TECHNICAL PAPER

BENEFITS OF NEW AND IMPROVED PEDESTRIAN FACILITIES: CASE STUDIES

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ABSTRACT

The provision of adequate crossing facilities is an important element of improving walkability, particularly in urban areas that have high volume and multi-lane roading networks. This paper discusses eight before and after case studies that have been undertaken for new and improved pedestrian crossings in Auckland, Hamilton and Christchurch. This included signalised and zebra crossings', crossing aids and school (kea) crossings on roads carrying different volumes of traffic and with varying pedestrian crossing demands. A key aspect of the study was to quantify the user perception of facilities provided before and after implementation. The study also looked at current crash problems and delays at each site and the level of publicity and education provided both before and after the projects were constructed.

A key outcome of the study was an increase in the induced crossing rates at or near the crossing facilities.

The pedestrian attitude survey results reinforced the importance of safety, delay and directness on pedestrian perception. Safety was identified as the key issue at all sites, with pedestrians specifying improved safety at all of the sites after implementation. Another outcome was reduced perceived waiting times, particularly at sites with kerb extensions and refuges.

INTRODUCTION

Walking is an essential mode of transport for almost everybody. New and improved pedestrian facilities provide greater access and mobility within our communities. A pedestrian friendly environment plays an important role in encouraging walking as a mode of travel and this has proven health and environmental benefits. Supporting and promoting the option to walk for short distances and as part of multipurpose trips is a key objective of various national, regional, and local transport and community plans.

The New Zealand Transport Agency (NZTA) has recently updated the procedures for the evaluation of pedestrian improvement projects. These procedures use a benefit value of $2.70/km for new pedestrians using a new or improved pedestrian facility. Estimating the increase in pedestrian flows (as opposed to existing pedestrian flows) will thus be important in the economic evaluation of new or improved facilities.

The aim of this research was to quantify and assess the benefits of new or improved pedestrian facilities by recording examples of induced pedestrian rates in a standardised format that can be used in transport planning and project funding. In the research a monitoring database containing before-and-after pedestrian count data for various new and improved pedestrian facilities, along with a list of accompany factors. The intent over time is to bring together a larger sample of sites to enable analysts to predict induced demand and other success factors for each scheme.

This study investigates eight sites across New Zealand where pedestrian facility improvements were being undertaken. The initial intent was to collect data at more sites but the research team had significant problems getting information, particularly before facilities were constructed, despite considerable effort in this regard. The three issues that contributed to this difficulty were 1) the limited number of facilities going in at high pedestrian demand locations (many of the high demand sites already had treatments), 2) the high turn-over in staff managing the walking and cycling programmes in many Council and 3) the disjoint between the pedestrian planners and the contractors installing the facilities (we were not given adequate time to do before surveys at several sites due to construction being brought forward or due to the flexibility given to contractors on construction timing). The sites investigated in this study are listed below:

Table 1: List of Study Sites

Location	Type of Improvement
Moorhouse Avenue, Christchurch	Signalised pedestrian crossing
Hereford Street, Christchurch	Raised Zebra crossing with warning light system
Sparks Road, Christchurch	School patrolled Zebra crossing
Hoon Hay Road, Christchurch	Kea Crossing
Ensors Road, Christchurch	Refuge Island and kerb extension
Collingwood Street, Hamilton	Kerb extensions
Tristram Street, Hamilton	Refuge Island
Margot Street, Auckland	Kea Crossing

Data collection formed an important part of this research study. The investigation included collecting information on the site location and characteristics, facility development and consultation process, before-and-after pedestrian counts and perception surveys for each of the sites analysed. These perception surveys looked at changes in the perception of pedestrians towards certain key factors such as safety, delay and directness that have a bearing on deciding the location to cross the road.

LITERATURE REVIEW

An international literature review was carried out as part of this research. The aim of the literature review was to collect information related to the methodologies, results and background information established in similar studies. In the review we considered studies conducted in other parts of the world that dealt with before-and-after comparison of pedestrian facility improvements. It was observed that research conducted in this area has been extremely limited (only three directly relevant studies were identified), which highlights the need for monitoring of pedestrian facilities to assess the benefits provided by them.

There has been a significant amount of research and development of policy to incorporate pedestrian benefit into existing funding mechanisms and the benefit of encouraging pedestrian activity particularly environmental and health benefits. To provide a comprehensive review of the pedestrian research areas of interest, some of the more relevant studies have been included in the research report (Turner etal, 2009).

