Feasibility of Implementing European/ North American "Pedestrian Crosswalk" Laws In New Zealand

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ABSTRACT

New Zealand has road rules that do not generally give priority to pedestrians when crossing side roads and intersections. This is relatively unusual as in many other parts of the world pedestrians have laws giving them priority over turning traffic and traffic approaching intersections. This project compares the legal provisions for pedestrians in New Zealand to the rest of the world and considers the implications of changing New Zealand's current road rules to give pedestrians greater priority.

Pedestrian crash data for urban intersections was collected and analysed. The most common crash types were the left and right side crashes. These occur when a vehicle strikes a pedestrian approaching from the left or right side of the vehicle. The three main causes of pedestrian crashes are pedestrian factors (46%), poor observation from the driver (19%), and failure of the driver to give way or stop (6%). Pedestrians walking or running heedless of traffic, a pedestrian factor, made up 23% of all pedestrian crashes.

A perception survey was undertaken to determine how well the general public understands the current road rules in New Zealand, and how willing they would be to give way to pedestrians. From the survey it was determined that 40% of people are already willing to give way to pedestrians, and that another 38% would be prepared to give way if there was additional markings on the road to delineate the pedestrian crossing.

Modelling of the change in travel time for pedestrians and motorists caused by the suggested rule change was completed using PTV Vissim. This found that the approximate net life cycle cost of the change is only $30,661 per T junction and $184,975 per X junction. Given that the cost of a single pedestrian fatality is $3.05 million in a 50km/h zone these costs are negligible.

1. INTRODUCTION

The road rules in New Zealand heavily favour motorists over pedestrians. This is a relatively unique situation as, in the majority of the rest of the world, pedestrians generally have priority when crossing side roads and intersections. This is shown Figure 1 and Figure 2. Living Streets Aotearoa, an organisation that promotes walking friendly communities, have suggested that the road rules in New Zealand change in order to bring New Zealand in line with the rest of the world.

The terms "signalised" and "unsignalised" are used throughout this report. In this context a signalised intersection is an intersection where there are traffic lights in operation. An unsignalised intersection is one that is priority controlled by a Give Way or Stop sign, or has no form of control. Round-a-bouts can also be referred to as unsignalised intersections, but these were not considered in this project.

2. METHODOLOGY

First, a study of the varying laws and legislation throughout Australia, Europe, and North America was undertaken. The related crash data for these areas was also investigated. This ensured a thorough understanding of how the different laws affect pedestrian behaviour and safety. The international laws were then compared to the New Zealand laws.

The New Zealand Transport Agency's (NZTA) Crash Analysis System (CAS) was used to retrieve and analyse New Zealand's pedestrian crash data from the previous five years. This was done to identify current pedestrian crash trends and to see how they may alter if the

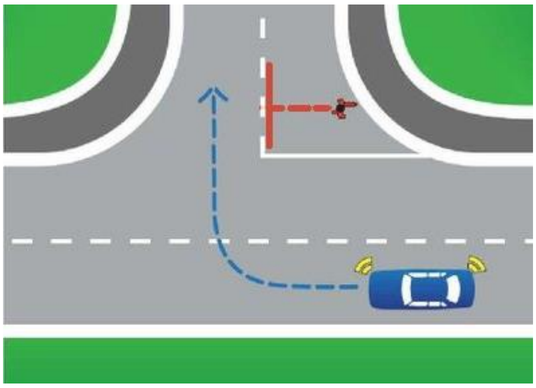

Figure 1. Road rules in New Zealand

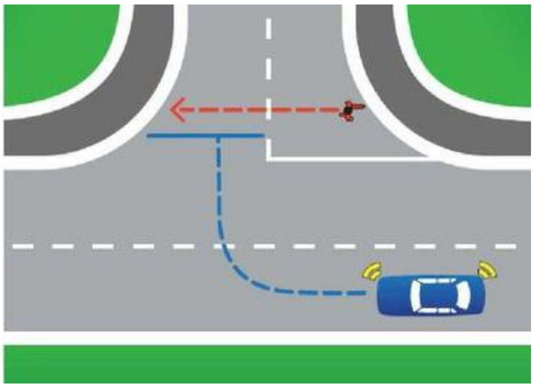

Figure 2. Road rules in Australia, Europe, and North America

suggested rule change was implemented. Another investigation into overseas crash data was planned. However, due to the less detailed data collection methods of other countries this proved to be quite difficult.

