COST BENEFIT ANALYSIS

Allowing cyclists on the footpath

More information

NZ Transport Agency
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Accessible Streets Regulatory Package 2020

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New Zealand Government

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Introduction

Encouraging cycling is important for health, societal and environmental reasons. Cycling has been shown to have clear benefits for cardiorespiratory health and can reduce risk of certain cancers and rates of all-cause mortality (Celis-Morales, Lyall, Welsh et al, 2017). Over the last 30 years there has been a dramatic decline in children cycling to school along with a substantial reduction in adults cycling for transport (MoT, 2015).

New Zealand law currently states that bicycles (with wheels larger than 355mm diameter) are not to be ridden on footpaths, except for mail delivery. It is, however, legal to ride a scooter or skateboard on the footpath, so long as this is done safely (Land Transport Road User Rule SR2004/427). There is currently no legal minimum age to cycle on the road, although New Zealand Police recommend that children under the age of 10 should not ride on the road unsupervised, while the NZ Transport Agency state that children may be ready to ride on the road unsupervised from age 11 (NZTA, 2013; NZ Police, 2017).

In 2014, a petition to legalise footpath cycling by children was considered by the Transport and Industrial Relations Committee. It argued that children are not ready to cycle on the road safely and need the opportunity to learn to cycle in a safe environment that is easily accessible (Report of the Transport and Industrial Relations Committee, NZ House of Representatives 2017).

The current proposal is to change the road rules to allow the use of wheeled devices on footpaths. The proposed option is to change the current rules to allow people of all ages to use vehicles on the footpath as long as they:

- are operated in a courteous and considerate manner, in a way that does not constitute a hazard, and gives right of way to pedestrians,
- do not travel faster than 15km/h (to ensure safety to other users sharing the footpath), and
- are not wider than 750mm (to enable multiple users to still access the footpath).

As part of the policy development and to inform public consultation, a cost-benefit analysis has been carried out to evaluate the proposal as set out above. Data to carry out the cost-benefit analysis is limited, and assumptions have to be made to quantify and monetised the benefits and costs involved.

Literature review

To assist in the cost-benefit analysis a number of research studies were reviewed to identify the costs and benefits of cycling on footpaths.

Costs

The greatest cost relates to the number of crashes and severity of injuries that result from allowing all-age cycling on footpaths and whether there would be a subsequent decline in crashes and injuries if cycling is allowed on footpaths.

The NZ Transport Agency commissioned a study of footpath cycling rule options. Abley Transportation Consultants (2016) carried out the study and, in their report, they reviewed the academic literature on cycling and footpath safety. The report stated as follows:

> "NZ Transport Agency Crash Analysis System (CAS) and the NZ Injury Query System (NIQS) data were used to understand footpath cycling crashes in NZ. A major limitation of the available data is the lack of cycling volume data for footpath and road cycling, which would allow the respective crash rates to be estimated. Another limitation is that the categorisation of on-road and footpath cycling crashes can sometimes be difficult and there is no clear definition for crash location."

> "Nevertheless, CAS data showed footpath cycling crashes accounted for approximately 10% of the reported cycle crashes in New Zealand in the last 10 years. Almost all cycling fatalities have resulted from cycling on the road."

> "The CAS data showed that the number of footpath cycling crashes involving a pedestrian was less than 2% of the total footpath cycling crashes. There were no fatal injuries involved in these crashes. The majority of the crashes involved visibility issues between cyclists and pedestrians. However, the NIQS data showed there is likely to be high under-reporting of both pedestrian and cycling crashes (i.e. the Police do not attend all of these crashes occurring in the road reserve). The CAS and NQIS data did show consistency in that pedestrians typically sustain more injuries than cyclists in a pedestrian/cycle crash."

> "Young people (under 16 years old) feature most prominently in the cycling crash statistics for both on-road and footpath crashes, which may partially reflect the higher levels of cycling by younger people, but perhaps also a lack of experience and risk perception. For younger cyclists, a false sense of security may be associated with some footpath cycling, perhaps with some risks being less obvious than those on the road." (Abley Transportation Consultants, 2016).

The Abley Transportation report (2016) concluded that ideally pedestrians, cyclists and motor vehicles should be separated, but as this is currently unfeasible on most roads, providing particularly vulnerable cyclists the option of riding on the footpath when necessary and allowing organisations to legally train children to ride safely on footpaths would improve cycle safety overall. The final recommendation was to allow children 12 years and under (and any accompanying adults) to cycle on the footpath. On considering this report and other evidence, the Select Committee Review agreed with this recommendation.

A further limitation in the evidence presented was that there were no studies on the speeds of children cycling on the footpath. Higher speeds increase the risk and severity of collisions, and harm, both in terms of injury and reductions in perceived safety, to pedestrians.

Following the publication of the Abley Transportation study, research was carried out to address the matter of cycling speeds on footpaths. Randal, Baland and Keall (2018) measured the speed of children currently cycling on footpaths in Wellington, along with speed measurements of children legally riding scooters on footpaths as a comparison.

