Pedestrian Behaviour and the Design of Accessible Rail Crossings

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1 Introduction

Australian rail fatality statistics show that nearly twice as many pedestrians as car occupants are killed each year at rail crossings (ATSB 2003a). However, while there are well-defined Australian standards for vehicle rail crossing design, current national standards for pedestrian rail crossing design are less comprehensive (Standards Australia 1993).

Rail operators and state governments have acknowledged the need to develop better national standards for rail crossing design, particularly when considering the needs of people with disabilities (Wheelchair Safety at Rail Level Crossings Taskforce 2002). Indeed, work has already commenced on revising the Australian standard for pedestrian rail crossing design (see section 5.3 of this paper).

One of the keys to developing safer rail crossing designs is to gain a better understanding of pedestrians' behaviour as they interact with crossing infrastructure. For example, how vigilant are pedestrians when using a crossing? Is risky behaviour rare or commonplace? Are particular demographic groups more inclined to take risks than others? How do pedestrians with disabilities navigate a rail crossing safely?

This paper presents the findings from studies of pedestrian behaviour at rail crossings carried out by the authors between 1998 and 2005. The paper covers the following areas:

- recent rail crossing fatality statistics;
- empirical results from surveys of pedestrian behaviour at rail crossings;
- particular needs of pedestrians with disabilities;
- recommendations for safer crossings; and
- current work towards a national pedestrian rail crossing standard.

1.1 Definitions

The following list defines some of the rail crossing terms used in this paper.

- **Active crossing** – a crossing that has audible warnings, flashing lights and/or gates that are triggered by the approach of a train.
- **Crib crossing** – a crossing where pedestrians must walk along a zig-zag path through staggered fences on each side of the tracks. Crib crossings are usually passive (see 'passive crossing' below).
- **DDA** – the Australian federal Disability Discrimination Act (1992), which sets out requirements for preventing discrimination against people with disabilities. The DDA is accompanied by the Disability Standards for Accessible Public Transport (2002), which provide guidelines on DDA-compliance for public transport facilities.
- **Flange gap** – the groove between the rail and surrounding pavement that is required for the train wheel flange at a crossing.
- **Isolated crossing** – a rail pedestrian crossing that is not adjacent to a road or railway station.
- **Passive crossing** – a crossing that does not have audible warnings, flashing lights or gates. No train detection devices are present at passive crossings.

2 Pedestrian fatalities

2.1 Fatalities by mode

While deaths at rail crossings in Australia represent less than 1% of the national road toll, they often attract media and community attention. Much of the focus tends to be on vehicle accidents and derailments, yet fatality statistics show that the most common type of rail fatality is a pedestrian being hit by a train while crossing railway tracks (see Figure 1).

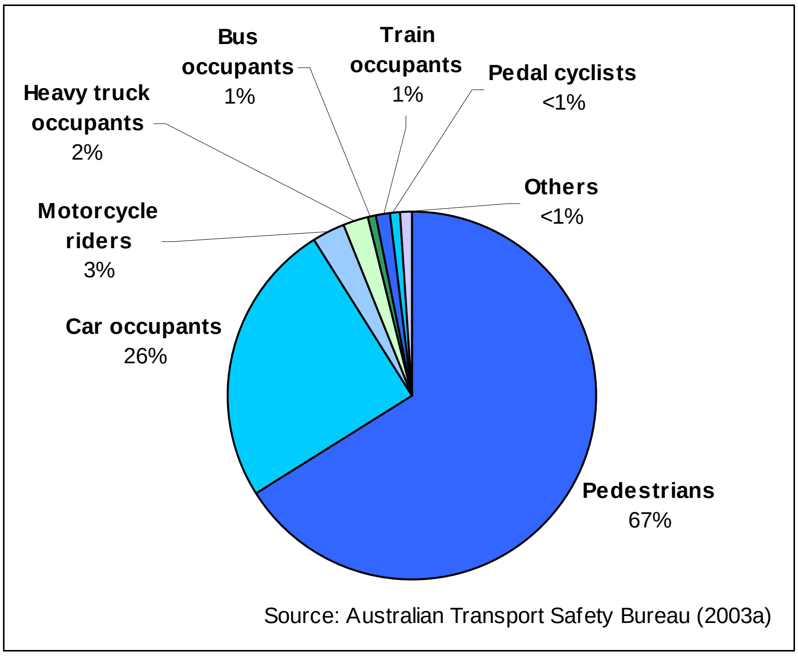

Figure 1: Level crossing accident fatalities by mode of transport, Australia, 1997-2002

2.2 Fatalities by pedestrian characteristics

Figure 2 shows the breakdown of pedestrian rail fatalities by age and gender during the years 1997-2002 inclusive. The comparisons are quite striking. Males made up 84% of pedestrian fatalities. Of these, 43% were in the 15-29 age group. In other words, more than one-third of all pedestrian rail fatalities in Australia were 15-29 year old males. Similar proportions have been observed in historical data (ATSB 2003c).

