



## THE PRINCIPLES OF PEDESTRIAN NETWORK PLANNING

- Pedestrian characteristics, preferences and activity
- Community walkability
- Approaches to providing for pedestrians
- Pedestrian network components



# THE PRINCIPLES OF PEDESTRIAN NETWORK PLANNING

Pedestrians are a diverse group of people with varied needs and abilities. By meeting the needs of the less able, a quality walking environment is provided for all.

Walkable communities have qualities that have a marked effect on the amount of walking people enjoy.

A variety of approaches and opportunities exist to better provide for walking. Each is discussed so that users of the guide can identify the approach that may work for them in the local context.

Choosing the best facilities that will help pedestrians to cross roads is important for their safety and convenience. This part provides a framework for considering all users and factors to help choose the best crossing option.



# 3 PEDESTRIAN CHARACTERISTICS, PREFERENCES AND ACTIVITY

## PEDESTRIAN CHARACTERISTICS AND PREFERENCES

Pedestrians – diverse characteristics and needs

The who, where and why of walking trips

Why people don't walk more

Pedestrian safety profile

Pedestrians on wheels

## 3.1 Introduction

Pedestrians are a diverse group of road users, with characteristics reflecting the general population [13]. While many pedestrians are fit and healthy, have satisfactory eyesight and hearing, pay attention and are not physically hindered, this is not the case for all pedestrians [10].

Given the diversity of pedestrians, scheme designs should consider a wide range of user needs, including the needs of children, those with mobility aids and older pedestrians. By 2051, one in four New Zealanders will be 65 years or older compared with the current one in eight [107].

Schemes should, wherever possible, be designed for pedestrians with the lowest level of ability. This removes access barriers for those with special needs, and ensures pleasant, convenient routes that are beneficial for all pedestrians [29, 66].



Photo 3.1 – Pedestrians, Christchurch (Photo: Megan Fowler)

## 3.2 Definition of terms

A 'pedestrian' is a person on foot, or in or on a contrivance equipped with wheels or revolving runners that is not a vehicle [110]. This can include an able pedestrian, a person pushing a pram, a person on a skateboard, a person in a wheelchair and a number of other users.

For ease of use throughout the guide, pedestrians have been grouped into three categories:

- on foot
- on small wheels
- mobility impaired.



Photo 3.2 – Pedestrian using mobility scooter, Wellington (Photo: Lesley Regan)

Table 3.1 shows the subgroups within each category.

| Table 3.1 – Types of pedestrian |  |
|---------------------------------|--|
| Type of pedestrian              | Sub groups   |
| On foot                         | <ul style="list-style-type: none"> <li>Able pedestrian</li> <li>Runner/jogger</li> <li>Adult pedestrian</li> <li>Young pedestrian</li> <li>Impaired pedestrian</li> <li>Aged pedestrian</li> <li>Pedestrian with a guide dog</li> <li>Sensory impaired pedestrian</li> <li>Pedestrian with a cane</li> </ul> |
| On small wheels                 | <ul style="list-style-type: none"> <li>In-line skates</li> <li>Roller skates</li> <li>Skateboards</li> <li>Kick scooters</li> <li>Pedestrian with a pram</li> </ul>  |
| Mobility impaired               | <ul style="list-style-type: none"> <li>Mobility scooters</li> <li>Manual wheelchairs</li> <li>Electric wheelchairs</li> <li>Pedestrian with a walking frame</li> </ul>   |



Photo 3.3 – Pedestrians with prams, Auckland (Photo: Megan Fowler)



Photo 3.4 – Wheelchair user, Christchurch (Photo: Glen Koorey)

### 3.3 Physical space required

Pedestrians require differing spaces within which to manoeuvre. Newer wheelchairs are increasingly wider than their predecessors and this should be considered when designing for pedestrians. Mobility scooters are usually longer but the same width as manual wheelchairs.

Figure 3.1 indicates the physical space required for pedestrians.



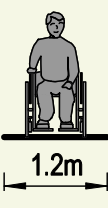
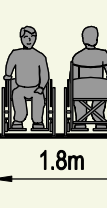
|   |  |   |  |
|---|--|---|--|
|  | <p>a) A clear width of 1000 mm is adequate for people with ambulant disabilities. It just allows passage for 80 percent of people who use wheelchairs.</p> |  | <p>c) A clear width of 1500 mm allows a wheelchair and a pram to pass.</p>                       |
|  | <p>b) People who use wheelchairs require a clear width of 1.2 metres.</p>  |  | <p>d) To allow two wheelchairs to pass comfortably, a clear width of 1.8 metres is required.</p> |

Figure 3.1 – Physical space requirements [10]

### 3.4 Walking speed

Walking speed is affected by [28]:

- pedestrian characteristics such as age, gender and physical condition
- trip characteristics such as walking purpose, route familiarity, trip length and encumbrances
- route characteristics such as width, gradient, surfacing, shelter, attractiveness, pedestrian density and crossing delays
- environmental characteristics such as weather conditions.

