RESEARCH REPORT 588

Why are some urban traffic signals much less safe than others?

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NZ TRANSPORT AGENCY WAKA KOTAHI
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Understanding the risks of urban signalised intersections

Some urban signalised intersections carry a much higher risk of serious injury or death than others, but the reasons are not well understood.

Recent research undertaken by Abley Transportation Consultants compared signalised intersections that have good safety records, with those that do not, in order to understand the reasons for the differences.

The research arose out of the development of the Transport Agency's High-risk intersections guide (2013), which revealed some urban signalised intersection were performing better, in terms of safety, than others, despite using the same types of signal controls.

The reasons why this should be the case were not immediately apparent, and an initial review of the literature confirmed that, despite a large body of literature being available on safety, very little of it addressed the underlying variables that contribute to crash risks at intersections, other than traffic flow.

The research collated a list of 36 operational, physical and environmental factors that could potentially have an impact on an intersection's safety performance.

The research qualitatively analysed a number of urban signalised intersections in terms of how these factors might influence their safety. Unlike more common statistical approaches for modelling crash risk, the research used a qualitative whole-system approach to identify factors that might normally be missed due, for example, to the random nature of crashes and their severity, or the processes used to define variables for mathematical analysis.

The aim was to help practitioners select effective safety treatments for urban signalised intersections. The results of the research will enable practitioners to:

- identify factors or combinations of factors that should be implemented or avoided to enhance safety outcomes
- specify potential safety issues when designing urban signalised intersections
- indicate the likely reduction in fatal and injury crashes when installing remedial treatments at urban signalised intersections.

The research

The research was conducted in three broad stages.

The first stage involved qualitative analysis of a broad range of intersections in Auckland, Christchurch and Dunedin. The analysis looked at the crash history of the sites, including the operational, environmental and physical factors that had been coded for the crashes in the Crash Analysis System. The analysis suggested although some factors contribute to crashes at all intersections (for example, alcohol and drugs, failing to look for or see other vehicles when changing lane position or direction, and loss of control when turning), they are proportionally less common at poorly performing intersections, where other factors become more prevalent. Other factors (such as horizontal alignment, striking an object, and crashes involving pedestrians and cyclists) that were expected to influence safety outcomes, actually had a negligible effect on the intersections' performance.

A significant finding of this stage of the research was that no single factor appeared to contribute overwhelmingly to poor safety performance. However, around half of all crashes, across intersections with all levels of safety performance, could be attributed to 10 top crash factors, with the remaining crashes apportioned between a further 200 factors.

At the second stage of the research, the number of intersections analysed was refined to 40. Site visits were used to analyse these intersections for non-coded factors contributing to their safety performance.

This stage of the research found recurring themes in the causes of crashes, with a number of key factors being present in at least half of the poorly performing intersections. None of the factors identified were present in all the poorly performing intersections, but some were present in at least half of those intersections that had experienced two or more crashes of the same type.

Overall, the causes of poor safety performance appeared to differ, depending on the intersection and its characteristics. Some of the worst performing intersections had combinations of factors that appeared to interact to give a worse outcome than could be explained by the sum of the individual factors. This observation led the research team to recommend that intersections with a poor safety performance should be assessed

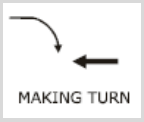
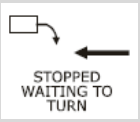
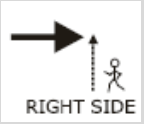
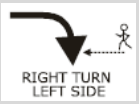
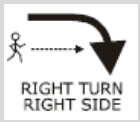
on a case-by-case basis to identify the underlying factors and most appropriate treatment strategy.

The final stage of the research involved analysing the crash performance of 100 different intersections. The analysis focused on whether any of the factors identified in the previous research stages were more common at intersections with higher rates of certain types of crashes:

- crossing (no turns) crashes
- right-turn against crashes
- crashes involving pedestrians.

Only crashes causing injury or death were included.

The following table shows the factors found to be significant for each crash type, their effect on injury crashes and the degree of confidence for each factor.

Crash type	Factor found to be significant	Effect on number of injury crashes	Degree of confidence
HA 	Number of signal displays less than 5	Increase	>95%
	No mast arms	Increase	>95%
LB  	Either filtering banned or part-time	Decrease	>90%
	Angle of skew less than or equal to 15°	Decrease	>90%
	Single opposed through lane	Decrease	>95%
NA/NB  	Either shared left/through or right/through lane	Increase	>90%
	Appreciable gradient on intersection approach	Decrease	>95%
	Angle of skew on intersection approach less than or equal to 5°	Increase	>95%
ND/NF  	Right-turn filtering not allowed full time	Decrease	>95%
	Right-turn filtering not allowed at all	Decrease	>95%
	No shared right/through lane	Decrease	>90%
	No right-turn red arrow	Increase	>95%
	No left-turn red arrow	Increase	>95%
	Angle of skew on intersection approach less than or equal to 5°	Increase	>95%

From this stage of the research, 10 factors were found to be statistically significant at greater than 95% confidence and four factors were found to be statistically significant at greater than 90% confidence. Some findings were counter to expectations and the research report recommends further research into these factors. With respect to the other factors, the report concludes that this stage of the research demonstrated the value of introducing remedial intersection treatments, at poorly performing intersections, to modify these factors.

Overall, the research found intersection form and traffic volumes are the main predictors of crash performance. Other factors and combinations of factors can help to further explain good or poor crash performance; however, these are very minor in relation to the primary explanatory variables.

The research also showed that, at times, the safety performance of an intersection cannot be accurately predicted or explained based simply on its form, design features or operating characteristics.

There may also be no individual set of treatments to reduce crashes at every intersection approach. For this reason, tailored studies and safety audits remain a useful technique at intersections exhibiting poor safety performance, to help identify site-specific problems and appropriate remedial measures.

Concluding recommendations include incorporating the research results into guides for practitioners who design signalised intersections in urban areas. The research report contains a summary table presenting the key conclusions from the research alongside findings from previous research, which will be useful for this purpose.