CYCLIST SAFETY – REDUCING THE CRASH RISK

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ABSTRACT
Cycling is a sustainable mode of travel and is supported by a number of government strategies. While there are benefits in promoting more cycling the risk of having a crash while cycling is typically higher than while travelling as a driver or passenger in a motor vehicle. Recent research has demonstrated a 'safety in numbers' effect for cyclists. While this is reassuring, the challenge is to create an environment for cyclists that is as safe as possible. This can be achieved through a series of measures, including, reducing traffic volumes and speeds on high volume cycle routes, building on-road cycle lanes and intersection facilities and construction of off-road cycle paths. This technical note reports on a study that has used the empirical Bayes method ('before and after' studies) and crash prediction models to determine safety benefits of these measures/treatments.

Introduction

Government transport strategies, including 'Getting There on foot, by cycle', promote/require the development of cycling and walking plans and infrastructure improvements to encourage more 'active' mode trips. While there are benefits in promoting more cycling, particularly for shorter trips (less than 6km), the risk of having a crash while cycling is higher than while travelling in a motor vehicle. This is both a measured and perceived increased risk, which influences the uptake of cycling by adults and also influences parents decisions on whether their children can cycle.

Research by Turner et. al. (2006) has demonstrated that there is a 'safety in numbers' effect for cyclist versus motor vehicle accidents. This means that the risk per cyclist reduces as the number of cyclists using a route increases. The research considered cycle accidents at traffic signals, roundabouts and between intersections. The models show that the accident risk per cyclist at higher volumes was several magnitudes of order lower than at low cycle volumes. So one way to improve the safety of each current and future cyclist is to increase cycling numbers and another is to encourage cyclists to concentrate the majority of their journey onto higher volumes routes. While this is reassuring, it remains that when a motor vehicles driver or passenger chooses to switch to cycling, their crash risk will generally increase, particularly when travelling lower volume cycle routes or high volume and high-speed motor vehicle routes. The challenge is to create an environment for cyclists that is as safe as possible.

The Cycle Network and Planning Guide (Land Transport NZ, 2004) identifies a number of measures that can be used to improve safety, such as reducing traffic volumes and speeds on high volume cycle routes, building on-road cycle lanes and intersection facilities and construction of off-road cycle paths. The safety benefit of most of these measures has not as yet been quantified. This technical note presents research on the safety effects of installing on-road facilities both at intersections and mid-block locations.

Flow-only Models for Cyclists

Table 1 shows the models developed by Turner et. al. (2006). The models are based solely on the volume of motor vehicles and cycles using each facility and are only for cycle accidents that involved a motor vehicle. It has been estimated that approximately 73% of on-road cycle accidents involve motor vehicles and only 49% of total cycle accidents occur on-road.

Table 1: Accident prediction models for Cyclists Accidents (Flow-only)

Accident Type	Equation (accidents per approach)	Error Structure	Significant Model
Signalised Crossroads			
Same Direction (codes A, E, F & G)	$A = 7.49 \times 10^{-4} \times Q_e^{0.29} \times C_e^{0.09}$	P#	Yes
Right-turn-against (code LB)	$A = 4.41 \times 10^{-4} \times q_7^{0.34} \times c_2^{0.20}$	NB (K=1.3)*	Yes
Roundabouts			
Entering versus circulating (HA, LB, KB & KA)	$A = 2.40 \times 10^{-5} \times Q_e^{0.79} \times C_c^{0.32}$	NB (K=0.8)*	Yes
Mid-Block			
All non-intersection Accidents	$A = 1.73 \times 10^{-7} \times Q^{1.38} \times C^{0.23} xL$	P#	Yes

*K is the Gamma shape parameter for the negative binomial (NB) distribution.
Poisson models, so no 'k' value.