A perception survey was created and run over four weeks in August. It focused on the public's understanding of the relevant road rules currently in place in New Zealand and their willingness, as motorists, to give way to pedestrians in different situations. The survey was released online to maximise participation. Invitations to complete the survey were distributed over the University of Canterbury's, Automobile Association (AA) New Zealand's, and Living Streets Aotearoa's Facebook pages.

Finally PTV Vissim, a traffic flow simulator, was used to model pedestrian and vehicle delays using nine different flow combinations under the current road rules and the suggested change. Two intersection types were considered; a T junction, and an X junction. From these simulations the travel time decrease for pedestrians, and the corresponding travel time increase for vehicles was determined for the different flow rate combinations. The economic costs and savings of the suggested change was also calculated for each intersection type.

3. LITERATURE REVIEW

3.1. New Zealand Road Rules

The Land Transport (Road User) Rule 2004 (Ministry of Transport, 2014) provides some limited but clearly defined situations where pedestrians have priority over motor vehicles. Motorists are only legally required to give way to pedestrians at signalised and unsignalised (zebra) pedestrian crossings, school crossings, driveway thresholds and within sheared space zones. It should also be noted that pedestrians are very rarely mentioned in the New Zealand Road Code when compared to other countries (Land Transport New Zealand, 2012).

3.2. Australian Road Rules

The Australian Road Rules (Australian Transport Council, 2012) are very similar to the New Zealand Road Rules. However, they give greater importance to pedestrians by setting up a give way relationship with the motorist. Including the four situations mentioned in the New Zealand rules, Australian motorists also have to give way to pedestrians;

- when making a U-turn
- when turning left at an unsignalised slip lane
- who are crossing, or about to cross, the street onto which a left or right turning vehicle is turning onto (but not the street it is turning from)

3.3. European Road Rules

The road rules in Europe vary from country to country but all provide far more provisions for pedestrians than in New Zealand or Australia. Some examples of pedestrian crossing laws from France, Ireland and Switzerland are listed below;

- "Every motorist is obligated to yield, stopping if necessary, to a pedestrian regularly engaged in crossing a street or clearly manifesting the intention to do so ...." (Matchett, 2011)
- "Vehicles do not have an automatic right of way on the road. The overriding rule is, in all circumstances, proceed with caution. You must always yield to pedestrians already crossing at a junction …" (Road Safety Authority Ireland, 2013)
- "Approaching a pedestrian crossing where traffic is not regulated (signalised), drivers shall yield priority to all pedestrians and wheelchair users who are already engaged on the crossing or who are waiting in front of it with the visible intention of using it." (Matchett, 2011)

3.4. North American Road Rules

The road rules in Canada and the United States of America (USA) also provide far greater priority for pedestrians. However, the American concept of a crosswalk and the ambiguity of its definition leads to its inconsistent use between states. Despite this, the laws still provide good priority for pedestrians. In Indiana, USA, the law states that motorists "must slow down when approaching an intersection and be prepared to come to a complete stop if a vehicle or pedestrian with the right-of-way is approaching from another direction" (Indiana Bureau of Motor Vehicles, 2013). In British Columbia, Canada, drivers must also treat all unmarked crosswalks as marked crosswalks (Insurance Corporation of British Columbia, 2012).

4. RESULTS

4.1. Crash Analysis

The NZTA's CAS was used to retrieve all of the relevant data relating to pedestrian crashes at signalised and unsignalised urban intersections between 2009 and July 2014. Overall, 1,750 crashes fitting this criterion were identified. Of particular interest were the factors contributing to the crashes and the vehicle and pedestrian movements involved in the crashes.