Female fatalities were more evenly distributed across age groups, although nearly one-third of female fatalities was in the over-60 age group.

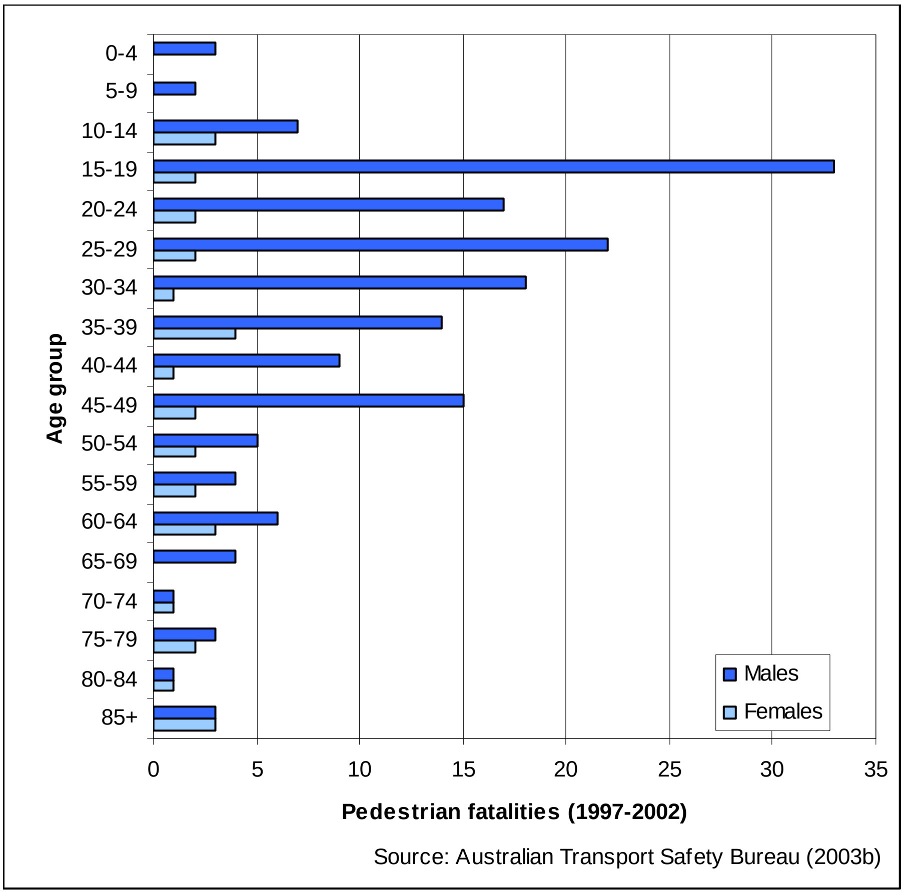

Figure 2: Pedestrian train collision fatalities by age and gender (excluding suicides) Australia 1997-2002

2.3 Contributing factors to pedestrian deaths at rail crossings

Table 1 lists some of the factors that contribute to pedestrian deaths at rail crossings.

Table 1: Common contributing factors to pedestrian deaths at rail crossings

Category	Contributing factors
Lack of awareness	• Not aware of train approaching • Second train approaches shortly after first train
Entrapment	• Trapped on tracks (eg. fallen over, trapped wheelchair) • Insufficient time to cross for slow-moving pedestrians
Risk-taking	• Misjudgement of train speed • Trespass – playing or walking on the tracks
Deliberate	• Suicide • Homicide

The observational surveys described in this paper sought to establish the common pedestrian behaviours that may lead to injury or fatality at crossings – particularly in the categories of risk-taking and lack of awareness.

3 Pedestrian behaviour

3.1 The Mooroolbark trial

In late 1998, the former Victorian Public Transport Corporation (PTC) initiated an investigation into manual gates at passive crib crossings. The PTC wanted to determine whether manual gates would provide safety benefits by encouraging pedestrians to stop and look for trains before crossing the tracks.