The study involved observing children 12 years and under cycling or riding scooters on their way to or from four schools in Wellington City. The study observed children from two primary schools (years 1 to 6), one full primary school (years 1 to 8) and one intermediate school (years 6 to 8), during July and August 2017. These schools were chosen to ensure children observed were not older than 12 years of age. The observation sites near the schools were selected to observe behaviour on both flat and sloped roads (to get a fairer measure of speeds) and various control measures were used to ensure the validity of the results. Results were collated and the difference in mean speeds between scooter-riders and children on bicycles was then assessed for statistical significance using Student's t-test.

A total of 105 children were observed riding a bicycle or scooter on the road or footpath. Of these:

- 77 were riding scooters on the footpath
- 25 were riding bicycles on the footpath
- 3 were riding bicycles on the road.

Overall, there was no significant difference (p=0.569) between the average speed of scooter riders and cyclists on the footpath, with average speeds of 10.9km/h and 10.2km/h respectively. Children cycling on the road appeared to travel the fastest, with an average speed of 16.6km/h, although the estimated average is imprecise because of the very small sample size. Mean and median speeds of observed scooter riders and cyclists on the road and footpath are shown in Table 1 below.

Table 1: **Average speeds of scooter riders and cyclists**

Travel mode	Footpath/Road	Observations	Mean speed (km/h)	Median speed (km/h)
Scooter	Footpath	77	10.9	9.6
Bike	Footpath	25	10.2	9.3
Bike	Road	3	16.6	23.6

Source: Randal, Baland and Keall (2018).

While acknowledging the limitations of their study, the researchers concluded that based on the observations of speeds, allowing children 12 years and under to cycle on footpaths is unlikely to impose increase injury risk of pedestrians beyond that already imposed by children riding a scooter.

In Australia, MRCagney (2018) prepared a discussion paper for *Victoria Walks* to inform the debate in response to calls from some cycling organisations for changes to road rules to allow all-ages cycling on footpaths in Victoria.

The study addressed whether footpath cycling would increase the safety risk for people walking. MRCagney (2018) reviewed a number of Australian (Victoria, New South Wales, and Queensland) and UK studies. In their overall assessment MRCagney (2018) state that there is clear evidence that people walking and cycling on footpaths generally travel at very different speeds introducing a safety risk. They go on to state that:

> *"While pedestrian-cycle collisions are rare events and account for a very small proportion of total injuries to pedestrians and cyclists in road environments, these collisions do have the potential to result in serious injury or even fatality. The review of evidence suggests that pedestrians (rather than cyclists) and elderly pedestrians are most at risk from injury from pedestrian-cycle crashes. If a rule change were to result in increased cycling activity on footpaths, there are risks of negative safety impacts for people on foot."* (MRCagney, 2018)

The MRCagney (2018) also reviews whether all-ages footpath cycling is likely to reduce safety risks for people cycling. They came to the conclusion that there is no clear evidence that cycling on footpaths is safer than cycling on streets.

The impact on the functionality of footpaths was considered and they express the opinion that increased cycling is likely to be incompatible with successful multi-functional footpath spaces particularly in activity centres and city centre locations.

It is important to note that the above concerns raised in the MRCagney (2018) report are based on very limited empirical evidence and this is acknowledged by the authors.

There are also a number of studies that have investigated the pedestrian-cyclist collision risk on shared paths. A study by the NSW Roads and Traffic Authority with Taverner Research (2009) of 10 shared path locations in Sydney, Newcastle and Wollongong over a total of 672 observation hours observing 51,031 pedestrians and 12,319 bicyclists, concluded that the perception of danger is much greater than the actual risk to bicyclists and pedestrians on shared paths. They observed only five near miss incidents and no actual contact between bicyclists and pedestrians.

A report by Drummond (1989) concluded that the problem of casualties due to collisions between cyclists and pedestrians on footpaths was very small such that it need not be considered in the formulation of policy.

Trevelyan and Morgan (1993) found that the integration of cyclists and pedestrians on shared paths would largely protect cyclists from vehicle impact injuries without unreasonably enhancing the risk to pedestrians. They proposed that there were no reasons to justify the exclusion of cyclists from pedestrian areas. It was found that pedestrians do not alter their behaviour in the presence of cyclists, but cyclists do adjust appropriately to pedestrian density. The report concluded that collisions between cyclists and pedestrians seldom occur and that a great variety of regulatory and design measures could be taken to ensure the safe and efficient integration of cyclists and pedestrians.

The OECD review paper Safety of Vulnerable Users (1998), concluded that conflicts were generated mainly by narrow footpaths, narrow cycle-tracks, relatively high speeds of cyclists, poor visibility, or considerable age difference between cyclists and pedestrians. Nevertheless, it stated that few conflicts were dangerous, but the damage increased when several of the factors mentioned are combined.