Figure 3 shows the different factors that have contributed to pedestrian crashes in the past five years. Pedestrian factors are by far the largest contributor to pedestrian crashes making up 46% of the total crash causes for both signalised and unsignalised intersections. Poor observation from the driver makes up 26% of the total crash causes, and failure of the driver to give way or stop makes up only 12%.

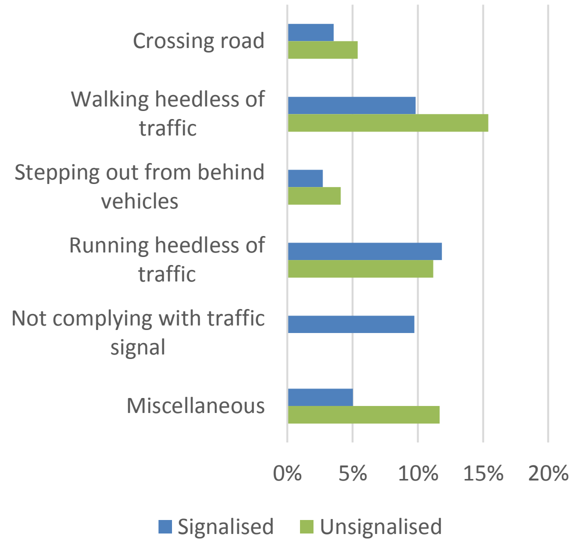

Figure 4. Pedestrian factors contributing to pedestrian crashes at signalised and unsignalised intersections in urban areas

Figure 4 shows the breakdown of the major individual pedestrian factors. Pedestrians walking or running heedless of traffic are the largest contributors and account for approximately 23% of all crash cause factors. It should be noted that, when the data is split between signalised and unsignalised intersections, pedestrians walk heedless of traffic 5% more at unsignalised intersections than at signalised intersections. But, there is

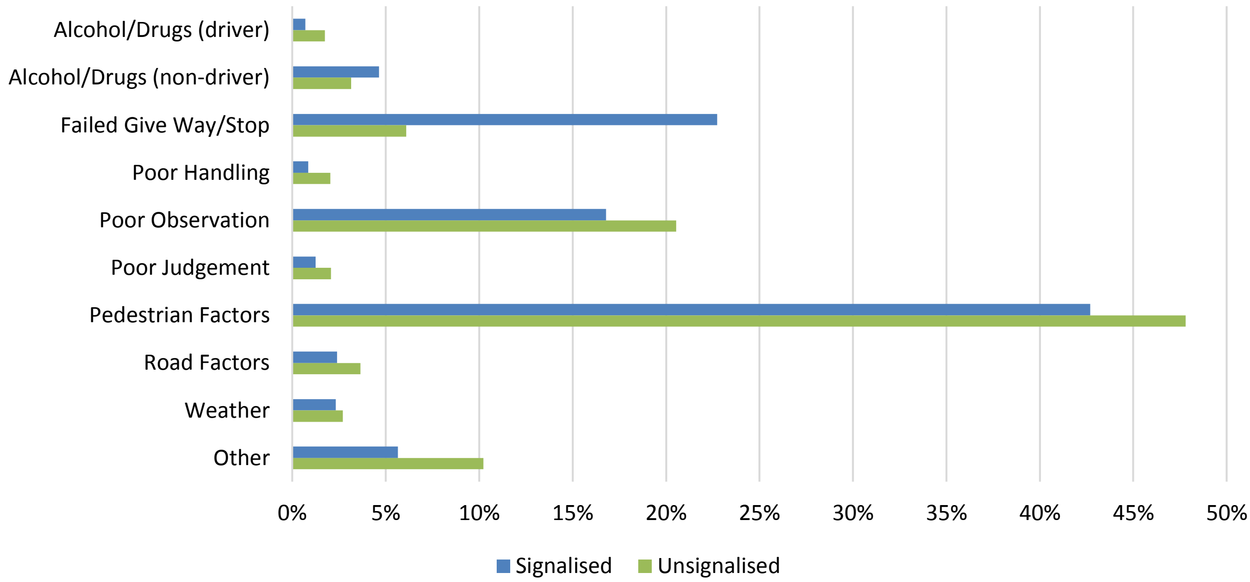

Figure 3. Factors contributing to pedestrian crashes at signalised and unsignalised intersections in urban areas

only a 1% difference for pedestrians running heedless of traffic at signalised and unsignalised intersections.