Consultants carried out 'before' and 'after' studies of manual gates at a pedestrian crossing adjacent to Mooroolbark station in Melbourne (Sinclair Knight Merz 1999). Mooroolbark is a residential area in the outer eastern suburbs, 45 minutes by train from Melbourne's central business district. The railway station adjoins a strip shopping centre, large commuter car park and other public facilities. The crossing used for the trial was at the far end of the station platforms (see Figure 3).

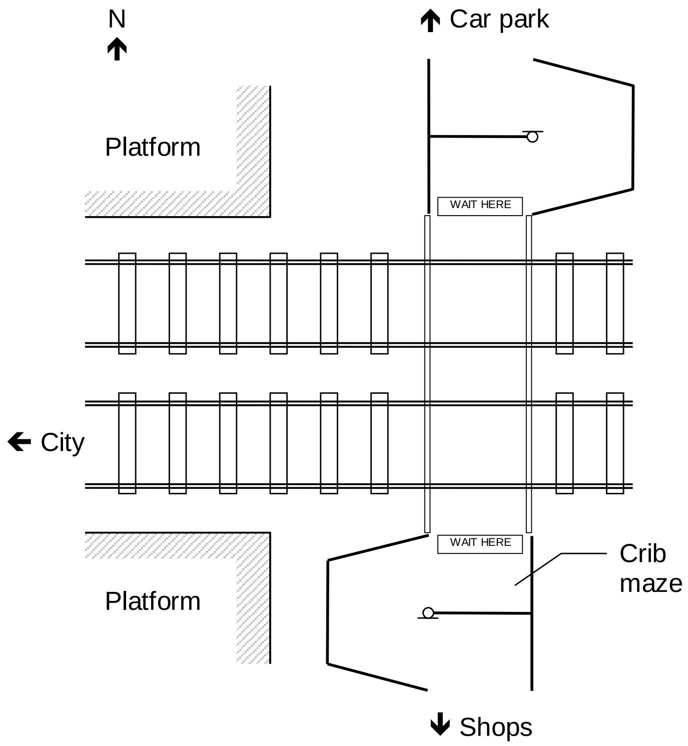

Figure 3: Layout of the trial crossing

Although the manual gate trials were eventually discontinued (ironically because of safety concerns), the data collected in the studies were helpful in understanding pedestrian behaviours in typical crossing situations.

The Mooroolbark trial used video and interview surveys to capture information on pedestrian characteristics and behaviours. The interview survey provided information on pedestrian characteristics, as well as the number of times per week pedestrians used the crossing. Footage from the video survey was analysed to determine the proportion of pedestrians that checked for trains, and to observe various risky behaviours that may contribute to near-misses and fatalities.

3.2 Pedestrian characteristics

The pedestrian interview survey was conducted between 9:30 am and 6:30 pm on Tuesday 1 December 1998, capturing peak and off-peak periods. An interviewer randomly approached 100 pedestrians just after each had crossed. The interviewer recorded the gender and approximate age of the respondent, and how often they used the crossing. The results are summarised in Figure 4 to Figure 6 on the following page.

The results show that:

- roughly equal numbers of males and females used the crossing;
- all age groups were well-represented;
- most pedestrians were familiar with the crossing, with 88% using the crossing at least once per week.

The high familiarity of pedestrians with the crossing is of particular interest. On the one hand, many pedestrians are likely to be familiar with train speeds, directions and timing, perhaps contributing to better judgement while crossing. On the other hand, familiarity may cause complacency, with some pedestrians taking risks and being less vigilant when using the crossing. The purpose of the video survey (described in the next section) was to provide objective measurements of pedestrian vigilance and risky behaviour.

3.3 Video survey

A video camera was mounted on a fence on the south side of the crossing to provide continuous footage of the crossing area (see Figure 7). A number of three-hour segments were recorded on selected weekdays during November and December 1998, including mid-morning periods between approximately 8:00 and 11:00 am, and afternoon peaks between 3:00 and 6:00 pm.

The video camera recorded several thousand pedestrians using the crossing. From the video footage, a sample of 208 pedestrian movements was analysed in more detail. The information collected from the analysis included:

- gender and approximate age of crossing pedestrians;
- date and time of day;
- direction of travel;
- scanning behaviour of pedestrians before and while crossing the tracks;
- time needed to cross;
- other qualitative observations - for example, comparisons of single pedestrian and group behaviour.