The literature reviewed that was directly relevant to this project is detailed below.

City of Camas and Washington State DoT (1999) undertook a before and after study of a pedestrian crossing facilities in the City of Camas. They looked at a crossing treatment to increase visibility and safety to assist pedestrians crossing Everett Street. The treatment consisted of passive infrared sensors to detect when pedestrians were present at the landing of the crossing and when they have crossed the street. Also a raised island was constructed in the middle of the street to assist pedestrians while crossing and to calm traffic. Kerb cuts were also provided in the median.

The following table shows the results from a before-and-after comparison survey undertaken at the site. The study found that construction of the crosswalk led to an increase in the number of pedestrians using the facility. A decrease in the percentage of people crossing at other locations on Everett Street was observed, although the number of pedestrians crossing at adjacent intersections was found to increase.

Table 2: Percentage of Pedestrians Crossing Everett Street: Before and After

Crossing Location	Before	After
19th Ave/Everett St (within crosswalk)	78%	83%
19th Ave/Everett St (outside crosswalk)	9%	7%
Everett St: Mid-block (17th to 19th and 19th to 21st)	9%	3%
Everett St: Adjacent Intersections (17th and 21st)	4%	7%

A survey of motorists' behaviour at the site also found that more cars slowed down or stopped for pedestrians crossing at the improved facility.

Knoblauch et al (2001) undertook a before-and-after study in three American cities that examined the effect of crosswalk markings on driver and pedestrian behaviour at unsignalised intersections. The researchers collected data on a number of parameters including vehicle and pedestrian volumes, vehicle speeds, and driver and pedestrian behaviour.

The study produced some useful data. However, it did not discover any meaningful changes in pedestrian volumes before and after the improvements were made. The table below presents a summary of the study's findings.

Table 3: Study Conclusions

Hypothesis	**Measurement of Effectiveness**	**Conclusion**
Before/after differences are due to the installation of the crosswalk markings and not other factors.	Vehicle Volumes Traffic Gaps Pedestrian Volumes	No meaningful before/after changes were found in either vehicle volumes or traffic gaps. No meaningful before/after changes were found in pedestrian volumes. Lack of before/after changes in overall vehicle and pedestrian activity means that changes can be more confidently attributed to the installation of the marked crosswalks.
Crosswalk markings do not affect the way drivers respond to pedestrians	Vehicle Speed (approaching and at crosswalk)	Although the magnitude of the observed speed changes were small, drivers appear to respond differently (e.g., drive slower, when approaching a pedestrian in a marked crosswalk).
Crosswalk markings disrupt traffic flow because some drivers will stop and yield to crossing pedestrians.	Driver Yielding Behaviour	No changes in driver yielding were observed. Drivers were not either more or less likely to yield to a pedestrian in a marked crosswalk.
Pedestrians feel protected by marked crosswalks and act more aggressively when crossing.	Aggressive Pedestrian Behaviour	No change in blatantly aggressive pedestrian behaviour indicates that pedestrians do not feel overly protected by crosswalk markings.
Pedestrians will not use marked crosswalks.	Percentage of Crossing Pedestrians in the Crosswalk	Pedestrians walking alone tend to use marked crosswalks especially at busier intersections. Pedestrians walking in groups do not tend to use marked crosswalks. Overall, crosswalk usage increased after the installation of the crosswalk markings.

Sharples et al. (2001) conducted research to identify factors associated with a range of pedestrian crossing facilities that might encourage or discourage walking in urban areas. A series of surveys were conducted at ten different crossing types at thirty sites in six towns and cities in Scotland. The surveys consisted of an on-street survey of the general public, a self completion survey of school children, and surveys of pedestrians with a range of mobility impairments.

The research found that the main reasons pedestrians used formal crossing points, in broadly equal proportion, were those of convenience, directness of route and safety. The main reasons given for not using a pedestrian crossing located near the position at which the road was crossed, were that the traffic was light or nonexistent or that it would take too long.

The research also concluded that the main factors in deciding to use a particular crossing facility were road safety, rated as important by 96% of the sample, followed by volume of traffic cited by 91%, particularly those crossing at puffins, toucans and zebra crossings. The majority of pedestrians tended to prefer signalised crossings to pedestrian islands and zebra crossings. Zebras were preferred to traffic islands at traffic calming schemes.

An interesting conclusion of this research suggested that provision of crossings is probably a minor factor in maintaining levels of walking among the population. Pedestrians are generally satisfied with current provision and no great increase in trips would be achieved by changing them.