A paper entitled Research, Development, and Implementation of Pedestrian Safety Facilities in the United Kingdom by Davies (1999) raised concerns about the safety of shared pathways, in particular where footpaths have been converted into shared facilities. It provides research which suggests that clear linear separation or grade separated paths between walking and cycling tracks would reduce the conflict and make the paths safer for vulnerable users such as the visually impaired.

Grzebieta, McIntosh and Chong (2011) investigated the pedestrian-cyclist collision risk on shared paths. The three objectives of the study were to quantify:

(a) the number of fatalities resulting from bicycle-pedestrian impacts in Australia;

(b) the number of injuries in NSW;

(c) The risk of fatalities and injuries, and contextualise this risk by comparing it to other risks events, e.g. lightning strike, plane crash etc.

They undertook two related studies. The first study determined the number of fatalities resulting from a cyclist impacting a pedestrian for the whole of Australia. The second study assessed the number of injuries to pedestrians in NSW. The risk of a fatality and injury in NSW was also assessed and compared to other risk events. A preliminary analysis of bicycle speeds using Global Positioning System (GPS) data from cyclists was also carried out to determine average speeds of cyclists on different cycling infrastructure.

The analysis showed that whilst there were a large number of traffic related cycling deaths and pedestrian deaths (over the five-year period), there were only four fatalities due to cyclists-pedestrian collision for the period 2001 to 2006. In all four fatalities the pedestrian died as a result of the impact. No cyclist fatality was recorded resulting from a cyclist crashing into a pedestrian.

Taking into account the above statistics and estimated number of people cycling, the risk calculated was extremely low. For Sydney over the five-year period the risk of a pedestrian being struck by a cyclist was in the order of 1 in 75 million trips. Using an alternative method, the risk was estimated at 0.05 fatalities per million persons. This comparison indicates that the risk of a pedestrian being struck down by a bicyclists and killed is less than the risk of being struck by lightning (0.1 chances of fatalities per million person years), 23 times less likely than tripping on a footpath or roadway (1.15 chances of fatality per million person years), 200 times less likely than being involved in an airline crash (10 chances of fatality per million person years), and 700 times less likely than being struck and killed by a motor cycle (35 chances of fatality per million person years).

For the 5-year period 2000/01-2004/05 there were 163 pedestrian hospital admissions resulting from pedal cycle collisions, accounting for 7.6% of all pedestrian injuries. The majority of the injuries appear to be head and superficial injury of the lower leg. In terms of risk this is 163 injuries per 75 million trips, or approximately 1 injury in every 460,000 trips. In person years, this represents 8.2 pedestrians injured per million-person years. This appears to be an event which is around 8 times greater than tripping on a footpath and killing yourself as a result and just slightly risker than being killed in an airline crash event. In other words, it is still a very low risk event. The recorded speed of cyclists was around 21km/h.

Based on the above analysis the authors state that the risk of a fatality resulting to a pedestrian collision is presently a very rare event for the whole of Australia. With respect to hospitalisation injuries there appears to be on average around 33 people admitted to hospital every year in NSW. The number of hospitalisation injuries in Australia is most likely well in excess of 100 people per annum. The authors acknowledge that numbers are likely to be an underestimate due to under-reporting and recording. Nevertheless, the authors state that the risk of a pedestrian being injured as a result of an impact with a cyclist is a low risk event. They recommend that the speed of shared pedestrian-cyclists pathways be reduced to 10km/h to mitigate potential conflicts particularly with elderly citizens.

The research concludes that "the costs of any initiative introduced needs to account for the very low risk of the collision event occurring and weighed against the substantial health benefit gains resulting from increasing bicycling activity." The researchers do caution that this conclusion might

change due to the ageing population, increase in cycling activity and the demand by local government for shared pedestrian-cyclists footpaths in an attempt to increase physical activity.

The most substantial Australian research into the safety of footpath cycling took place in Victoria in the late 1980's. It began with an observational study of cyclist exposure patterns on arterial and non-arterial roads and footpaths, the results of which were compared with Police-reported casualty crash data to estimate crash risks. For riders aged under 11 (for whom this behaviour was legal), almost half of the riding occurred on the footpath, compared to about 20% of riding by those aged 18 and over.

The estimated risk of a police-reported casualty crash per billion seconds of cycling was higher on the road than on the footpath for riders of all ages, and ranged from 1.5 for children on non-arterials to 6.8 for adults on non-arterials. The risks of riding on the footpath were approximately double for children and adolescents as for adults. Based on a Victorian telephone survey asking about cycling behaviour if footpath cycling was legalised, it was concluded that a minimum reduction of approximately 160 crash involvements of current cyclists per year could occur if footpath cycling was legalised. However, the report cautioned that the actual effect on numbers of Police-reported crashes would be lower due to under-reporting of crashes and that it was difficult to estimate the extent to which legalising footpath cycling might attract current non-cyclists to cycling, thus diluting any crash reductions.