Figure 5 shows the distribution of vehicle and pedestrian movements involved in pedestrian crashes. Table 1 explains the movement codes used in Figure 5. The two most common movements involved in pedestrian crashes are the NA (left side crash) and NB (right side crash) movements. Some of these crashes will relate to vehicles turning out of a side road. However, these crashes cannot be separated from the rest of the NA and NB data. For these crashes and the rest of the turning movements (NC, ND, NE, NF) it is likely that the unsignalised distributions will become similar to the signalised distributions as the suggested rule change will effectively cause unsignalised intersections to be treated like signalised intersections.

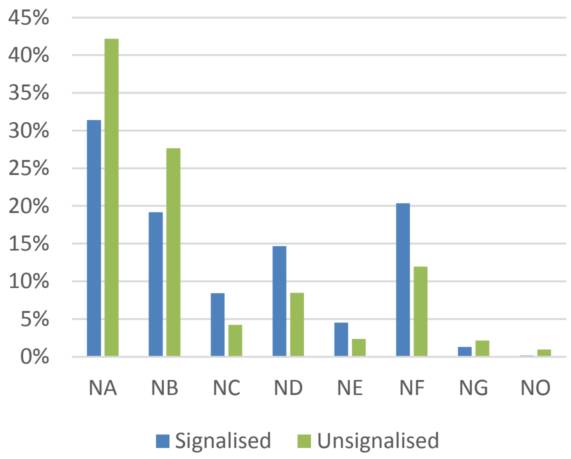

Figure 5. Movements involved in pedestrian crashes at signalised and unsignalised intersections in urban areas

If the New Zealand road rules do change it is expected that crash patterns at unsignalised intersections will become more similar to those at signalised intersections. It was hoped that the vehicle movement and causal factor data collected from CAS would be able to be compared to similar pedestrian crash data from overseas. This would have shown if there was any noticeable differences between the data sets. It would have also indicated the possible effects of the suggested rule change. However, it was not possible to find suitable data for comparison, as each country collects different sets of information for each crash.

4.2. Perception Survey

Overview

A perception survey on pedestrian right of way was created. It focused on the public's understanding of the relevant road rules currently in place in New Zealand and how willing they would be to give way to pedestrians in different situations. The survey also investigated how having additional markings on the road, to define the pedestrian crosswalk, affected responses. The public's preference for six different marking types was also explored.

The survey was conducted online using the Qualtrics survey software. The survey was live from the 15th August until the 12th September. During this time 876 people completed the survey. The survey was mainly distributed through the University of Canterbury's, AA New Zealand's, and Living Streets Aotearoa's Facebook pages.

Bias

Bias occurs when a selection of people are over represented in a survey population. This can cause the results to vary from what is expected. As this survey was distributed online there is potential for bias to occur.

There was an even distribution of respondents across gender. The age group distribution was varied. The smallest group represented was those under 19, who accounted for 5% of the total respondents, and the largest group represented was those who were 45 to 54 and accounted for 21% of the total respondents. The older the respondents were the more likely they were to give way to the pedestrian. Of the 876 respondents 43% had driven overseas sometime in the last five years. These people were much more likely to give way to pedestrians than those who had not. The frequency of travel mode also had a significant effect on the survey results.

Survey Results

The survey found that, on average, people's understanding of the current New Zealand rules was acceptable, as shown in Figure 6. However, 35% of respondents did not know that they were required to give way to pedestrians on the footpath when entering or leaving driveways.