METHODOLOGY

The research focused on the key types of mid-block crossing facilities, namely:

- Pedestrian refuges (with or without kerb extensions);
- Zebra crossings;
- Kea crossings; and
- Signalised crossings (mid-block and at intersections)

The two study regions initially selected were Auckland and Christchurch. These locations were chosen due to the commitment of respective councils to this project and the likely range of facilities being implemented in these areas. However, after significant problems in identifying sufficient number of suitable sites for the study, due to a limited number of pedestrian facility improvements being implemented by local authorities in these two areas, two additional sites were also included from Hamilton. A total of eight sites were selected and monitored.

Table 4 below lists the various categories of information that was collected for the selected sites.

Table 4: Site - specific data collection

Category	Description
Site characteristics	Included quality of footpaths, characteristics of surrounding area, level of signage, availability of resting places, other crossing facilities in vicinity of the subject facility and types of pedestrians in the area.
Land Use	The predominant land use in the general area and that fronting the pedestrian facility.
Road Classification and Traffic Flows	This was collected from Local Authorities.
Road Cross-Sections	Included number of lanes, median type. seal width, crossing distance.
Weather	The weather conditions during the survey were recorded.
Accident Statistics	Accident history within 50m either side from the facility for the period 2003-2007 was collected from the NZTA Crash Analysis System (CAS).
Promotion and Community Consultation	Any community consultation and promotion of the facilities such as a local promotion campaign or similar marketing strategy from the Local Authorities was noted.
Drivers for Construction of New Facility	This covered road construction, whether problem site – delay or safety issues, whether part of area-wide strategy, or any other.

Given that a key objective of the research project was to determine the effect of new and improved pedestrian facilities on the induced number of pedestrians, pedestrian count data was considered to be one of the most important site characteristics. Pedestrian volumes inevitably fluctuate day-to-day, due to weather conditions, day of the week, time of the year and school/university term time. To reduce the effects of these fluctuations, it was proposed that the before-and-after pedestrian counts be conducted:

- during similar (preferably fine), weather conditions; and
- at a similar time of the year.

To maintain survey consistency, counts where measured:

- on the same day of the week (Wednesday);
- at the same time of day; and
- at a consistent time with respect to school/university holidays.

To evaluate the likely variability in pedestrian counts by time of day, base data from a control site used in the research study “Predicting Accident Rates for Cyclists and Pedestrians” (Turner et al, 2001) has been used. The control site was located at a signalised crossing located near Christchurch Hospital and used pressure detectors that counted pedestrians that stand on them. Continuous pedestrian flow count data, reported in quarter hour periods, was collected over a period of a year between December 2003 and November 2004. To assist in determining when the best time is to collect accurate data, data from the control site was used to produce two graphs showing the coefficient of variance (COV) for weekdays and weekends (see **Figure 1 and 2)**

Figure 1 shows that the coefficient of variance of pedestrian counts on different weekdays is similar and generally between 40% and 60%. It is important to note that Figure 1 does not indicate that it is suitable to use counts collected on different weekdays during the same week. Although no analysis has been carried out for this scenario, it is likely that the coefficient of variance of counts obtained using such a technique would be quite high.

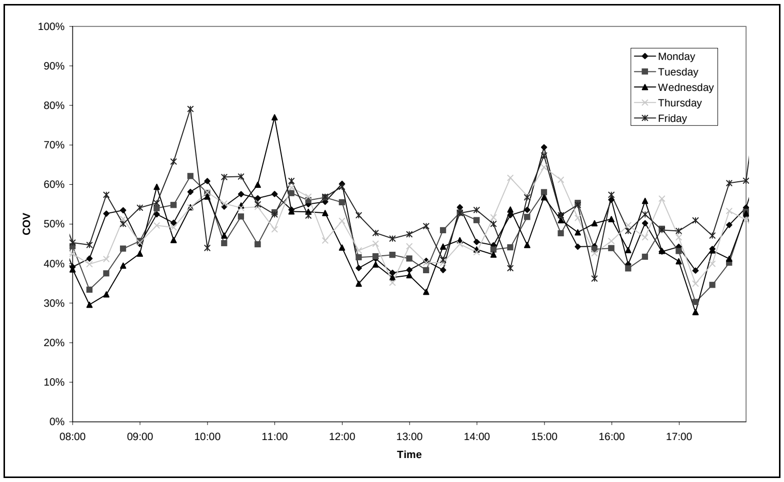

Figure 1: Coefficient of variance between quarter hour counts on weekdays

Figure 1 also suggests that the coefficient of variance is lowest around noon, and this is therefore potentially the best time to survey. Higher variability around the afternoon and morning peaks is possibly due to the lack of an allowance being made for school holidays in the analysis. If school holidays are avoided this would still appear to be a suitable time to conduct pedestrian counts. Based on these results survey data was collected at most sites between 12 and 1-30pm.