There is little published data available regarding the effects of footpath cycling on pedestrian safety. Drummond (1989) examined the records of admitted patients and those treated in emergency departments at eight hospitals in Victoria. The study identified only two pedestrians who were injured as a result of a collision with a cyclist on a footpath (and two potential additional cases where actual location could not be determined) during the period 1 April to 20 December 1987. The study concluded "pedestrian casualties" resulting from collisions with cyclists on the footpath are a relatively small problem but cautioned that it could not measure the number of pedestrians whose injury was too slight to require hospital treatment or the reduction in amenity to pedestrians caused by concerns about potential collisions with cyclists.

Australia-wide hospital data for land transport accidents provides limited but more recent information on injuries associated with footpath cycling (Henley and Harrison, 2009). In the financial year 2006-07, 103 (2.3%) hospitalised pedal cyclists were coded as injured on "footpath next to road", compared with 105 on a cycleway, 2,248 on a roadway, and 1,548 with unspecified place of occurrence. In the same year, 27 pedal cyclists were hospitalised for a total of 59 days as a result of a traffic accident where the counterpart in the collision was a pedestrian or animal (whether on the footpath or on the road). This corresponds to 0.5% of hospitalised cyclists and 0.4% of cyclists bed-days as a result of a traffic accidents. There were 42 pedestrians hospitalised for a total of 230 bed-days as a result of a traffic accident where the counterpart was a pedal cyclist (whether on the footpath or on the road). This corresponds to 2.8% of hospitalised pedestrians and 1% of pedestrian bed-days from traffic accidents. Data from the Queensland Trauma Registry from 2005 to 2009 showed that of the 2,300 cyclists admitted to hospital or died in hospital, only 22 (1%) were coded as having collided with a pedestrian or animal (Queensland Trauma Registry, 2010).

Haworth and Schramm (2010) carried out an online survey between October 2009 and end of March 2010. As can be seen from Table 2 below, 33.9% of respondents reported riding on footpaths, of whom two-thirds ride there reluctantly, regardless of trip purpose. About a third of riders who ride on urban roads also report doing so reluctantly. Most of the riding in other locations occurs by choice.

Table 2:   Percentage of Riders Who Ride in Particular Locations and Frequency and Distance Ridden and Motivation

Location	% who ride here	% who choose to ride here	% who ride here reluctantly	Mean days per week	Mean kms per weeks
Footpath	33.9	11.0	22.9	2.67	9.87
Bicycle path	65.7	55.2	10.5	3.25	37.94
Urban roads	92.6	61.9	29.1	3.89	96.93
Rural roads	37.0	32.9	4.1	2.43	89.07
Velodrome	5.1	4.9	0.2	0.60	16.53
BMX track	1.5	1.3	0.1	0.24	1.20
Skate park	0.9	0.8	0.1	0.14	0.75
Off-road/dirt	28.0	26.7	1.3	1.38	30.93
Other	2.6	2.4	0.2	0.84	32.35

Source: Haworth and Schramm, 2010.

The study showed that new riders were more likely to ride on the footpath than continuing or other riders (see Table 3).

Table 3:   Percentage of New, Continuing and Other Riders Who Ride in Particular Locations

Location	% who ride here			% who choose to ride			% who ride reluctantly		
	New	Continuing	Other	New	Continuing	Other	New	Continuing	Other
Footpath	39.5	32.1	33.1	17.4	9.3	9.3	22.0	22.8	23.8
Bicycle path	68.6	65.2	64.5	61.9	53.1	54.2	6.7	12.1	10.3
Urban roads	89.5	92.8	91.0	54.0	66.8	58.7	35.4	26.0	32.3
Rural roads	26.2	42.4	64.7	22.2	38.0	31.1	4.0	4.4	3.6
Velodrome	3.8	6.7	3.2	3.6	6.4	3.0	0.2	0.2	0.2
BMX Track	0.8	1.9	1.1	0.8	1.7	1.1	0.0	0.2	0.0
Skate park	0.2	1.3	0.9	0.2	1.0	0.9	0.0	0.2	0.0
Off-road/dirt	16.7	34.6	24.0	15.3	33.3	22.5	1.5	1.1	22.5
Other	0.8	3.4	2.4	0.6	3.3	2.1	0.2	0.1	0.3

Source: Haworth and Schramm, 2010.

A larger proportion of the distances ridden by new riders was on footpaths (6.5%) than for continuing (3.9%) or other (4.5%) riders (see Table 4).

Table 4: **Percentage of Total Distance Ridden That Occurs in Particular Locations for New, Continuing and Other Riders**

Location	% total distance			Mean distance per week (kms)		
	New	Continuing	Other	New	Continuing	Other
Footpath	6.46	3.93	4.49	3.22	3.73	3.10
Bicycle path	29.83	19.43	21.65	25.35	25.46	20.40
Urban roads	46.63	52.63	53.94	65.85	99.03	84.21
Rural roads	10.49	15.34	13.85	19.43	34.80	27.19
Off-road/dirt tracks	3.96	6.87	5.35	4.13	10.50	6.58

Source: Haworth and Schramm, 2010.