Where:

A = Annual number of accidents for an approach or mid-block section
Q_e = Motor vehicle flow entering the intersection for an approach
C_e = Cycle flow entering the intersection for an approach
q_7 = Motor vehicle flow turning right from the opposing approach
c_2 = Cycle flow entering the intersection from an approach and travelling straight through
C_c = Circulating cycle flow at an approach
Q = Total two-way motor vehicle flow for the link
C = Total two-way cycle flow for the link
L = Length of the link in kilometres

The low values of the model exponents in Table 1, which are a lot lower than 1.0, and are always lower than the motor vehicle volume exponent, indicates there is a 'safety in numbers' effect for cyclists. While the number of cycle accidents increases with increased cycle volumes, the accident rate per cyclist reduces significant as volumes increase.

Models for On-Road Cycle Facilities

The benefits of cycle facilities were assessed using two methods, 1) cross-sectional studies, or accident prediction models and 2) before and after studies, in which an empirical Bayes approach is used. The results from these two methods are summarised below.

Accident Prediction Models

The models developed by Turner et. al. (2006) for traffic signals and mid-block sections were expanded to include additional variables for intersection and mid-block facilities respectively. Variables, such as parking frequency and turnover and the density of access points were considered. The study sample size consisted of 44 signalised crossroad intersections (so 176 approaches) and 97 mid-block sections of various length (L). 54 of the intersection approaches and 44 of the links had cycle facilities. Table 2 shows a selection of the accident prediction models produced. Table 3 defines each of the predictor variables (other than those defined above).

Table 2: Accident prediction models for Cyclists Accidents

Accident Type	Equation (accidents per approach)	Error Structure	Significant Model
Signalised Crossroads #			
All Cycle Accidents – Flow only	$A = 8.86 \times 10^{-3} \times Q_e^{0.14} \times C_e^{0.04}$	P	No
All Cycle Accidents – Including Cycle Lanes Variable	$A = 6.16 \times 10^{-3} \times Q_e^{0.17} \times C_e^{0.03} x CyLane$ $CyLane = 1.41$	P	Yes
Mid-Block			
All Cycle Accidents – Flow Only	A = 8.60x10^{-3}x $Q^{0.25}$x $C^{0.17}$x $L^{0.37}$	NB (K=1.6)	Yes
All Cycle Accidents – Including Flush Median Variable	A = 1.05x10^{-2}x $Q^{0.25}$x $C^{0.16}$x $L^{0.45}$ x Flush, Flush = 0.63	NB (K=1.7)	Yes
All Cycle Accidents – Including Cycle Lanes Variable	A = 7.11x10^{-3}x $Q^{0.25}$x $C^{0.19}$x $L^{0.38}$ xCyLane, CyLane = 1.21	NB (K=1.6)	Yes
All Cycle Accidents – Including Speed Variable	A = 2.04x10^{-3}x $Q^{0.23}$x $C^{0.18}$x $L^{0.37}$ x $S^{0.40}$	NB (K=1.6)	Yes

# there were insufficient accidents to break down into the two major accident types (same direction and right-turn against)
P = Poisson models, so no 'k' value.

Table 3: 'Non-Flow' Variables for Cycle Accident Prediction Models#

Variable	Description
CyLane	A covariate that indicates a cycle lane. At intersection it is a cycle lane provided up to and including the limit lines and usually a straight through cycle lane.
Flush	A covariate that indicates that a flush median is provided along a road section
No Parking	This covariate is used if there is no parallel parking permitted next to the kerb. None of the study sections had angled parking.
Parking Utilisation	Parking utilisation along each mid-block section was categorised as very low, low, medium or high. Parking utilisation is a combination of the proportion of the mid-block with parking and turnover of that parking.
As	This is the number of minor side-roads along the mid-block section
Ar	This is the number residential access points along the mid-block section.
Ao	This is the number of educational, commercial and industrial access points along the mid-block section.
Speed (S)	Mean speed of motor vehicles along each mid-block section.
W & We	'W' is the width of the kerbside traffic lane. 'We' is the effective width of kerbside lane, including vehicle lane plus cycle lane, where present.
Lns	This is the number of through motor vehicle lanes in each direction