Table 1. Vehicle movement crash codes for pedestrians crossing the road

	A	B	C	D	E	F	G	O
N	LEFT SIDE	RIGHT SIDE	LEFT TURN LEFT SIDE	RIGHT TURN RIGHT SIDE	LEFT TURN RIGHT SIDE	RIGHT TURN LEFT SIDE	MANOEUVRING VEHICLE	Other

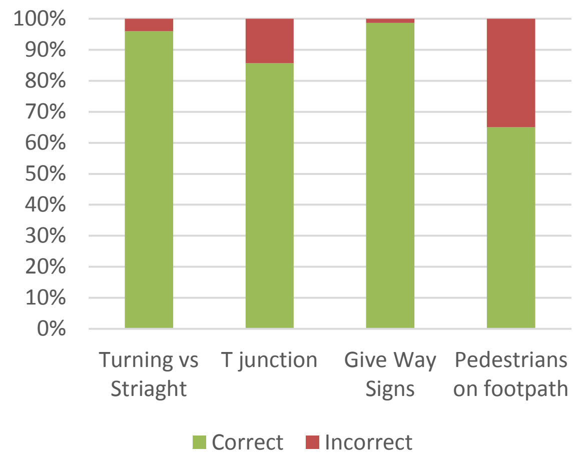

Figure 6. Responses assessed against current road rules

The respondents' average willingness to give way to pedestrians is shown in Figure 7. The results are split depending on how frequently they travelled by foot or car. 'Often' was defined as two to three times a week or more, and 'rarely' was defined as once a week or less. Twenty four respondents identified as travelling rarely by both foot and car and were excluded from this analysis. Table 2 shows how the frequency of travel mode for the respondents was spread.

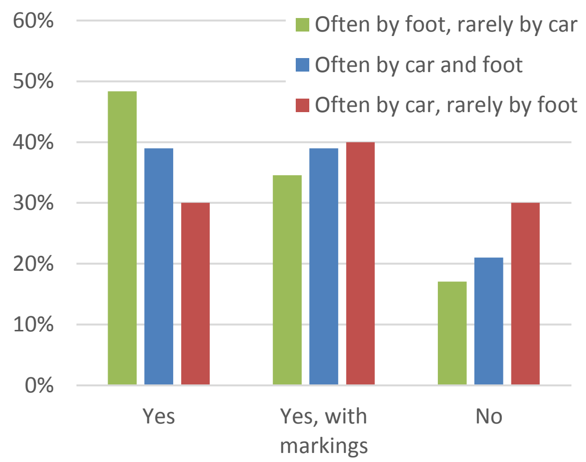

Figure 7. Average willingness of respondents to give way to pedestrians split by their frequency of travel mode

Table 2. Distribution of frequency of travel

Description	Count
Often by foot, rarely by car	159
Often by car and foot	482
Often by car, rarely by foot	189

Having additional markings to delineate the pedestrians' path and to show that the pedestrian has the right of way almost doubles the average willingness of the respondents to give way. Figure 8 shows the most popular marking type, a ladder marking.

Figure 8. Possible crosswalk marking

4.3. Modelling

Software

PTV Vissim was used to model pedestrian and vehicle delays under the current road rules in New Zealand and the suggested change. PTV Vissim is a microscopic multi-modal traffic flow simulation software package. Microscopic simulation means that each entity is simulated individually, and so are the interactions between them. As PTV Vissim is multi-modal it has the ability to simulate more than one type of traffic. It can simulate cars, trucks, buses, trams, motorcycles, bicycles, and pedestrians. Only cars and pedestrians were used during the simulations.

Set Up

Two intersection layouts were considered; a T junction and an X junction. The T junction had one pedestrian crossing point on its minor leg, and the X junction had a pedestrian crossing on both of its minor legs. Both intersections' minor legs were controlled by Give Way signs. Simulations were run for both intersection types under the current New Zealand Road Rules and the suggested change. Three different flow rates were used for the pedestrian and vehicle flows. These were combined to give nine different flow combinations that were used during the simulations. The different pedestrian and vehicle flow rates used as simulation inputs are shown in Table 3. Table 4 shows the total flow rates through each intersection type.