However, in terms of the mean distance travelled per week, continuing riders actually rode further on footpaths (3.73 kms) than new riders (3.22kms) or other riders (3.10kms). The analysis of riding location and choice found strong differences according to riding purpose. Utilitarian riders were the most likely to ride on the footpaths, followed by social and then fitness riders (see Table 5).

Table 5: **Percentages of Utilitarian, Social and Fitness Riders Who Ride in Particular Locations**

Location	% who ride here			% who choose to ride			% who ride reluctantly		
	Utilitarian	Social	Fitness	Utilitarian	Social	Fitness	Utilitarian	Social	Fitness
Footpath	51.3	37.4	19.0	17.5	13.4	5.0	33.8	24.0	14.0
Bicycle path	78.9	67.2	54.7	72.7	58.8	40.2	6.2	8.3	14.5
Urban roads	94.7	85.9	90.9	55.6	56.3	68.9	39.1	29.5	22.2
Rural roads	20.6	40.7	48.8	16.9	33.6	45.2	3.6	7.1	3.6
Velodrome	1.5	2.3	9.0	1.4	2.0	8.7	0.1	0.3	0.3
BMX track	1.1	2.0	1.6	1.0	2.0	8.7	0.1	0.0	0.2
Skate park	0.6	1.5	1.0	0.6	1.5	0.8	0.0	0.0	0.3
Off-road/dirt	22.2	35.1	30.3	21.1	33.1	29.1	1.2	2.0	1.2
Other	1.8	1.5	3.5	1.5	1.3	3.5	0.3	0.3	0.0

Source: Haworth and Schramm, 2010.

The study showed that overall, 69.4% of footpath crashes were single-vehicle crashes (involving only the bicycle). Footpath crashes more commonly involved pedestrians (9.7%) than other locations with the exception of bike paths (18.1%). Footpath crashes (like bike path and off-road crashes) resulted in less serious injuries than crashes on urban roads. Head injuries, concussion and internal injuries were less common in footpath crashes than crashes in other locations.

Haworth and Schramm (2010) stated as follows:

"In conclusion, the available evidence suggests that riding on the footpath is associated with less serious injuries to cyclists than riding on the road and does not appear to cause serious injuries to pedestrians. Footpaths are important facilities for both inexperienced and experienced riders and for utilitarian riding, especially in locations riders consider do not provide a safe system for cycling."

Benefits

A number of studies have analysed the health benefits of cycling. In New Zealand, A NZ Transport Agency study carried out by MRCagney (2008) recommended that health benefits of cycling should be included in the Economic Evaluation Manual (EEM) and should be applied in full to new cyclists and existing cyclists. The report recommended that the per km cycling benefit should be $2.14 (based on 2007NZ$).

Krizek (2007) has classified the benefits of cycling and cycling facilities into direct benefits and indirect benefits. Direct benefits refer to the benefits to cyclists, whereas indirect benefits refer to the benefits generated to society as itemised in Table 6 below. According to this classification, direct benefits include health benefits, recreational benefits and the value of time saved. Indirect benefits can be broken down into environmental externalities and industrial benefits.

Table 6: **Classification of the economic benefits of cycling and cycling facilities**

Type		Example
Direct benefits	Health benefits Time saved Recreational benefits	Physical fitness Transport cycling Leisure, tourism
Indirect benefits	Environmental externalities Industrial benefits	Reduction in traffic congestion and air pollution Upstream flow-on benefits (e.g. employment in bike-manufacturing industries) Downstream flow-on benefits (e.g. repair and rental services, eco-tourism industry).

Source: Krizek, 2007.

In terms of health benefits Suh Jungho (2015) cites a number of studies that have documented a myriad of health benefits generated by cycling in terms of reduced risk for cardiovascular diseases, strokes, cancer and type 2 diabetes, and therefore mortality (Borjesson & Eliasson, 2012; Deeniham & Caufield, 2014; Oja, Vuori & Paronen, 1998; Oja el al., 2011; Sahlqvist, Song & Ogilvie, 2012). Oja et al. (2011). The World Health Organisation (2014) meta-analysed the existing literature on the health benefits of cycling and found evidence that there was a strong inverse

relationship between all-cause mortality and cycling as a form of physical exercise. This means that more cycling leads to lower all-cause mortality when other variables remain the same.

The Australian Department of Infrastructure and Transport (2012) reported that the health cost of inactivity in Australia had been estimated at $13.8 billion per year. Borjesson and Eliasson (2012) pointed out that an increase in the number in the number of cyclists may not lead to an increase in health benefits because cycling may be a substitute for other forms of exercise. However, Jungho Suh (2010) states that this point is debatable because active travel is widely promoted as a way for people who do not currently get to incorporate exercise into their daily life (White, Greenland, Hodge, & Bourke, 2014).

A study by Haworth and Schramm (2010) indicates that from a public health perspective, the opportunity to ride on the footpath may act to encourage cycling (particularly among new cyclists) because it is perceived to be less dangerous than riding on the road.