The vast majority of people walk at speeds between 0.8 metres per second (m/s) and 1.8 m/s (2.9 kilometres per hour (km/h) and 6.5 km/h) [139]. A fit, healthy adult will generally travel at a mean speed of 1.5 m/s (15th percentile (15%ile): 1.3 m/s), and the aged and those with mobility impairments travel more slowly, at around 1.2 m/s (15%ile: 1.0 m/s) [70, 104]. Mobility scooters can travel faster than most pedestrians, but may take time to manoeuvre between different road and footpath levels.

### 3.5 Abilities

Pedestrians vary widely in their physical and cognitive abilities. For example, children's heights and varying cognitive abilities at different ages need to be considered, as do declines in speed of reflexes, hearing and sight among older pedestrians. Abilities can even change during the same walking journey as the pedestrian becomes tired or acquires an encumbrance such as a parcel or a child.

Clusters of pedestrians with similar characteristics may be found at some types of land use, such as children in the vicinity of schools.

Table 3.2 summarises key pedestrian characteristics. Appendix 1 has more details of the typical characteristics of different types of pedestrian.

| Table 3.2 – Pedestrian physical characteristics    |  |  |
|--|--|--|
| How pedestrians differ                             | Affecting  | Impacting on   |
| Height   | Ability to see over objects<br>Ability to be seen by others  | Sight lines  |
| Speed of reflexes                                  | Inability to avoid dangerous situations quickly  | Crossing opportunities   |
| Stamina  | Journey distance between rests   | Resting places   |
| Visual perception                                  | Ability to scan the environment and tolerate glare   | Sign legibility<br>Detecting kerbs and crossing locations<br>Trip hazards<br>Tactile paving<br>Judging traffic             |
| Attention span and cognitive abilities             | Time required to make decisions<br>Difficulties in unfamiliar environments<br>Inability to read or comprehend warning signs<br>Difficulty in judging gaps in traffic | Positive direction signage<br>Streetscape 'legibility'<br>Consistency of provision<br>Symbol use<br>Crossing opportunities |
| Tolerance of adverse temperatures and environments | Preference for sheltered conditions  | Route location and exposure<br>Provision of shelter from wind and rain   |
| Balance and stability                              | Potential for overbalancing  | Providing steps and ramps<br>Kerb height<br>Gradients<br>Crossfall<br>Surface condition                                    |
| Fear for personal safety and security              | Willingness to use all or part of a route  | Lighting<br>Surveillance<br>Lateral separation from traffic<br>Pedestrian densities<br>Traffic speed and density           |
| Manual dexterity and coordination                  | Ability to operate complex mechanisms  | Pedestrian-activated traffic signals   |
| Accuracy in judging speed and distance             | Inopportune crossing movements   | Provision of crossing facilities   |
| Difficulty localising the direction of sounds      | Audible clues to traffic being missed  | Need to reinforce with visual information  |
| Energy expended in movement                        | Walking speed  | Crossing times<br>Journey length<br>Surface quality  |

[10, 13, 66, 122, 139]

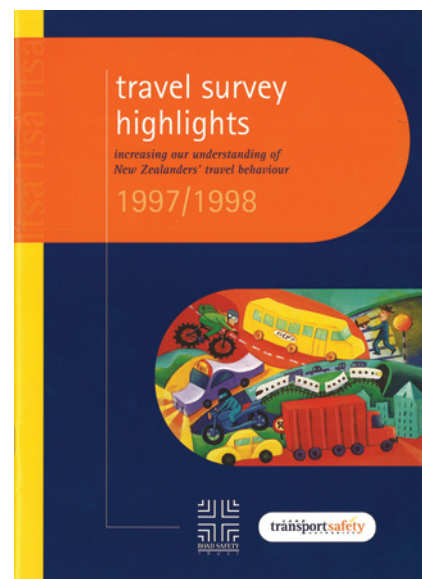
### 3.6 Pedestrian activity overview

The *New Zealand travel survey (2000)* [76] showed that of the estimated 6000 million-plus trips<sup>1</sup> made by New Zealand households annually, nearly one in five (18.7 percent) was made by walking. New Zealanders spend 215 million hours annually as pedestrians in the road environment and make around 2400 million road crossings on foot.

Around 70 percent of walking trips in the *New Zealand travel survey (2000)* involved getting from A to B solely on foot. Around 30 percent were undertaken in association with other modes of transport (eg walking from a parked car, or walking to and from public transport) [71].