Table 3. Flow rates entered into PTV Vissim

<table>
<tr><th>Flow Type</th><th>Max</th><th>Med</th><th>Min</th></tr>
<tr><td>Pedestrian (ped/h/crossing)</td><td>500</td><td>200</td><td>60</td></tr>
<tr><td>Vehicle (veh/h/leg) (T)</td><td rowspan="2">150</td><td rowspan="2">50</td><td>17</td></tr>
<tr><td>Vehicle (veh/h/leg) (X)</td><td>13</td></tr>
</table>

Table 4. Total flow rates through junctions

<table>
<tr><th colspan="2">Junction</th><th>Max</th><th>Med</th><th>Min</th></tr>
<tr><td rowspan="2">T</td><td>Pedestrian (ped/h)</td><td>500</td><td>200</td><td>60</td></tr>
<tr><td>Vehicle (veh/h)</td><td>450</td><td>150</td><td>51</td></tr>
<tr><td rowspan="2">X</td><td>Pedestrian (ped/h)</td><td>1000</td><td>400</td><td>120</td></tr>
<tr><td>Vehicle (veh/h)</td><td>600</td><td>200</td><td>52</td></tr>
</table>

Ten simulations per flow rate combination were run for each of the combinations with the maximum and medium vehicle flows. For the three flow combinations with minimum vehicle flows, 25 simulations were run. This was done to account for the fewer interactions between pedestrians and vehicles at the lower vehicle flow rate.

The time taken for the pedestrians to cross the road and the vehicles to travel through the intersection was recorded at each occurrence for each simulation. This data was exported from PTV Vissim. MATLAB was then used to collate the data and calculate the average time taken for the pedestrians to cross the road and each vehicle movement to occur. The difference between the travel times for the current New Zealand rules and the suggested change was then used to estimate the decrease in pedestrian delay and the increase in vehicle delay caused by the suggested rule change. The Economic Evaluation Manual (New Zealand Transport Agency, 2013) was then used to calculate the costs associated with the change in delays. This was done assuming that pedestrians and motorists travel time has a value of $16.23 per hour.

Table 5 shows how the delay and cost results were coded.

Table 5. Coding of delay and cost results

Delay decrease (s)	Delay increase (-s)	Cost saving ($1000)	Cost gains (-$1000)
1800 <	< 1800	< 75	< -100
1620 – 1800	1800 – 1620		
1260 – 1620	1620 – 1260	50 – 75	100 – 50
900 – 1260	1260 – 900	25 – 50	50 – 25
540 – 900	900 – 540	15 – 25	25 – 15
180 – 540	540 – 180	5 – 15	15 – 5
0 – 180	180 – 0	0 – 5	5 – 0

T Junction

Figure 9 shows the intersection set up used for the T junction simulations. The average pedestrian time savings are shown in Table 6 and the associated cost savings are shown in Table 7.

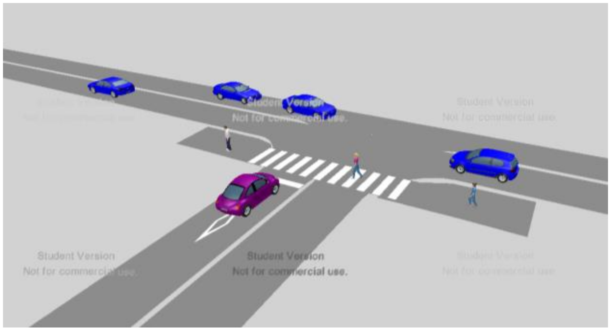

Figure 9. T junction layout for simulations

Table 6. Change to pedestrian delays at a T junction (seconds saved/ hour)

		Vehicle Max	Vehicle Med	Vehicle Min
Pedestrians	Max	1360	366	144
	Med	432	135	35
	Min	144	89	-6

Table 7. Pedestrian cost savings at a T junction ($ saved/ year)

		Vehicle Max	Vehicle Med	Vehicle Min
Pedestrians	Max	53,728	14,468	5,671
	Med	17,050	5,328	1,401
	Min	5,668	3,532	-234

The average vehicle travel time losses for all six vehicle movements are shown in Table 8 and the associated cost increases are shown in Table 9.