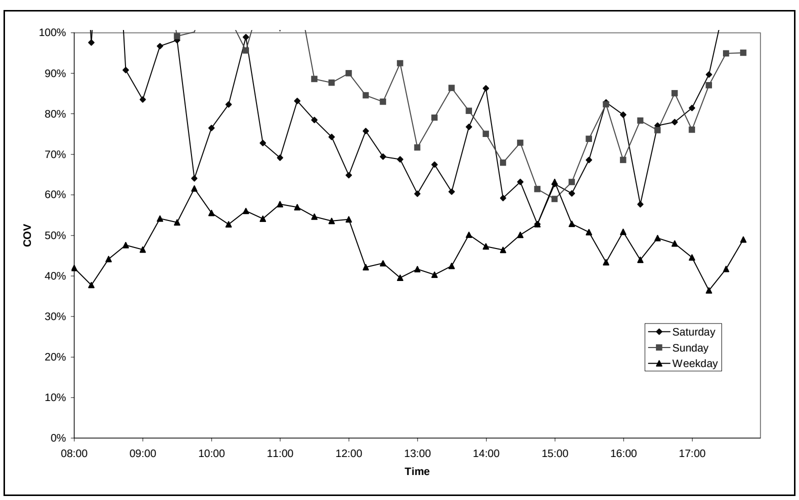

Figure 2: Coefficient of variance between quarter hour counts on weekends

The original proposed methodology suggests that a two-hour period should be used for most sites. It also suggests that only the peak hour will be considered in the analysis. After further analysis, the project team considered this inappropriate and decided that a longer count period should be considered. It was also decided that counts should be recorded in 15-minute intervals for the analysis. To investigate the benefits of increasing the count duration, three scenarios were considered:

- 2-hr continuous count (as proposed);
- 4-hr continuous count;
- Two, 1.5 hour counts on adjacent weeks.

Using the data on pedestrian rates for Mondays from the control site the mean variability for a number of different time periods were calculated for each scenario. These are shown in **Table** 5 The increase in total mean pedestrian volumes before and after the installation required for a statistically significant sample was then calculated.

Table 5: Increase in pedestrian volumes required for statistical significance

Scenario	Mean COV	n (Number of 15 minute survey intervals)	% Change Required
2-hr continuous count (as proposed);	50%	8	77%
4-hr continuous count	56%	16	52%
Two, 1.5 hour counts on adjacent weeks	47%	12	51%

The analysis found that the variability between a series of adjacent quarter hour counts (for a two-hour continuous count) is similar to the variability between counts taken at the same time of day, but during different weeks. The level of variability needs to be considered when assessing the statistical significance of a change in pedestrian flow between normal before-and-after pedestrian counts.

However, the estimate of variability between adjacent 15-minute counts typically increases as the count duration increases, due to fluctuating flows, and decreases if the count is separated into two adjacent weeks. The key influences on the statistical analysis are the estimate of this variability and the sample size (number of 15 minute intervals).

Table 5 shows the benefits of increasing the survey duration by collecting counts on adjacent weeks. Collecting counts over a period of two adjacent weeks was selected as it reduces the influence of activities that impact a particular day, such as weather changes and local events. If counts are collected on a single day, then it is more likely that the before-and-after analysis will not be comparing the effect of the new facility but will indicate the effects of certain one-off factors such as weather differences or a discount sale at a near by shop.

Pedestrian Perception Survey Results

In addition to physical data the research team and steering group were also very interested in pedestrian perceptions. Hence a sample of pedestrians were asked to rate their perceptions, with respect to safety, delay and directness before and after the facility was introduced. The key areas under each area are specified in Table 6 (refer to **Turner et al 2009** for the questionnaire).

Table 6: Pedestrian perceptions of safety, delay and directness

Safety	Please rate how safe you feel crossing at this facility. Are safety aspects important to you when deciding on a location to cross the street?
Delay	Please rate how much delay you experience when crossing at this facility. Are delay aspects important to you when deciding on a location to cross the street?
Directness	Please rate how directly this crossing facility is on your route. Is the directness of crossing facilities important to you when deciding on a location to cross the street?