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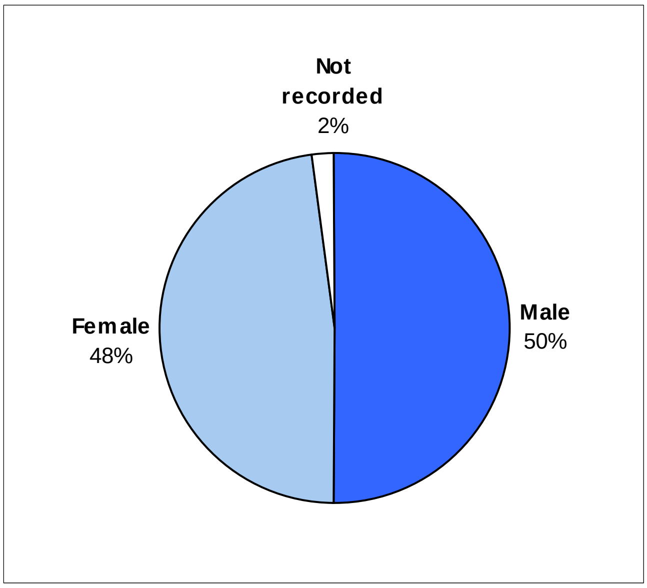

Figure 4: Proportion of males and females in interview sample

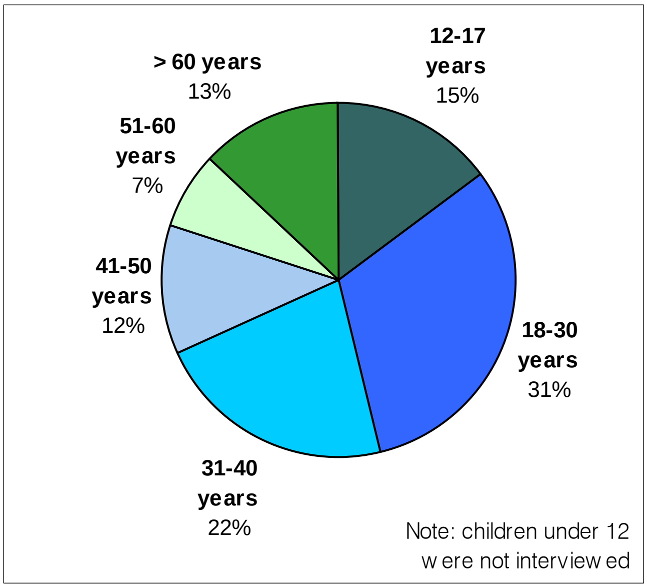

Figure 5: Proportion of age groups in interview sample

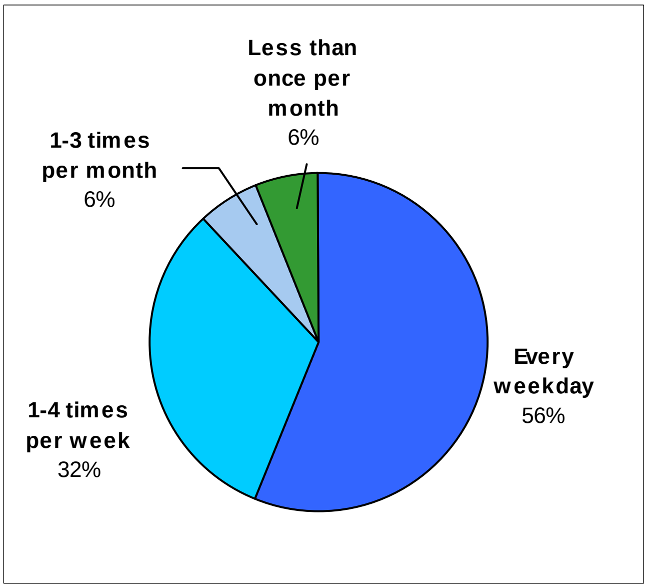

Figure 6: Frequency of crossing use

Figure 7: Video surveillance of the crossing

3.4 Pedestrian vigilance

Pedestrian vigilance at the crossing was measured by recording pedestrian head-checks for trains. Each time a pedestrian looked up or down the tracks, the location and direction of the head-check was recorded.

3.4.1 Locations of head checks

Figure 8 summarises the locations where pedestrians scanned for trains (see also Figure 3 for a diagram of the crossing).