Table 8. Change to vehicle delays at a T junction (seconds gained/ hour)

		Vehicle Max	Vehicle Med	Vehicle Min
Pedestrians	Max	-1599	-476	-133
	Med	-461	-150	-46
	Min	-110	-44	-18

Table 9. Vehicle cost increases at a T junction ($ spent/ year)

		Vehicle Max	Vehicle Med	Vehicle Min
Pedestrians	Max	-63,147	-18,814	-5,260
	Med	-18,210	-5,914	-1,804
	Min	-4,333	-1,722	-729

The net cost of the rule change to road users for T junctions can be calculated by adding the information from Table 7 and Table 9. This is shown in Table 10.

Table 10. Net cost to the road user of implementing rule change at a T junction ($/junction/year)

		Vehicle Max	Vehicle Med	Vehicle Min
Pedestrians	Max	-9,419	-4,346	411
	Med	-1,160	-586	-403
	Min	1,335	1,810	-963

X Junction

Figure 10 shows the intersection set up used for the X junction simulations. The average pedestrian time savings are shown in Table 11. The associated cost savings are shown in Table 12.

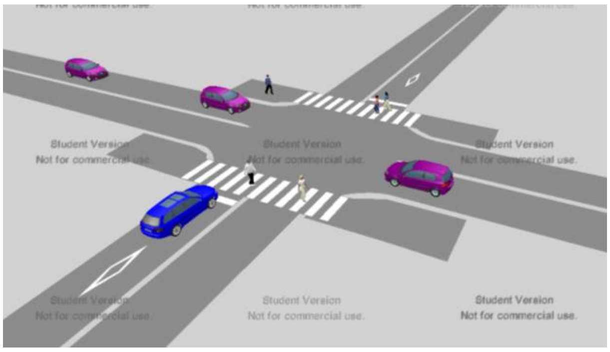

Figure 10. X junction layout for simulations

Table 11. Change to pedestrian delays at an X junction (seconds saved/ hour)

		Vehicle		
		Max	Med	Min
Pedestrians	Max	2425	588	193
	Med	942	310	81
	Min	309	95	-8

Table 12. Pedestrian cost savings at an X junction ($ saved/ year)

		Vehicle		
		Max	Med	Min
Pedestrians	Max	95,755	23,234	7,618
	Med	37,217	12,224	3,193
	Min	12,186	3,747	-329

The average vehicle travel time losses for all 12 vehicle movements are shown in Table 13 and the associated cost increases are shown in Table 14.

Table 13. Change to vehicle delays at an X junction (seconds gained/ hour)

		Vehicle		
		Max	Med	Min
Pedestrians	Max	-4069	-1408	-280
	Med	-1104	-316	-99
	Min	-1109	-38	-33

Table 14. Vehicle cost increases at an X junction ($ spent/ year)

		Vehicle		
		Max	Med	Min
Pedestrians	Max	-160,710	-55,623	-11,077
	Med	-43,607	-12,486	-3,911
	Min	-43,799	-1,489	-1,312

The net cost of the rule change to road users for X junctions can be calculated by adding the information from Table 12 and Table 14. This is shown in Table 15.