CASE STUDIES

The following table gives a brief overview of various characteristics of the different sites examined in this study.

Table 7: Overview of study sites

Location	Type of Improvement	Road category	Land Use	AADT	"Before" Study (Ped/hr)
Moorhouse Ave at Hoyts 8 / “Science Alive!”, Christchurch	Signalised crossing	Six lane median divided arterial	Commercial	40,000	75
Hereford Street, Christchurch	Raised zebra crossing with warning light system	Collector	Commercial	9,500	628
Sparks Road, Christchurch	School patrolled zebra crossing	Minor Arterial	School / Residential	10,700	148
Hoon Hay Road, Christchurch	Kea Crossing	Minor Arterial	School / Residential	7,000	43
Ensors Road, Christchurch	Refuge Island and kerb extension	Minor Arterial	Residential	8,200	7
Collingwood Street, Hamilton	Kerb extensions	Collector	Commercial / Education	6,500	30
Tristram Street, Hamilton	Refuge Island	Minor Arterial	Commercial / Education	21,000	25
Margot Street, Auckland	Kea Crossing	Local Road	School / Residential	2,200	69

The information in this table may be useful in identifying the site most similar to the reader’s requirements, and the respective case study may then provide an indication of the degree of success that implementation of a particular pedestrian facility has had in that environment. A brief summary of each of the case studies is provided below.

Case Study 1: Moorhouse Avenue at Hoyts 8 / "Science Alive!", Christchurch

- *Site location and description*: The site is located to the south of the city centre, on one of Christchurch's busy arterial roads. The site can be described as a major arterial road separating key pedestrian destinations to the north and south.
- *Proposed pedestrian facility:* The pedestrian crossing facility at Moorhouse Avenue is a signalised pedestrian crossing which utilises overhead traffic signal mast arm poles.

Case Study 2: Hereford Street at Westpac Lane/National Mutual Arcane, Christchurch

- *Site location and description*: This site is located close to the centre of the city, within the central business district. This area is a busy pedestrian environment and the surrounding land use includes commercial, retail, office and educational facilities.
- *Proposed pedestrian facility:* The facility at Hereford Street is a raised zebra crossing with a warning light system. The crossing distance was also narrowed to 7m with kerb extensions.

Case Study 3: Sparks Road, Christchurch

- *Site location and description:* The site is located outside the entrance of Hoon Hay School and near the entrance to Our Lady of Assumption School (OLA) on Sparks Road.
- *Proposed pedestrian facility*: Improvements involved removal of the existing zebra crossing near the entrance to the Hoon Hay School and construction of a new school patrolled zebra crossing mid-way between the two school entrances.

Case Study 4: Hoon Hay Road, Christchurch

- *Site location and description:* The site is located near the entrance to the Our Lady of Assumption School (OLA) on Hoon Hay Road. Significant pedestrian activity is generated at this site due to pedestrians travelling to and from the school entrance. There is also a large BP station on the corner of Hoon Hay and the adjoining Sparks Road.
- *Proposed pedestrian facility*: Improvements on Hoon Hay Road involved construction of a new Kea Crossing near the entrance to the Our Lady of Assumption School.

Case Study 5: Ensors Road, Christchurch

- *Site location and description:* This site is located in the Christchurch suburb of Opawa, about three kilometres south east of the city centre.). The surrounding area is largely residential, with two schools being present in the vicinity of the site.
- *Proposed pedestrian facility:* The improved pedestrian facility comprised of a pedestrian island and a two metre wide kerb build out. A flush painted median and traffic island to the north of the intersection were also provided.

Case Study 6: Collingwood Street, Hamilton

- *Site location and description:* The site is located in a reasonably busy pedestrian environment in Hamilton West, close to the Waikato Institute of Technology and Hamilton Girls High School. Surrounding land uses include educational, business and some residential, with a car park to the west of the site.
- *Proposed pedestrian facility:* The pedestrian crossing facility at Collingwood Street involved the construction of mid-block kerb extensions which narrowed the width of the carriageway to 7m.

Case Study 7: Tristram Street (at Garry Keith Motors), Hamilton

- *Site location and description:* This site is also located close to the Waikato Institute of Technology in Hamilton West. There is a large pay and display car park facility on the southwest corner of the Tristram Street and Collingwood Street roundabout.
- *Proposed pedestrian facility:* The pedestrian crossing facility at Tristram Street involved the construction of a mid-block pedestrian refuge island.