Brook Lyndhurst consultants (2016) analysed the impacts of cycling and walking for the UK Department for Transport (DfT). They state that the "reviewed evidence suggest that the scope for health benefits from walking and cycling interventions are significant, and the potential savings far outweigh the investment costs in most cases. In fact, health benefits alone can outweigh scheme costs and are estimated to comprise between half and three quarters of total monetised benefits".

From their analysis, Brook Lyndhurst, state that physical inactivity contributes directly to illness, and the associated cost to the NHS has been calculated at between £0.9 billion per year (2006-07 prices). Indirect costs add another £8.2 billion per year (2002 prices) to this. They go on to state that US data puts the cost of physical inactivity at an average of $US544 per person per year (2008 prices). Brook Lyndhurst, after reviewing a number of studies state that the health benefits from cycling and walking can be valued in a number of different ways:

Overall, the direct health benefits from a 10% increase in physical activity would equate to £85 million;

- Achieving a 5% cycling mode share in London could generate over £183m per year in financial benefits due to reduced mortality;

- Potential savings to the NHS are £28.30 for each additional cyclist per year;

- Modelling work shows that if the UK could achieve cycling levels similar to Copenhagen, the savings to the NHS would be substantial; between £6 and £27 billion over 20 years;

- If a driver switches to cycling for a 5-km commute (one way) 5 days/week and 46 weeks/year, the health benefit is worth about 1300 £/year;

- For every 100,000-people taking up regular cycling commuting there would be 50 fewer deaths per year, translating into a net benefit of over £50 million (or £82.7m if using statistical deaths).

Cycling as an active transport mode in lieu of walking gives rise to time saving (Ellison & Greaves, 2011; Heesch, Giles-Cori, & Turrell, 2014). Ellission and Greaves (2011) found that cycling is the most competitive mode of transport for distances of up to 5 kilometres in terms of time spent in travelling.

Time has an opportunity cost or scarcity value for each individual, since time is a limited resource. The NZTA Economic Evaluation Manual has monetary values for different modes, including cycling (EEM, 2018).

According to Jungho Suh (2015) the indirect benefits of cycling are generally measured in terms of positive environmental externalities and increased economic activities through industrial linkages. The positive environmental externalities of cycling take place by reducing negative environmental externalities.

Economic Evaluation Manual (EEM)

(a) Crash Values

Unit values of crash costs are provided in Appendix A6 of the EEM for each type of movement category, speed limit, severity and vehicle involvement.

Table A6.4(a) of the EEM specifies the cost per crash by movement and vehicle involvement for fatal crashes in 50km/h speed limit area. For cyclists and pedestrians involved in a fatal crash we consider that it is appropriate to use the cost per crash in this table which is specified as $4.1m (May 2015).

- For serious injury crashes we consider that Table A6.4(b) of the EEM is appropriate for cyclists and pedestrians which is $430,000 (May 2015) for cyclists and $475,000 (May 2015) for pedestrians.

- For minor injuries the costs per crash for cycle is $24,000 (May 2015) and for pedestrian it is $36,000 (May 2015).

- For non-injury crashes the cost for cyclists is $13,000 (May 2015) and for pedestrians it is $700 (May 2015).

Table 7 summarises the EEM values for cyclists and pedestrians.

Table 7:   **Economic Evaluation Manual values for cyclists and pedestrians**

Category	May 2015	July 2018
Cyclist fatal injury	$4.1M	$4.346M
Cyclist serious injury	$430,000	$455,800
Cyclist minor injury	$24,000	$25,440
Cyclist non-injury	$13,000	$13,780
Pedestrian fatal injury	$4.1M	$4.346M
Pedestrian serious injury	$430,000	$455,800
Pedestrian minor injury	$36,000	$38,160
Pedestrian non-injury	$700	$742

Source: Economic Evaluation Manual, 2018.

The CAS data shows that total number of cycling casualties on footpaths as a result of collision with motor vehicles. It can be seen from Table 8 that fatalities are relatively low, serious injuries and minor injuries are around 12 and 57 per annum respectively.

Table 8:   Casualties 2013-2017

Category	Casualties 5-Year Total
Cyclist fatal injury	2
Cyclist serious injury	62
Cyclist minor injury	286

Source: Crash Analysis System (CAS).

We need to assess whether fatal, serious and minor injuries are likely to increase as a result of permitting cycling on footpaths. As discussed in the literature review, permitting cycling on footpaths is not likely to lead to a substantial increase in casualties. However, for this analysis we have adopted a cautious approach:

- Cyclist fatal injury: 1 per annum

- Cyclist serious injury: 12 per annum

- Cyclist minor injury: 57 per annum

The total cost of injuries per annum are shown in Table 9 below:

Table 9:   Cost of injuries to cyclist

Category	Cost Per Annum Million ($)
Cyclist fatal injury	$4.346M
Cyclist serious injury	$5.47 M
Cyclist minor injury	$1.45M
Total	**$11.27M**

Source: Crash Analysis System (CAS).