Table 15. Net cost to the road user of implementing rule change at an X junction ($/junction/year)

		Vehicle		
		Max	Med	Min
Pedestrians	Max	-64,955	-32,389	-3,458
	Med	-6,390	-262	-719
	Min	-31,613	2,259	-1,641

Application to Average Hourly Traffic Flows

Figure 11 shows the average hourly flow profiles for pedestrians and vehicles. If it is assumed that the peaks represent the maximum flows used in the simulation, the mid-day lull is the medium flow, and outside the peaks is the minimum flow, then the approximate cost of the suggested change can be calculated for T and X junctions. This gives an average net cost of $1,979 per junction per year for T junctions and $11,939 per junction per year for X junctions.

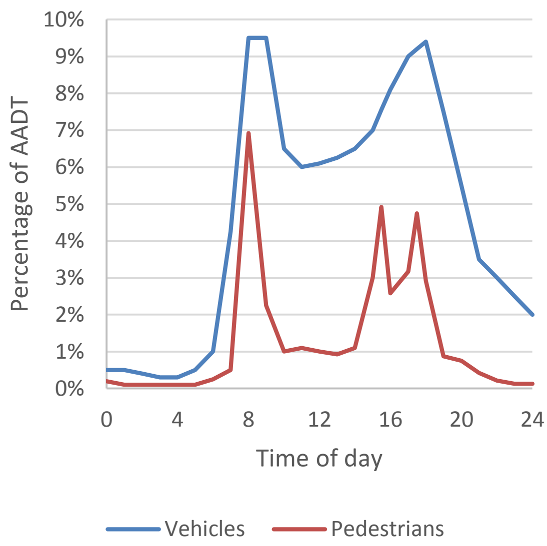

Figure 11. Hourly flow profiles for pedestrians and vehicles (adapted from Turner, Roozenburg, and Francis (2006) and Traffic Design Group Ltd and Transfund New Zealand (2001))

If a 40 year evaluation period and a discount rate of 6% are assumed then the life cycle costs of the suggested rule change can be calculated. The uniform series present worth factor (USPWF) for the stated assumptions is 15.4933. This gives a total life cycle cost of $30,661 for a T junction and $184,975 for an X junction. Given that the crash cost for a single pedestrian fatality in a 50 km/h zone is $3.05 million these costs are negligible (New Zealand Transport Agency, 2013). It should be noted that this analysis does not take into account any potential pedestrian safety benefits or costs the suggested rule change may make.

Limitations

PTV Vissim is able to create Surrogate Safety Assessment Model (SSAM) files. These files map potential traffic conflicts where two road users will collide if they do not take evasive action. This data was collected for each simulation run and was going to be analysed as a part of this project. However, due to issues with running the SSAM software this was not completed.

The pedestrian delay increase for the minimum pedestrian, minimum vehicle simulations will most likely be due to the limits of the PTV Vissim software. The number of runs for those simulations was increased from 10 to 25 to try and prevent this from occurring.

5. CONCLUSIONS

Unfortunately comparison of New Zealand's pedestrian crash data to other countries crash data could not be completed due to the other countries having less detailed recording methods. However, the New Zealand data highlighted that pedestrian factors are the largest contributor to pedestrian crashes. If the rule change does go ahead it could be expected that crash patterns at unsignalised intersections will become similar to those at signalised intersections.

The perception survey results are very promising as, on average, 78% of people are already willing to give way to pedestrians, provided there is some form of additional marking to delineate the pedestrians' right of way. This was much higher than expected.

The modelling results and analysis shows that any decrease in pedestrian travel time is matched by a slightly larger increase in vehicle travel time. However, the lifecycle costs of the suggested change per junction are negligible.

Currently, the rule change seems feasible. There is no economic reason to dismiss it, and the public have shown that they are willing to give way to pedestrians.

6. RECOMENDATIONS

Before the suggested rule change is progressed any further more research needs to be completed on the possible safety effects that the change may have. This could be completed through either simulations, with a software similar to PTV Vissim, or physical trials, by implementing the rule at select sites. If there are significant safety effects the economic evaluation should be reassessed. An investigation into how different crosswalk markings affect pedestrians and motorists could also be considered.

7. ACKNOWLEDGMENTS

I would like to acknowledge Dr Glen Koorey for his direction and support throughout the duration of this project.

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