While there was a small increase in the overall number of walking trips made during the 1990s, this did not keep pace with population growth, and the period saw a three percent drop in the share of household travel where walking was the sole mode of transport. The decline in walking as a mode of transport was most evident amongst those under 20. For example, there was a 10 percent decline (from 36 percent to 26 percent) in school journeys where walking was the sole mode of transport [71].

<sup>1</sup> Research into household travel undertaken for the *New Zealand travel survey*, identifies every leg of a journey as a 'trip'. For example, a trip to the bus stop, followed by a bus ride, followed by a walk at the other end would count as two walking trips and a public transport trip. Similarly a motor vehicle trip to work, with a stop on the way at a dairy, would count as two motor vehicle trips to two separate destinations. By focusing on 'trips', we can better see the multi-modal nature of many of our journeys, enabling us to plan better for all the modes of transport involved.



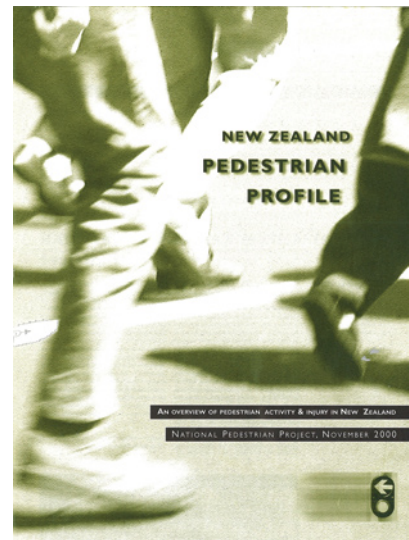
## National pedestrian information sources

The *New Zealand pedestrian profile* [71], published in 2000, provides an overview of pedestrian activity and injury in New Zealand. It was the first national document developed to provide such an overview and was based on analysis of New Zealand household travel survey data, crash analysis system data and hospitalisation data.

The New Zealand travel surveys [76] (now being updated annually) provide information on pedestrian activity as part of overall information on household travel in New Zealand. These surveys can sometimes be used to provide regional data, and may, over time, be able to provide some territorial local authority (TLA) level data.

Updated and additional information on pedestrian activity and injury will be available through the Ministry of Transport and Land Transport NZ websites, as part of the implementation of the government's *Getting there – on foot, by cycle* strategy.

A summary of pedestrian trips is in sections 3.7 and 3.8.



## 3.7 Journey time and distance

Figure 3.2 and Figure 3.3 show the time spent walking on 'walk-only' trips and 'all trips' (ie walk and another mode) in New Zealand. They show that for all trips including a walking element, half of the walking elements are more than five minutes. For walk-only trips, half are more than 10 minutes, 18 percent are more than 20 minutes and nine percent are more than 30 minutes [76]. A typical fit and healthy adult walks about five to six km in an hour. So a simple rule of thumb for undelayed walking is 10 minutes per km.

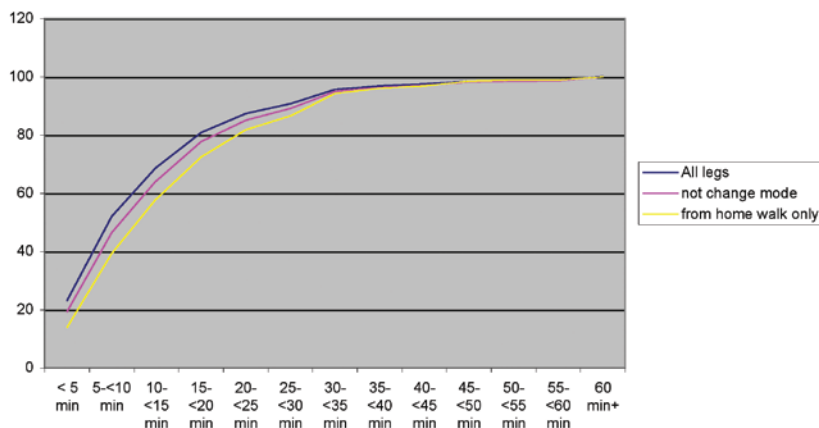


Figure 3.2 – Time spent walking – all trips [76]

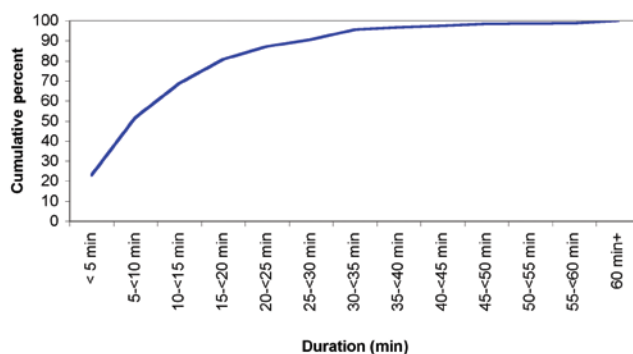


Figure 3.3 – Time spent walking – walk-only trips [76]

## 3.8 Who walks, where and why

Overall, females, the young, and the aged make the most walking trips [71].