We do not have data on casualties of pedestrians as result of collision with cyclists, but the literature review indicates that given the low speeds involved there are likely to be no fatal injuries. As discussed in the literature review, the Haworth and Schramm (2010) study showed that, of the total reported injuries on footpaths (72), crashes between pedestrians and cyclists were 9.7% of the total number of injuries (7).

Data from MOH/ACC indicate that over 10-year period serious and minor injuries to pedestrians as a result of collisions with motor vehicles were 37 and 16 per annum respectively. The literature review indicates that cycling on footpaths is likely to have a very minor effect on pedestrians as cyclists travel at slow speeds and injuries are likely to be low. Therefore, we consider that serious

injuries are likely to be 5 per annum and minor injuries are likely to be 10 per annum. The costs are shown in Table 10.

Table 10:   Cost of injuries to pedestrians

Category	Cost Per Annum Million ($)
Pedestrian serious injury	$2.28M
Minor injuries	$0.38M
Total	**2.7M**

Source: Accicent Compensation Corporation (ACC) and the Ministry of Health (MoH).

(b) Vehicle Emissions

Appendix A9 of the Economic Evaluation Manual gives guidance on calculating vehicle emissions such as carbon dioxide and particulate matter. If cycling on footpaths reduces the use of cars, then this benefit needs to be taken into account. The EEM provides guidance procedures on how to calculate emission loads which for our purpose needs to be modified. The approach adopted is as follows:

1. We assume that the speed for light cars that transport children to school and travel to work is on average 50km.

2. We next assume that the average length of light vehicle school and work trip that is likely to be displaced by cycling is 1.5km, as evidence indicates that such trips are likely to be short.

3. We next estimate the diversion rate from light motor vehicles to cycling.

In order to estimate the costs and benefits of permitting cycling on footpaths it is necessary to estimate the diversion from cars to cycling. We do not have either cross-sectional or time-series data and therefore we have to rely on secondary sources to carry out the estimated diversion rate.

The study by Davies et al. (2017) in carrying out a cost-benefit analysis of new cycling infrastructure in Queensland, Australia used diversion rates from the Australian Transport and Assessment and Planning (ATAP)/National Guidelines for Transport System Management (NGTSM). It should be noted that the diversion rates were derived mainly from the New Zealand travel behaviour change appraisal procedures in 2004. That study collated diversion rates from a range of projects in Australia, New Zealand and the United Kingdom. Table 11 shows the diversion rates used in the Davies et al. study. The weighted average diversion rates were 13% for cars and 10% for public transport.

Table 11:   **Trip diversion rates from Brisbane intercept surveys (Australian Transport and Infrastructure Council, 2015)**

Trips from	Diverting to	Diverting to
	Cycling – inner city	Cycling – outer areas
Car	10%	15%
Public transport	20%	0%

Source: Davies, 2017.

The weighted diversion factors of 13% and 10% for cars and public transport respectively are considered far too high for our purposes. It should be noted that the quoted figures are for a purpose built cycling facility and needs to be adjusted downwards for footpath cycling.

In New Zealand the study by Chapman el al. (2018) provides information of diversion rates for two cities in New Zealand (see Table 12). However, like the Australian study the diversion rates arrived at were for dedicated walking and cycling facilities. The study showed that an increase in active trips (both walking and cycling) implied a 5.3% decrease in the relative number of motorised trips. All of the motorised trips replaced by active trips are assumed to be short trips (less than 5km in length), averaging 2.2km. This reduction in motorised trips equates to a 1.21% of total (motorised) vehicle kilometres travelled (VKT). This reduction in car use of zero in 2011, 0.6% in 2012, and 1.21% (ongoing) by year 3 (2013) is a significant input into valuing carbon emission reductions (Chapman et al., 2018).

Table 12:   **Summary of results of the study**

Variable	Estimate
Net increase in non-motorized (active) trips (by 2013 in New Plymouth and Hastings)	30%
Increase in number of non-motorized (active) trips	17.3 million
Decrease in motorized trips	5.3%*
Saving in motorized vehicle-km (VKT) as % of total motorized VKT	1.21%
Saving in annual motorized VKT	4.87 million
Saving in CO_2 emission	1149 tonnes**
Health benefit (per year)	34.5 DALYs, 2 deaths saved

Source: Chapman et al., 2018.

The Haworth and Schramm study (2010) showed that allowing cycling on footpaths resulted in new riders but no information was provided on the diversion rate from cars to cycling. Allowing cycling on footpaths may result in parents allowing their children to cycle to school instead of taking their

children by car to school. It is possible some people who currently drive to work may decide to cycle to work or to 'park and ride' facilities and catch public transport. As we have no primary or secondary data to determine the diversion rate from cars to cycling we adopt a conservative approach and consider that there will be a 1% decrease in motorised trips amounting to approximately 0.25% of total light vehicle kilometres travelled (VKT).

In terms of distance in Km travelled by different modes we use information from the Household Travel Survey (HTS). Table 13 below shows the time and distances of different modes based on the HTS.