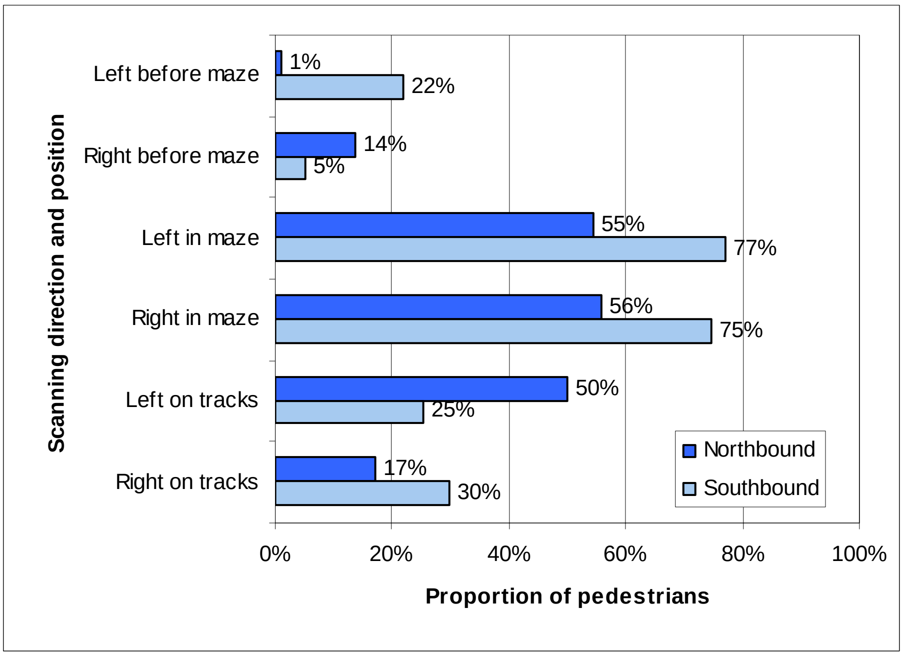

Figure 8: Directions and positions of pedestrian head-checks

The video evidence shows that most pedestrians scanned for trains while walking through the crib maze. The design of the maze encourages this behaviour, as it intentionally turns pedestrians to the left and right before they cross. A smaller number of pedestrians scanned while on the tracks.

At the Mooroolbark site, the station platforms lie immediately to the west of the crossing. Train activity at the station will tend to influence pedestrian scanning in this direction (left for northbound and right for southbound pedestrians).

3.4.2 Thoroughness of head-checks

The thoroughness of head-checks was measured in two ways:

- by counting the number of times each pedestrian scanned for trains; and
- recording whether pedestrians looked one way, both ways or not at all.

Figure 9 and Figure 10 show the number of scans and the thoroughness of scanning for each age group in the video sample.

