, 2015).

The following table summarises these values. Each parameter value is assigned a high/medium/low quality score that reflects how much confidence users should have in the value. Higher scores reflect values that are drawn from a larger number of studies, while lower scores reflect values that are drawn from fewer studies or studies with weaker methodologies, or values that have a larger range across multiple studies.

Table 19: Recommended interim parameter values

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Confidence level	Notes
Facility availability				
Footpath presence	Basic footpath available, relative to no footpath/ walking on the side of the road	1.59	Medium	Median WTP is similar to weighted average
Footpath width: Crowded conditions	Increase width by 1 metre ‘Crowded conditions’ defined as a flow rate above 33 pedestrians per metre of usable width per minute	0.14 (capped at 0.56)	Medium	Based on non-hedonic studies only; hedonic studies find lower values. Suggested cap based on analysis of walking speeds in congested conditions
Footpath width: Uncrowded conditions with narrow footpath	Increase width by 1 metre ‘Narrow footpath’ defined as two metres or less	0.07 (capped at 0.14)	Low	Half of the value for footpath width in crowded conditions, reflecting fewer benefits from improved walking speed
Pavement condition	Smooth pavement without cracks, relative to cracked or uneven pavement	0.03	Medium	

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Confidence level	Notes
Pavement quality	Attractive/high quality paving relative to basic asphalt paving	0.08	Low	Based on only one study
Covered route	Awnings, verandas, or canopies are present	0.28	Low	Based on only one study. Median value chosen over weighted average due to presence of some outlier values
Dropped kerbs	Crossings are level with streets or offer dropped kerbs	0.02	Medium	Based on non-hedonic studies only; hedonic studies find higher values
Footpath amenities				
Lighting or CCTV	Route is lit and/or monitored by CCTV	0.06	Medium	
Street trees or plantings	Trees or plantings are present on or adjacent to footpath	0.20	Medium	Based on non-hedonic studies only; hedonic studies find higher values
Seating	Seating is available on link	0.01	Medium	
Signage and wayfinding	Signs and wayfinding devices are available	0.02	Medium	
Activity and conflict				
Absence of clutter	No footpath clutter, relative to significant clutter	Not included	Medium	Captured in footpath width parameter
Footpath activity level: Moderate activity	There is a moderate amount of pedestrian activity on the street, relative to no activity	Not included	Low	Captured in footpath width parameter
Footpath activity level: Crowded	The footpath is crowded with pedestrians, relative to no activity	Not included	Medium	Captured in footpath width parameter
Remove conflict with cyclists	No or few cyclists are present on the link, relative to moderate cyclist volumes	0.10	Low	Lower value used to remove influence of outlier and more closely reflect

Attribute	Description	Willingness to pay to obtain improvement (ratio increase in walk time)	Confidence level	Notes
				Swedish parameter value
Surrounding land use				
Routes through parks	100% route through park, relative to routes in other areas	0.24	Medium	
Retail frontages	100% active retail frontage, relative to 0% active frontage	0.35	Medium	
Traffic environment				
Traffic volume	Reduce AADT by 1000 vehicles	0.05	Medium	Excluding hedonic studies produces a higher result, but this is due in part to outlier values
Traffic speed	Reduce average traffic speed by 1km/hr	0.03	Medium	Excluding hedonic studies produces a slightly lower result Capping benefit values may be desirable.

6.4.2 Implications and directions for future research

Among studies included in the meta-analysis, there was considerable variation in the attributes included to value the pedestrian environment, with the most common attribute included in only 36% percent of studies, as well as considerable variation in the valuation methodologies and units that were used. This demonstrates that there is a lack of a consensus among researchers with regard to both the most important contributors to the amenity of the pedestrian environment and the way that they should be valued. For many of the attributes identified, the authors have a low level of confidence in parameter values, although there is sufficient evidence to demonstrate that they are valued by users to some extent.

Additional research is needed in the area, both to increase confidence in parameter values and to allow for parameter values for subgroups and subpopulations. A wider research base from more regions of the world is needed, especially for attributes such as shade and shelter, which can be expected to vary based on local conditions. There is little research examining the valuation of factors among subgroups, such as the disabled or children, who may have substantially different needs as compared to the general population.

Future studies can improve the quality of the evidence by improving reporting protocols. They should take care to clearly report sample size, study methodology, attribute units, and confidence intervals or standard errors. This will allow for future meta-analyses to more easily and reliably pool results across studies.

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