The *New Zealand pedestrian profile* [71] identified that walking trips are made for a wide range of purposes, with social and recreation activities and shopping the most common reasons, followed by work and education related journeys.

Table 3.3 summarises the data from the *New Zealand travel survey (2000)* [76].

| Trip purpose               | Trip purpose as a percentage of all walking trips | Walking trips as a percentage of all modes for each trip purpose |
|----------------------------|---|--|
| To home*                   | 31.2  | 16.7   |
| Work (to job)              | 10.0  | 16.0   |
| Work (employer's business) | 2.2   | 8.1  |
| Education                  | 7.7   | 31.8   |
| Shopping                   | 14.2  | 20.9   |
| Personal business/services | 6.1   | 18.3   |
| Social/recreation          | 24.5  | 20.7   |
| Accompanying someone else  | 4.2   | 8.3  |
| <b>Total</b>               | <b>100.0</b>                                      | <b>-</b>   |

These results include walking as part of a journey by another mode.  
 \* Includes all trips with a destination that was the respondent's home. This may include returning home from work, education, etc.

Overall, females make 22 percent more walking trips than males but both sexes spend a similar amount of time walking, at around 11 to 12 minutes per trip. Women may be more likely to accompany children on trips to school and may have less access to the family vehicle.

### 3.9 Why people don't walk

Shortfalls in the physical environment are the most obvious deterrent to walking. Reasons often mentioned include [3, 5, 46, 101, 115, 139, 164, 169]:

- missing footpaths or sections of footpath
- poor-quality (cracked, uneven or slippery) walking surfaces
- obstacles on the footpath, including poorly placed street furniture
- lack of footpath maintenance, including litter, dog fouling and overhanging vegetation
- increased distances imposed by road layouts, barriers, footbridges and subways
- lack of continuous signing to potential destinations
- lack of continuous pedestrian routes
- missing or unsuitable crossing treatments creating severance
- poor-quality lighting
- speeding traffic
- lack of rest areas and seating
- traffic fumes and noise
- lack of shade
- lack of shelter from inclement weather
- lack of interesting features on the route.

Social and perceptual deterrents are also important. Potential deterrents include:

- a perceived lack of time to make journeys
- other modes perceived as more convenient
- a lack of confidence in the walking infrastructure
- confusion about which route to take and how far the destination is
- a perception that pedestrians generally have a low social status, especially in relation to car drivers
- fear of being attacked in isolated or potentially risky areas
- uncertainty about whether a route is fully accessible
- public routes that appear to be private
- a perception that motorists do not properly understand the rights of pedestrians.

Organisational and institutional issues have shaped the environment so that walking is more difficult. These have been compounded by a relative lack (until recently) of a collective voice for pedestrians. Issues include:

- land use planning that has resulted in longer distances between walking trip origins and destinations



- other modes of travel being given a higher priority than walking, resulting in pedestrians not being realistically accommodated within schemes designed for other travel modes
- a lack of knowledge and expertise among infrastructure providers and relevant professions on ways to provide for walking
- restrictive walking practices, where a concern for pedestrian safety results in walking being made less convenient
- considering it is inevitable that volumes and speeds of traffic will increase
- failure to protect or enhance the public realm, which makes walking less attractive
- tolerating obstructions placed on footpaths by third parties, shown by a lack of enforcement of actions such as parking on footpaths
- difficulties in quantifying changes in pedestrian numbers as a result of potential interventions
- difficulties in justifying walking schemes through 'traditional' economic criteria
- businesses paying mileage travel allowances to car drivers for very short trips
- a lack of research into pedestrians and walking journeys
- insufficient resources allocated to walking schemes.

All of the above interact, but addressing individual issues in isolation is unlikely to address all. A holistic view is needed to ensure the maximum benefits.

### 3.10 Pedestrian motor vehicle crash profile

From 2001 to 2005, pedestrians accounted for about one in 10 (10.5 percent) of all road deaths in New Zealand. In the main urban centres, on roads subject to urban speed limits, about one in three road deaths (32 percent) were pedestrians.

Annually, an average of 45 pedestrians are killed and 1100 are reported injured on New Zealand roads. While the number of pedestrians killed is trending downwards, reported pedestrian injuries have been unchanged for the last 15 years, despite the decline in walking by children who are the biggest group at risk [76].

Figure 3.4 shows the reported number of pedestrians killed and injured per 100,000 population [91].