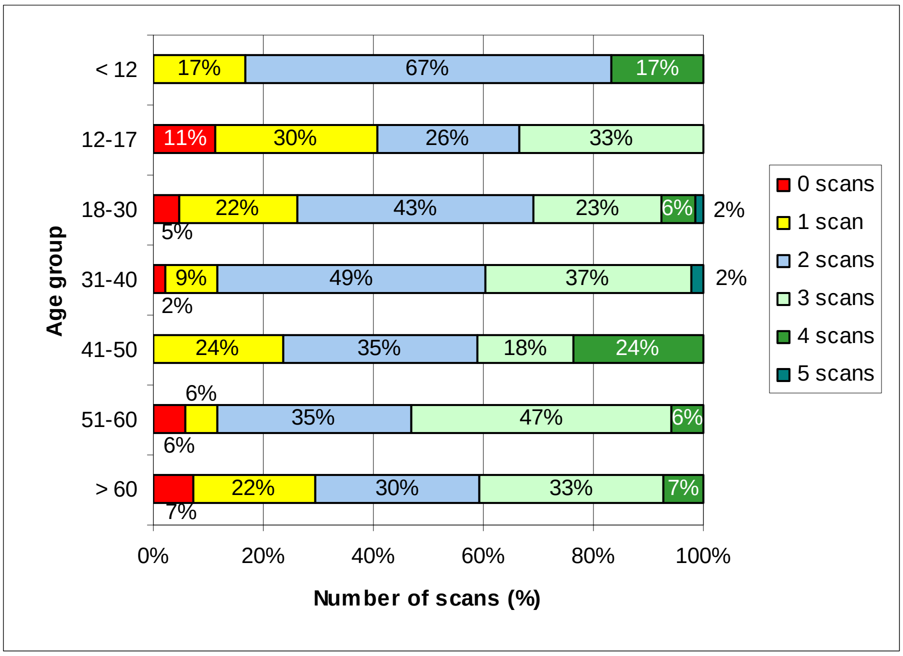

Figure 9: Number of head-checks

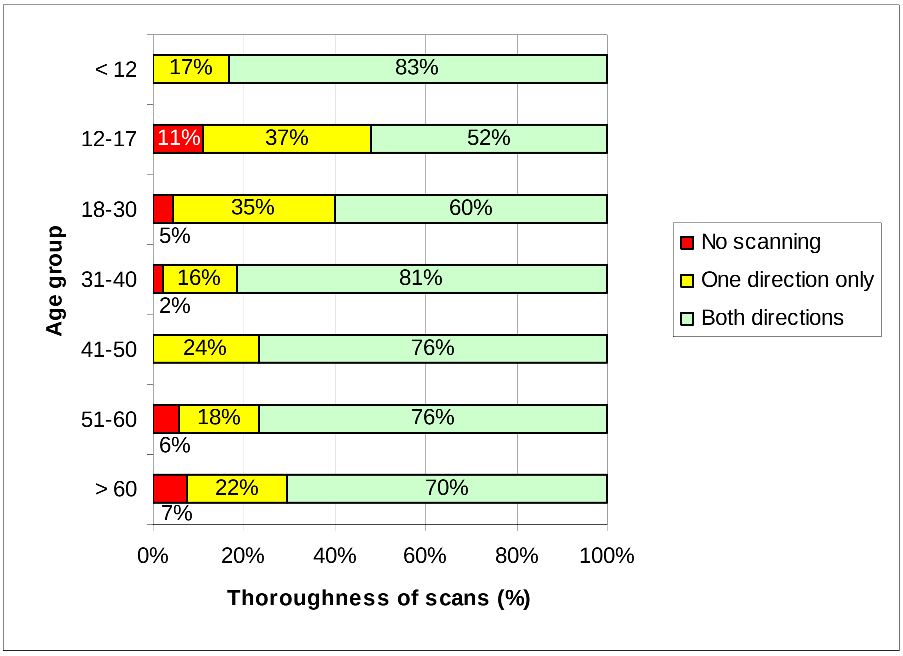

Figure 10: Thoroughness of head-checks

The results show that about two-thirds of pedestrians looked both ways before crossing. The 12-17 and 18-30 age groups, however, appeared to be less vigilant than other groups, with only 52% and 60% respectively scanning in both directions.

The video footage showed that adults accompanying children tended to be more vigilant than others walking alone. Individuals in a group (for example, those crossing after the arrival of a train) tended to scan less, presumably because they relied more on the collective scanning of the group.

3.5 Risky behaviour

A number of risky actions was observed on the video footage.

Several pedestrians (generally boys of secondary school age) entered the crossing, walked along the tracks and climbed directly onto the station platform. The reverse actions also occurred (ie. jumping from the platform onto the tracks).

In a similar fashion, a number of pedestrians entered and exited the crossing from the east side by walking along the railway tracks. This appeared to be a shortcut to residential areas to the north east of the crossing.

In one bizarre case, a teenage boy placed a chair on its side in the crib maze to block the passage of pedestrians. The next pedestrian moved the chair in order to pass.

A man, with his face covered by an umbrella, crossed within seconds of a train reaching the crossing. It was uncertain from the footage as to whether he had seen the train.

A small number of people paused for lengthy periods on the tracks. In one extreme example, an elderly woman stopped on the tracks to look through her handbag for approximately half a minute, being apparently oblivious to trains. In other cases, one person stopped while walking their dog and another stopped to pick up rubbish. Pedestrians may well have relied on their hearing to alert them of approaching trains. The warning bells on the road crossing about 200m to the west of the crossing may also have been audible to pedestrians.

3.6 Behavioural observations

The interview and video surveys showed that:

- most pedestrians scan for trains before they cross the tracks, with a smaller number also checking while on the tracks;
- pedestrians were generally familiar with the surveyed crossing, with most using it more than once per week;
- only two-thirds of pedestrians looked both ways before crossing the tracks;
- pedestrians in the 12-30 age range tended to be less vigilant than other age groups;
- adults accompanying children tended to be more vigilant;
- intentional risk-taking behaviour was observed, mainly in the younger age groups;
- some older pedestrians exhibited a lack of awareness of approaching trains.