Some of these variables have not shown up as important in the modelling undertaken to date

'Before and After' Study - Empirical Bayes

The 'before and after' study was undertaken for all mid-block sections in the sample set. Only 44 of the mid-block sections had cycle lanes installed (i.e. treated sections). An empirical Bayes method was used in this analysis, to enable regression-to-the-mean to be taken into account in the comparison. Further details on this method can be found in Persuad and Lyon (2006). Based on the accident history and adjusting for regression-to-the-mean, it was estimated that 46 accidents would occur along the 44 treated mid-block sections in the five-year 'after' period, if no treatment (i.e. cycle lane) had been undertaken. Based on the observed 'after' period and again adjusting for regression-to-the-mean it was estimated that the accident frequency had dropped to 41.6 accidents in the five years ‘after’ period following treatment. This corresponds to a drop of 4.4 reported injury accidents in the ‘after’ period due to the installation of cycle lanes; a 10% reduction.

Discussion and Summary

The cross-sectional analysis (accident prediction models) shows that the number of cycle versus motor vehicle accidents increases with increasing motor vehicle volumes (Q), cycle volumes (C) and speed (S). An exponent of 0.40 for the speed variable indicates that a 4 – 7% reduction in cycle accidents could be expected for every 10% reduction in speed, with the largest reductions being in lower speed environments e.g. below 50km/h. Both research studies show that there is a ‘safety-in-number’ effect for cyclists, with the risk for individual cyclists reducing as cycle volumes increase. The increase in cycle accidents with volumes and speed supports the guidance provided in ‘The Cycle Network and Route Planning Guide’ that recommends that safety can be improved by reducing motor vehicle volumes and speeds.

The models also show that as the length of the mid-block section increases the number of cycle accidents per unit length decreases. So the cycle accident rate is higher along shorter road sections, which may be influenced by the closer spacing of major intersections. This may be explained by closely spaced intersections being located in higher traffic volume areas, such as the CBD.

The research also indicates that roads with flush medians have a lower cycle accident rate than roads without, given the same cycle and traffic volumes and length. The mid-block model indicates a 37% reduction in cycle accidents on roads with flush medians.

The effect of cycle lanes and intersection facilities on cycle accident occurrence is still unclear. The cross-sectional analysis indicates that cycle lanes and intersection facilities may increase the number of accidents; possibly by as much as 21% and 41% at mid-block locations and intersections respectively. However the ‘before and after’ study of mid-block sections indicates a 10% reduction in accidents if cycle lanes are installed. What is unclear from the analysis is the influence of other factors in the cross-sectional analysis. Less than half the mid-block sections and only 25% of the signalised intersection approaches have cycle facilities. It is highly possible that there is some bias, to higher cycle accident sites, in the intersections/mid-blocks that have been treated. The other factor that may be influencing accidents at the treated sites is that we know from CCC cycle counts, that routes with cycle facilities have been maintaining cycle volumes, whereas routes with no facilities cycle volumes have seen a reduction. Given these influencing factors the results of the ‘before and after’ studies are likely to be the most reliable, which show a reduction in the cycle accidents when these facilities are installed. But greater benefits are likely to be realised from reducing volumes and speeds. Ideally a larger sample set will need to be used to confirm these findings. The research team would like to include sites from Melbourne in future research.

References

B. Persuad & C. Lyon, “Empirical Bayes Before-and-After Safety Studies: Lessons Learned from Two Decades of Experience” TRB Annual Meeting, Washington, USA (2006)

Land Transport NZ, “The Cycle Network and Planning Guide” Land Transport NZ, Wellington, New Zealand

S. A. Turner, P. Durdin & A.Roozenburg, “Prediction Models for Cycle Accidents” NZ Cycle Conference, Lower Hutt, New Zealand (2005).

S. A. Turner, A. Roozenburg & A. Francis “Predicting Accident Rates for Pedestrians and Cyclists” Land Transport NZ Research Report, Land Transport NZ, Wellington, New Zealand (2006).