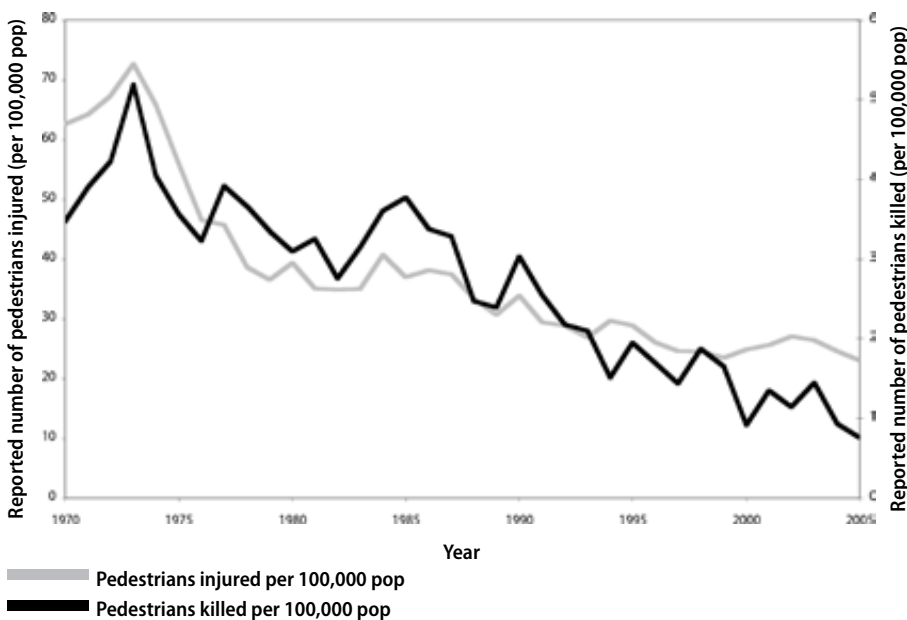


Figure 3.4 – Reported number of pedestrians killed and injured per 100,000 population

At a national level, crashes involving pedestrians occur mainly [71]:

- while pedestrians are crossing roads (around 90 percent)
- in built-up areas (two thirds of pedestrian deaths and 93 percent of injuries)
- within one to two kilometres of the pedestrian's home
- on relatively main roads rather than minor roads (54 percent on roads classified by TLAs as 'arterials', 25 percent on 'distributors/collectors', and only 21 percent on 'local' roads)
- near residential land use (half), commercial land use (one third)

- away from intersections (64 percent)
- away from formal pedestrian crossings (90 percent)
- when pedestrians are most likely to be out and about (eg during daytime, in fine weather, before and after the school day).

Traffic speed is a significant issue for pedestrians. The faster a driver goes, the more difficult it is for them to avoid hitting a pedestrian in their path. The faster the speed at which a pedestrian is hit, the more serious their injuries will be. A pedestrian hit at 30 km/h has a five percent chance of dying, compared with a 40 percent risk of death at 50 km/h. Hit at 70 km/h, 96 percent of pedestrians will die [2]. One in three pedestrian fatalities occurs on roads with a rural speed limit, but only one in 15 pedestrian injuries occurs in these localities [91]. This reflects the fragility of pedestrians when hit by cars at higher speeds. More information on the effect of vehicle speeds on safety is contained in *Down with speed* [2].

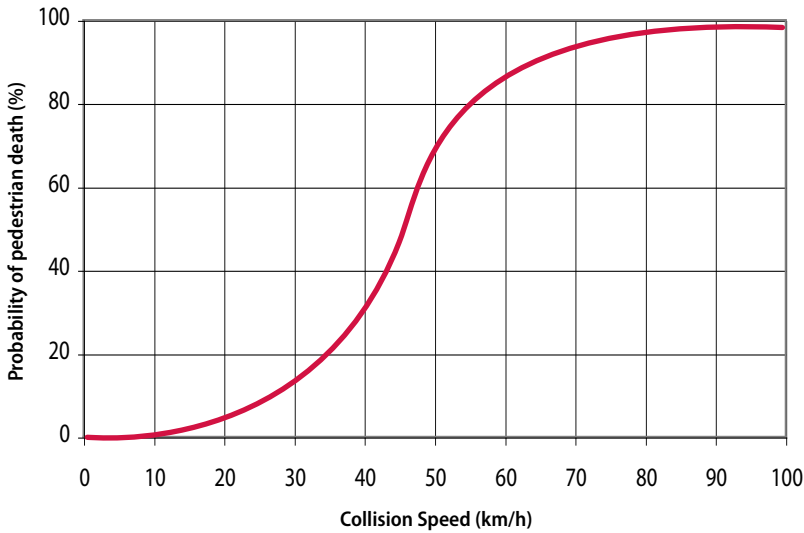


Figure 3.5 – The influence of collision speed on the probability of pedestrian death [2]



Photo 3.5 – Demonstration of the effect of speed on pedestrian accidents, Christchurch (Photo: Tony Francis)

Both older and young pedestrians are at particular risk. Those aged over 75 are involved in 18 percent of pedestrian fatalities, although they represent only six percent of the population [91]. Their likelihood of being struck is also greater than most other age groups [76]. Those aged under 19 represent 46 percent of injuries, yet make up only 30 percent of the population [91].