4 Pedestrians with disabilities

Pedestrians with disabilities often have special additional needs at crossings and may demonstrate different behaviours to other pedestrians. The Disability Standards for Accessible Public Transport give general guidance on providing public transport infrastructure for people with disabilities (Commonwealth of Australia 2004), however the standards do not provide specific guidance on rail crossings.

Community awareness of disability issues at rail crossings came to a head in late 2001, when two tragic pedestrian level crossing fatalities occurred within weeks of each other in Melbourne's eastern suburbs. Both fatalities involved wheelchair users who were unable to move their chairs off the railway tracks before the train reached the crossing.

The Victorian Department of Infrastructure subsequently commissioned the authors to examine the range of issues faced by people with disabilities at rail crossings and develop design principles for accessible crossings (Sinclair Knight Merz 2003, McPherson and Daff 2004).

The authors carried out a series of interviews and workshops with representatives from disability groups, including a wheelchair user who had narrowly escaped a collision with a train. The interviews and background research identified seven main areas where rail crossings often cause problems for people with disabilities (see Table 2).

For further details of the research study, the reader is invited to download the study report from http://www.doi.vic.gov.au (conduct a search for the words 'disability' and 'crossing' from the DOI's home page).

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Table 2: Common crossing problems for pedestrians with disabilities

Problem	Example
Uneven crossing surfaces, potholes and flangeway gaps, cause hazards for wheelchair and mobility aid users. Asphalt pavements are prone to deterioration at crossings, particularly in sections immediately adjacent to the rails. The pavement may break up or deform, creating an uneven surface and accentuating the flange gap	 *Asphalt has broken up at this crossing, creating a tripping hazard and obstruction*
Limited manoeuvring space sometimes inhibits larger wheelchairs and scooters from moving safely through the crossing and accessing emergency escape paths.	 *This narrow path and fencing allow very little room for manoeuvring scooters*
Insufficient warning times for slower moving pedestrians.	*The minimum time between the initial audible warning and arrival of the train in Victoria is 25 seconds. At automatic gated crossings, the warning typically sounds for about 7 seconds before the gate closes. For some slower pedestrians (including wheelchair users, frail elderly pedestrians and vision-impaired pedestrians), this warning time is insufficient to clear the crossing before the gates close.*
Lack of visual and aural warnings for hearing and vision-impaired pedestrians. At most of the 170 isolated crib crossings in Victoria, there are no visual and aural warnings such as lights and bells. Pedestrians must rely on sighting trains by looking up and down the track, or by listening for the train's approach. Vision and hearing impaired pedestrians and wheelchair users can be disadvantaged in these situations.	 *Visual and aural warnings are particularly important where clear sight lines are obstructed*

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Table 2 continued

Badly-aligned crossing paths that are not at 90 degrees to the rails may cause navigational problems for vision-impaired users. A particular problem is caused when the openings on each side of the crossing do not line up, possibly causing confusion and straying off the crossing path.	 *The angle of this crossing would cause significant problems for vision-impaired and blind pedestrians (photo used with permission from Ivan Peterson, Banyule City Council, Melbourne)*
Lack of navigational aids, such as high-visibility lines and tactile indicators. Although most crossings have fencing on either side of the tracks, there are often no other tactile or high-contrast visual aids to assist navigation across the tracks.	 *Fences and paths are difficult to distinguish at this crossing*
Lack of integration of the crossing with the surrounding footpath and road network. Narrow paths, steep gradients, uneven surfaces and lack of integration with the surrounding pedestrian network may prevent some pedestrians with disabilities using the crossing.	 *Rough surfaces and steep gradients on the approach to this crossing may make this crossing inaccessible for some pedestrians*

5 Conclusions

5.1 At-risk pedestrian groups

The video surveys showed that 12-30 year old pedestrians were generally less vigilant than other pedestrians. This observation is consistent with the fatality statistics presented in Figure 2, which show the highest number of pedestrian rail fatalities in the 15-29 age group (particularly males).

Pedestrians with disabilities are also particularly vulnerable, generally requiring more time to cross the tracks safely. Wheelchair users and other pedestrians with limited mobility can be particularly affected by rough surfaces and physical obstructions. Sight and hearing-impaired pedestrians can be put at risk in the absence of clear warnings and navigational cues.