Case Study 8: Margot Street, Grey Lynn, Auckland

- *Site location and description:* The site is located in a largely residential environment on Margot Street near the entrance to the Diocesan School for Girls.
- *Proposed pedestrian facility:* The improvements consisted of installation of a new Kea Crossing with side islands on Margot St near the entrance to the Diocesan School for Girls.

Table 8 shows the pedestrian counts before and after implementation of a new pedestrian facility for the eight sites analysed in this study.

Table 8: Pedestrian numbers: Before and After

Location	Type of Improvement	"Before" Study (Ped/hr)	"After" Study (Ped/hr)	% increase	Significant increase?
Moorhouse Ave at Hoyts 8 / "Science Alive!", Christchurch	Signalised crossing	75	80	7%	No
Hereford Street, Christchurch	Raised zebra crossing with warning light system	628	607	-3%	No
Sparks Road, Christchurch	School patrolled zebra crossing	148	228	54%	Yes
Hoon Hay Road, Christchurch	Kea Crossing	43	64	49%	Yes
Ensors Road, Christchurch	Refuge Island and kerb extension	7	8	14%	No
Collingwood Street, Hamilton	Kerb extensions	30	57	90%	Yes
Tristram Street, Hamilton	Refuge Island	25	46	84%	Yes
Margot Street, Auckland	Kea Crossing	69	98	42%	Yes

Overall, all of the sites except for the zebra crossing at Hereford Street in Christchurch experienced an increase in pedestrian flows after implementation of the new facility. The magnitude of these increases varies, with some sites experiencing an increase in pedestrian numbers of up to 90%, (Collingwood Street, Hamilton) while others experienced only a 7% increase (Moorhouse Avenue, Christchurch). While most sites have exhibited varying degrees of increase in pedestrian volumes, the increase at some of these sites such as Moorhouse Avenue, Hereford Street and Ensors Road is well below the figure for percentage increase that is deemed to be statistically significant. Therefore, it can reasonably be concluded that construction of new facilities at these locations has not had a significant impact on pedestrian usage.

Analysis of the before-and-after pedestrian counts and pedestrian crossing desire lines indicated that the desire lines remained more or less the same before and after implementation of the improved pedestrian facility. However, significant changes were observed in the proportions of pedestrians crossing along each of the desire lines. The magnitude of these changes was found to vary from site to site. However, it was broadly observed that construction of an improved pedestrian facility resulted in an increased proportion of pedestrians using the desire line describing crossing at the location of the improvement.

A key outcome of this analysis is the importance of pedestrian desire lines to the location of the pedestrian facility. The utility of a new facility is maximised when it is placed along the path of pedestrians' most desirable crossing path. On the other hand, a facility that does not lie along the path that is most preferred by pedestrians may result in it not being utilised by a large proportion of pedestrian users in the area, as is the case with the Collingwood Street kerb extensions.

Results of Pedestrian Perception Responses

Figures 3 to 5 show the changes in the perceived levels of safety, delay and directness at the eight study sites. Survey respondents at each site gave a different degree of importance to each parameter. However, it was found that pedestrians across all of the sites were unanimous in rating safety as the most important factor while considering where to cross a road.