Pedestrians injured/million road crossings

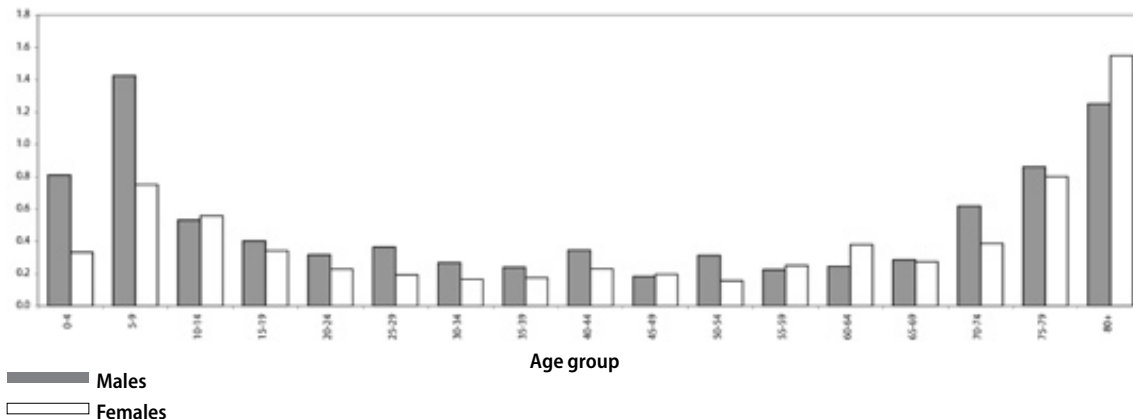


Figure 3.6 – Risk of injury crossing roads by age and gender [76].

While road crash statistics are invaluable in identifying the sites and pedestrian groups with particular road safety issues, they do not provide any qualitative measures such as how safe a pedestrian feels, the risks they take and the reasons for their choice of route [10]. Nor do they indicate which routes are perceived to be so dangerous that pedestrians either completely avoid them or take extra care in them. Moreover, pedestrian crashes and injuries that do not involve a motor vehicle or another road user, or that happen away from the roadway (eg falls due to poorly maintained footpaths) often go unreported.

### 3.11 Falls – slips, trips and stumbles

Approximately 400 people are admitted to hospital in New Zealand each year due to slips, trips and stumbles on the same level in the road environment. They tend to be elderly as shown in Figure 3.7 and are more likely to be seriously injured if they fall.

Fall on same level from slipping, tripping, and stumbling 2001–2003

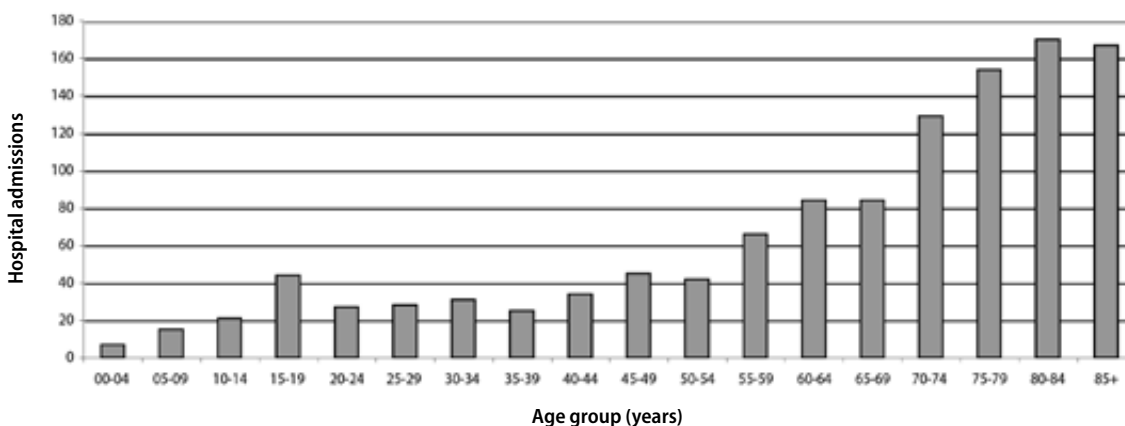


Figure 3.7 – Hospital admissions from falls in the road environment (2001 – 2003).

#### Slips

Slips are caused by inadequate friction between the foot and the pavement. This can be due to the material and construction of the sole of the shoe, the nature of the pavement surface, the presence of lubricants such as water, any surface treatments such as sealers, and the maintenance of the surface. Polished hard surfaces can become slippery due to the presence of fine dust or grit as well as by water.