5.2 Priorities and actions for safer crossings

The various studies described in this paper have highlighted some of the risk-taking behaviours that may contribute to pedestrian fatalities at rail crossings. The studies also illustrate how the physical design and conditions at a crossing can influence pedestrians' ability to cross safely.

The Sinclair Knight Merz study (2003) considered these findings and recommended several priorities and associated actions for providing safer, more accessible rail crossings (see Table 3 below).

Table 3: Priorities and actions for increasing crossing safety

Priority	Objective	Actions
1	Increase pedestrian awareness of train approach	• continue upgrading passively-protected crossings to full active protection • provide visual and aural warnings where practicable • target advertising and education programs to at-risk groups (eg. Males in the 15-29 age group)
2	Reduce the likelihood of pedestrians becoming trapped on crossings	• implement an improved crossing maintenance and fault-reporting program • develop a minimum surface quality standard • progressively adopt rubber-based surfaces • realign crossings where crossings are not at (or close to) 90 degrees to tracks • monitor advances in flange gap filler technology
3	Provide adequate warnings for slow-moving pedestrians	• design, trial and implement advance warning systems • investigate lower-cost train detection systems

Table 3 continued

Priority	Objective	Actions
4	Improve physical access	• ensure crossing paths have at least 1.8 metres of useable width • provide accessible approaches • provide tactile ground surface indicators on the threshold of the crossing • provide tactile ground surface indicators and high-contrast lines on the path edges • reconfigure dimensions of crib mazes and emergency escape paths where they are inaccessible for larger wheelchairs and scooters
5	Achieve consistency in crossing design	• develop crossing design standards • progressively upgrade non-compliant crossings so that layouts, aural and visual warnings, and tactile indicators comply with the new standards
6	Selective grade separation	• identify candidate crossings for grade separation • plan and implement a staged program of grade separation where practicable

Table adapted from Sinclair Knight Merz (2003)

5.3 Postscript: a new Australian standard

A committee of rail professionals has been updating Australian Standard 1742.7 (Railway Crossings) to accommodate DDA requirements and improve safety for all pedestrians including those with disabilities. The main issues that this update is concerned about are summarised below.

- Changing the geometry of the crib maze at passive crossings to allow the passage of larger wheelchairs and 'gophers' while still compelling pedestrians to look both ways before crossing.
- The provision of more visual and audible cues at active crossings to better cater for those with hearing and visual disabilities.
- The provision of a 'red man' display at active rail crossings similar to those at road crossings.
- Consideration of displays to alert pedestrians of an approaching second train – long considered to be a factor in many pedestrian accidents.
- The provision of more visual cues on the crossing.
- Minimisation of the flange gap.
- Some rationalisation of the wording of warning signs. In a legal environment the wording of signs assumes a degree of importance. However the degree to which signs have any bearing on accident prevention has not be established.
- Consideration of latches on escape gates to prevent wrong way movement through the bypasses at active crossings. Wrong way movement through bypasses is a common feature of a number of recent pedestrian accidents in Victoria.

When completed, the revised Australian standard will promote more consistent and better-designed rail crossings. Providing that governments continue to allocate substantial funds for upgrading existing crossings, accidental pedestrian deaths at crossings will hopefully diminish in the coming years.

References

ATSB (2003a) *Level crossing accident fatalities* Canberra: Australian Transport Safety Bureau

ATSB (2003b) *Australian railway accident fatalities – latest data* Canberra: Australian Transport Safety Bureau

ATSB (2003c) *Australian railway accident fatalities – historical data* Canberra: Australian Transport Safety Bureau

Commonwealth of Australia (2004), *Disability Standards for Accessible Public Transport*, *Amendment 2004 (No. 3)* Canberra: Attorney-General's Department

McPherson, C D and Daff M (2004) Innovations in disability access at pedestrian rail crossings *8th International Level Crossing Symposium* Sheffield UK

Sinclair Knight Merz (1999) *Report on the Stage 1 Gate Crossing at Mooroolbark* Final report for Public Transport Corporation Melbourne: SKM

Sinclair Knight Merz (2003) *Disability Access at Pedestrian Rail Crossings Study – Final Report* Melbourne: SKM

Standards Australia (1993) *AS1742.7 Manual of uniform traffic control devices - Railway crossings*

Wheelchair Safety at Rail Level Crossings Taskforce (2002) *Report to the Minister for Transport* Melbourne: Department of Infrastructure