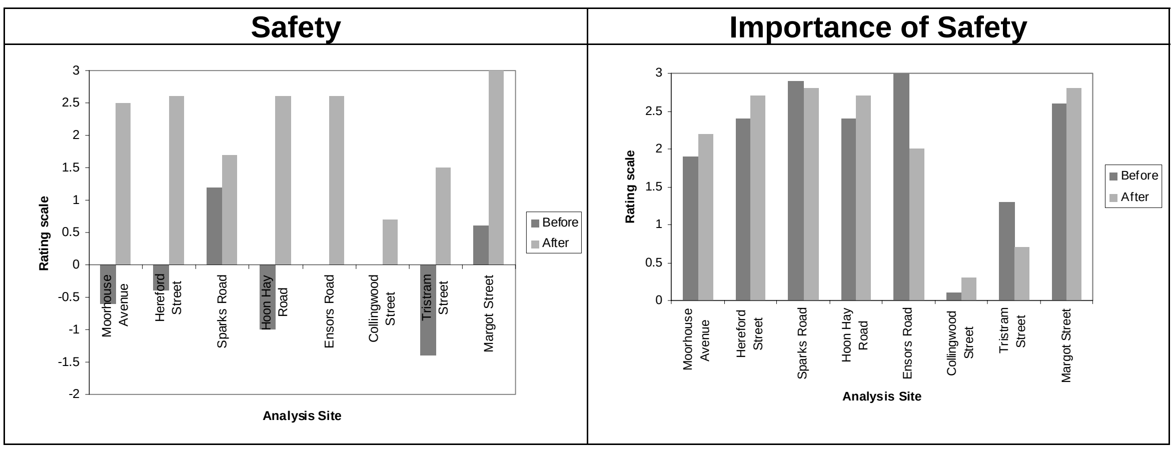

Figure 3: Changes in perceived level of safety and importance of safety

It is obvious from the above figure that pedestrians are unanimous in their perception that improved facilities at the above locations have provided a safer crossing environment. It can also be seen that at five out of the eight sites analysed (Moorhouse Ave, Hereford Street, Hoon Hay Road and Sparks Road in Christchurch and Margot Street in Auckland), the perceived level of safety after implementation of a new facility had a rating that was at or above 2.5 out of a maximum of 3. Each of these locations had a 'before' safety perception rating that was mildly negative, neutral or slightly positive. This suggests that pedestrians at these locations have derived great safety benefits from the construction of new facilities.

The other three locations (Collingwood Street and Tristram Street in Hamilton and Sparks Road in Christchurch) also displayed significant increases in perceived levels of safety, although not of a magnitude comparable to the five sites described above.

Table 9 below compares the actual crash rate at each of the sites with the perceived before and after safety rating as given by respondents. It can be seen that sites with a high actual crash rate also have a lower perceived rating of safety in the before scenario.

Table 9: Comparison of actual crash rates with perceived safety

Location	Actual Crash Rate (Injury crashes per year) (2003 - 2007)	Perceived Safety (Before)	Perceived Safety (After)
Moorhouse Ave at Hoyts 8 z/ “Science Alive!”, Christchurch	0.8	-0.6	2.5
Hereford Street, Christchurch	0.4	-0.4	2.6
Sparks Road, Christchurch	0	1.2	1.7
Hoon Hay Road, Christchurch	0	-1	2.6
Ensors Road, Christchurch	0.2	0	2.6
Collingwood Street, Hamilton	0.2	0	0.7
Tristram Street, Hamilton	0	-1.4	1.5
Margot Street, Auckland	0	0.6	3

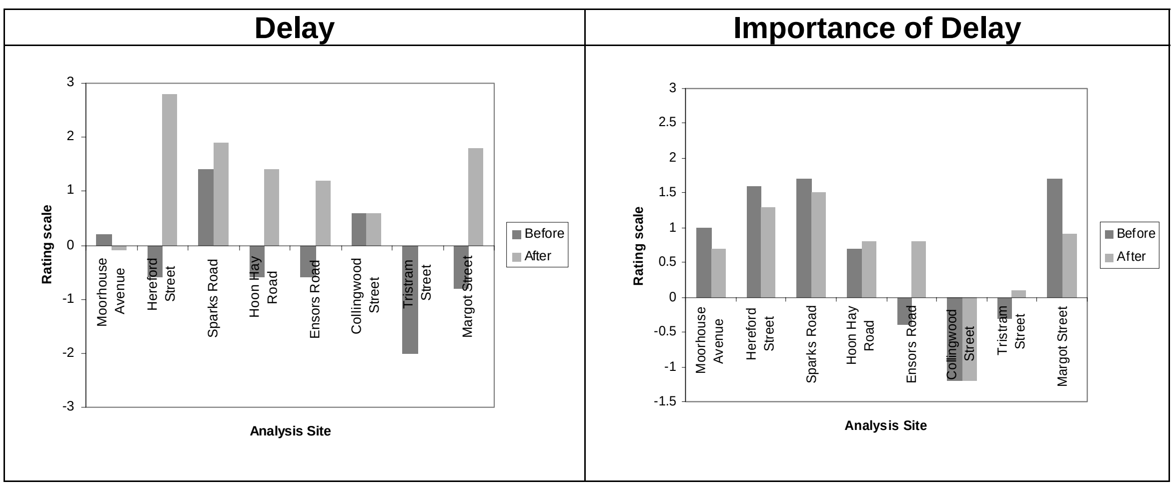

Figure 4: Changes in perceived level of delay and importance of delay

We can observe from the above figure that implementation of new pedestrian facilities has resulted in reducing the amount of waiting time experienced by crossing pedestrians at all but two of the locations analysed.