A pedestrian's gait also affects the friction required for stability. Running requires more friction than walking. When people know a surface is slippery they can compensate by taking shorter steps and avoiding sudden movements.

Because of the complex nature of friction measurement and performance, international requirements are not uniform. The New Zealand Building

Code DS1/AS1 requires a co-efficient of friction of 0.4 on level surfaces increasing by 0.125 for every percent of gradient. Table 2 of the code provides guidance on the suitability of a variety of materials. Joint Australian/New Zealand standards specify how to measure the friction of new and existing surface materials. For footpath surfaces, the sliding skid resistance of a wet surface is the critical test. This is measured by a pendulum tester using a rubber slider to simulate the sole of a shoe [135, 136].

Because the amount of friction required depends on the context, the joint Australian/New Zealand standards have moved away from a single value of required friction. Official guidance for applying these standards is provided in *An introductory guide to the slip resistance of pedestrian surface materials HB197:1999* and *Slip resistance of pedestrian surfaces—guide to the reduction of slip hazards*. [132, 133].

The only matter under the control of those providing the infrastructure is the specification of the surface material and its treatment and maintenance. It is advisable to provide a safety factor by exceeding the requirements of the standards, thereby catering for activities such as running that require more friction.

### Trips

A pedestrian trips when the surface being walked upon has an abrupt increase in height that is large enough to snag the toe of a shoe and cause the pedestrian to lose balance [18]. The study of human gait shows that the toe is generally the lowest part of the swinging foot [18]. However, just before 'initial contact' the foot pivots so that the heel touches first. The toe is the last part of the foot to lift off at the start of the swing and the heel is first to make contact at the end of the swing. Hence it is most often the toe that makes contact with the obstacle.

Gait analysis indicates that the clearance between toe and ground during the 'swing phase' is small. This relates to persons walking on an even surface, where the expectation is to place each foot on a surface of the same level as the previous step, as on paved footpaths and roadways. A study by Murray [116] found toe to ground clearance in the range of 1–38 mm with a mean of 14 mm. Based on this data, a rise in height of 14 mm would represent a trip hazard to 50 percent of the people tested. It is estimated that 10 percent of those tested would trip if the rise was 6 mm. Unfortunately, older pedestrians who are most at risk lift their feet the least, and are least likely to recover if they catch their toe on an obstacle.

The relative probability of catching the toe is shown in figure 3.8

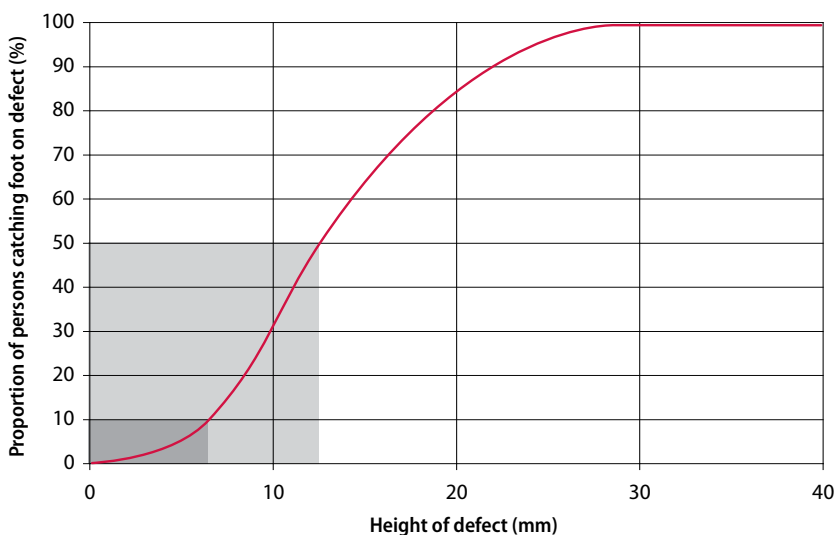


Figure 3.8 – Probability of catching foot on abrupt height change [116].

Based on this analysis, 6 mm is commonly used as the intervention standard for sudden changes in footpath level, but a stricter standard would appear to be justified. This would also explain why tactile paving strips laid on the footpath surface with a rise of only five mm chamfered at 45 degrees have been the subject of complaints from older pedestrians. Depressing tactile paving tiles slightly into the surface would appear to be beneficial.

Trips can also occur when a stair riser is taller than expected, or not noticed. This is particularly likely where there is a single step.

Bird, Sowerby and Atkinson [177] analysed the number of third party insurance claims for accidents on footways with respect to the height of footway defect. The exposure of pedestrians to defects of differing heights was also taken into account. It was found

that the probability of an accident occurring increases logarithmically until a defect height of about 40mm, after which the probability remains constant. At higher step heights the defect is more likely to be noticed so the risk does not increase further. This is illustrated in figure 3.9 for varying levels of pedestrian flow.