Table 13:   Travel Mode Share

Travel Mode	Million Hours Per Year	Million KM Per Year	Million Trip Legs Per Year
Light Vehicles	825	32,865	3751
Pedestrians	143	666	751
Cyclists	22	304	82
PT (bus/train/ferry)	60	1459	158

Source: New Zealand Household Travel Survey, 2017.

Based on the above information the estimated total diverted VKT by light vehicles is approximately 82.2 million km per year.

There are tables that specify vehicle emission by speed and gradient in the EEM. As primary data is not available we use the data in Table A9.5 for light vehicles. For vehicles travelling at 50km/h the values for PM10, NOX, CO and HC are shown in Table 14 below.

Table 14:   Vehicle emission factors by speed at 0 gradient

Speed KM/hr	PM10 g/km	NOx g/km	CO g/km	HC g/km
50km/hr	0.03	0.5	3.0	0.24

Source: Economic Evaluation Manual, 2018.

We multiply the total diverted km travelled by the data in Table A9.5 (Table 14) for the emission factors and Table 15 shows the estimated tonnes.

Table 15:   Estimated tonnes

PM10	NOx	CO	HC
2.47 tonnes	41.1 tonnes	247 tonnes	19.7 tonnes

The total emissions are then valued by the damaged costs as specified in Table A9.1 and shown in Table 16 below. The costs are updated to 2018 by using the EEM update factors.

Table 16: Damage values for use in project evaluations $/tonne

Pollutant	Cost in NZD/tonne 2016	Cost in NZD/tonne 2018
PM$_{10}$	$460,012	$492,213
NO$_x$	$16,347	$17,491
CO	$413	$442
HC	$1,310	1,402

Source: Economic Evaluation Manual, 2018 (adjusted).

The data in Table 15 is then multiplied by the damage values in Table 16. Table 17 shows the estimated values. The total damage values of all pollutants are **$2.1 million per annum**.

Table 17: Damage Values Total Emission Benefits

Pollutant	Cost Million (2018)
PM$_{10}$	$1.22M
NO$_x$	$0.72M
CO	$0.11M
HC	$0.028M
Total	**$2.1M**

The EEM value of CO2 (as at June 2016) is set at $65.58 per tonne (see Appendix A9). For assessment of CO2 emissions, we use the following formula in the EEM (Appendix A9.7) which is:

Light CO2 (in tonnes) = VOC ($) x 0.0009.

For VOC we use the data for light vehicles in Table A5.1 for 50km with zero gradient which is $0.218. As we estimated the car diverted VKT to be 82.2million per year the total light CO2 is 16,128 tonnes. The product of this is then multiplied by the set value of CO2 updated to 2018 which is $70.17 per tonne. The total cost of carbon emission is therefore approximately M$1.13 per annum.

(c) Health Benefits of Cycling

Cycling benefits relate to people that change modes e.g. from private vehicles to cycling (being inactive to active) and these are included in the composite benefit value as shown in Table 18 below. Therefore, a composite benefit of $1.45 per cyclist per kilometre travelled is applied in this analysis. We also assume that there will be a 0.5% increase in cycling trips which we estimate to be approximately 1.5 million extra cycling trips. This amounts to approximately 2.3 million extra

kilometres travelled by cyclists. The total composite benefit is therefore approximately M$3.3 per year.

Table 18:   Economic Evaluation Manual – cycle facility benefits ($cyclist km – 2008)

Benefit	Benefit per cyclist (km)
Health	$1.30
Safety	$0.05
Road traffic reduction	0.10
Composite benefit	**$1.45**

Source: Economic Evaluation Manual, 2018.

(d) Vehicle Operating Costs (VOC) Benefits

As noted above we estimated that 82.2 million vehicle kilometres travelled per annum will be saved. Vehicle operating costs (VOC) is set at $0.218 per kilometre. We estimate that saved VOC is approximately **M$17.92** per annum.

Summary of Costs and Benefits Per Annum

Table 19: **Costs and Benefits of cycling on footpaths**

Costs	$ million per annum	Benefit	$ million per annum
Cyclist fatal injury	$4.346M	Vehicle emission benefit – PM_{10}	$1.22M
Cyclist serious injury	$5.47M	Vehicle emission benefit – NO_x	$0.72M
Cyclist minor injury	$1.45M	Vehicle emission benefit – CO	$0.11M
Pedestrian serious injury	$2.28M	Vehicle emission – HC	$0.028M
Pedestrian minor injury	$0.38M	Vehicle emission – CO_2	$1.13M
		Cycling composite benefit	$3.3M
		VOC benefits	$17.92M
Total Costs	**$13.926M (approx.)**	**Total Benefits**	**$24.428M (approx.)**

The EEM states that a 6% discount rate per annum should be used and we adopt that rate. While the standard time period is set at 40 years, the EEM states for Travel Demand Management (TDM) projects a 10-year period is appropriate. We consider that cyclising on footpaths is more akin to a TDM project and therefore a 10-year period should be adopted. We also keep both the costs and benefits over the 10-year period static.

Conclusion

Using a 6% discount rate and a 10-year period the benefit-cost ratio is approximately 1.75

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