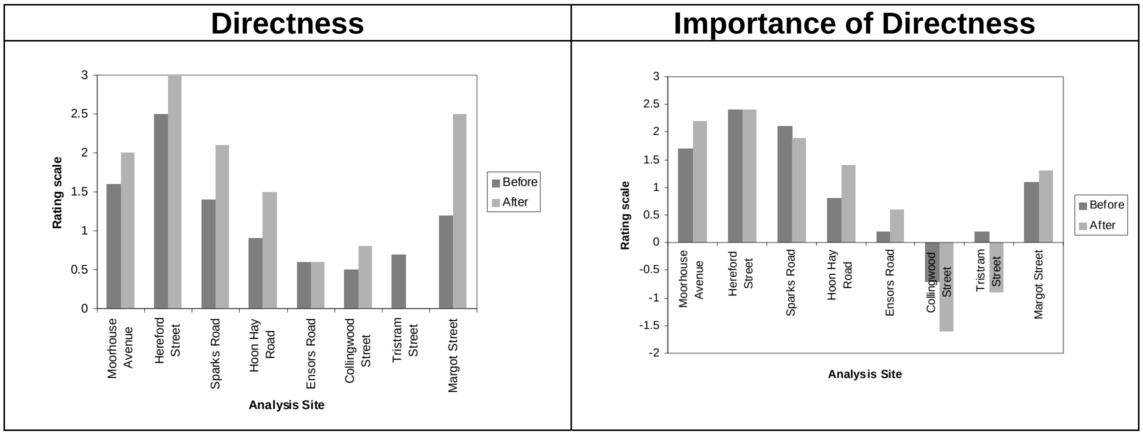

Figure 5: Changes in perceived level of directness and importance of directness

The above figure for directness indicates that six out of the eight sites have resulted in providing a more direct crossing path to pedestrians. The exceptions are the refuge islands and kerb extension at Ensors Road, where pedestrians did not report a change in directness, and the refuge island at Tristram Street, where pedestrians reported that the new facility did not lie on the most direct path.

CONCLUSIONS

The implementation of improved pedestrian facilities resulted in increased usage at seven out of the eight sites analysed during this study. In some cases the total number of pedestrians crossing the road did not increase, but the number crossing at the purpose built pedestrian crossing facility increased, compared with crossing at other desire lines.

Implementation of new pedestrian facilities resulted in reducing pedestrians' perceived waiting time at six out of the eight study sites. The importance of delay during the after survey was found to be lower than or equal to the importance of delay during the before survey for five out of the eight analysis sites. This suggests that the importance of delay frequently becomes secondary once other criteria such as levels of safety are improved.

Six out of the eight study sites were either situated directly on the most common path used by pedestrians, or resulted in providing a more direct crossing path which was subsequently adopted by pedestrians. For a new facility to have maximum utility for pedestrians, it must be located on or close to the most preferred paths used by pedestrians while crossing the road.

Figure 6 below depicts how the different facilities fared in the various criteria asked for in the 'after' perception surveys. Safety was rated as the most important factor considered by pedestrians while choosing a location to cross the road. The perception surveys indicated that pedestrians at all the eight study sites reported feeling safer while crossing the street after implementation of the new pedestrian facility. Pedestrians at five of the eight study sites reported an average 'after' safety rating of 2.5 or more out of a maximum of 3, which indicates that these facilities were successful in providing an extremely safe perceived crossing environment.

<table>
<tr><th></th><th>Safety</th><th>Delay</th><th>Directness</th></tr>
<tr><td>Highest perceived rating</td><td>Kea Crossings</td><td>Zebra crossings</td><td>Zebra crossings</td></tr>
<tr><td rowspan="2"></td><td>Signalised crossing</td><td>Kea Crossings</td><td rowspan="2">Kea Crossings ,
Signalised crossing</td></tr>
<tr><td>Zebra crossings</td><td>Kerb extension / refuge Island</td></tr>
<tr><td>Lowest perceived rating</td><td>Kerb extension / refuge Island</td><td>Signalised crossing</td><td>Kerb extension / refuge Island</td></tr>
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Figure 6: Performance of various facilities with respect to safety, delay and directness

Zebra crossings were found to have the highest average ratings for levels of delay and directness after completion of the facility. In terms of safety, Kea Crossings were observed to perform the best. On the other hand, pedestrians perceived construction of kerb extensions/refuge islands to have had the least contribution to improvement of safety and directness at the respective locations.

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