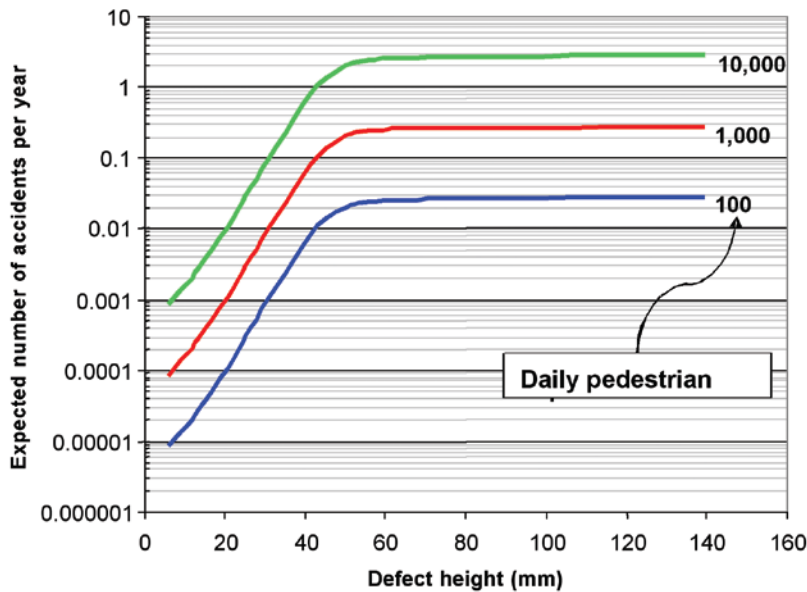


Figure 3.9 – Accident occurrence with respect to defect height for different daily pedestrian volumes.

The inclined portion of the curves can be approximated by:  $E = 2 \times 10^{-8} N e^{0.1982d}$

Where: E = the expected number of accidents per year  
 N = the number of pedestrians passing per day  
 d = the height of defect

Thus, this equation can be used to develop a maintenance strategy for the timeliness of repair of defects of a given height in various situations, based on an accident rate threshold.

### Stumbles

Stumbles happen when the surface is higher or lower than expected. Stumbles become more likely as undulations in the surface rise above 12 mm [18].

## 3.12 Pedestrians on small wheels

Devices that allow people to travel on small self-propelled wheels, notably skateboards, kick scooters, roller skates and in-line skates have the advantage over walking on foot in that they reduce travel time. They are, therefore, useful for utility travel.

There are concerns associated with these devices as their users travel faster than those on foot but slower than motorised vehicles. Evidence suggests that the risk of serious injury to the user reduces when devices are used on the footpath. However, exposure to risk is difficult to quantify as there is little data on trip numbers and significant under-reporting of minor injuries.

Some overseas evidence suggests that up to 15 percent of all injuries to pedestrians on the footpath occur while they are using skates or skateboards [50]. Many users of these devices are children who are already especially vulnerable. There is little research on the design of infrastructure for them [93].

The Road User Rule [110] currently allows a person using a wheeled recreational device to use either the footpath or the roadway. There does not appear to be a strong case for prohibiting their use on footpaths in New Zealand, as there is no evidence of a high degree of risk to either users or pedestrians, although there may be a perception of danger, especially for older pedestrians. There may, therefore, be a case for banning the use of these devices in specific areas of high pedestrian use, or separating them from pedestrians. In some cases, it may be appropriate to allocate designated routes in areas with a large number of users of wheeled recreational devices.

For design purposes, it may be assumed that skateboarders, kick scooter users, roller skaters, in-line skaters and runners/joggers are walking pedestrians and, therefore, subject to the same design principles as those travelling on foot [93]. However, high quality surface conditions and smooth kerb crossings benefit users of small wheeled devices as well as the mobility impaired.

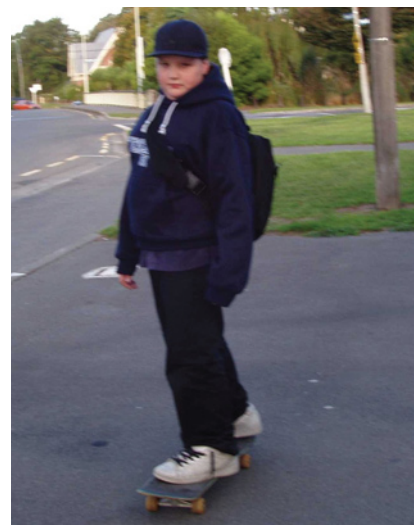


Photo 3.6 – Skateboarder, Christchurch (Photo: Susan Cambridge)



Photo 3.7 – Scooters heading off (Photo: Celia Wade-Brown)

