Children on Bicycles – How Safe Are They?

A Report to the Child Injury Prevention Foundation

Rebecca J Bromell, 2016

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Executive Summary

While cycling is encouraged among New Zealand children to combat childhood obesity, it is not without its dangers.

Several factors contribute to a child cyclist's risk of having, or being injured in the event of, an accident.

Child cyclists are required by law to wear a standards approved helmet, but for them to be effective they should be of the right size and worn properly. A child's risk of an accident is also increased if their bicycle is not roadworthy, e.g. ineffective brakes from worn brake pads.

Advice is available regarding the theoretical requirements for safe cycling by children [1]. However, there is a lack of information as to when children can physically cope with the practicalities required under current road rules and regulations. There is also little data published about children's knowledge about these rules and regulations.

This study aimed to explore these various factors.

Children between the ages of 8 and 12 from four primary schools participated in the study. By means of a simple questionnaire information was elicited regarding their riding habits and understanding of basic road rules. Cycle shop staff assessed their bicycles as to roadworthiness and checked their helmets regarding structural soundness, fit and if worn correctly. A practical assessment was then undertaken on a model cycle lane that had been painted on a road adjacent to each school specifically for this study.

Two hundred and ninety-three 8-12-year-old children participated in one or more parts of the study. Complete data – bicycle check, helmet check, questionnaire information and observations from the practical test – were available for 190 children.

Of the 214 helmets that were checked, 41% (87) were deemed 'unsafe' because either the helmet was damaged, worn incorrectly, or there were problems with the straps being either too loose and/or wrongly positioned.

Eighty-five of the 205 bicycles checked (41%) were not considered roadworthy by the cycle shop staff member carrying out the assessment. Of these 85, 75% (31% of all bicycles) were so classified because of worn brake pads (a number of these had other issues also). One bicycle had brakes fitted but the brake cables were not attached. One bicycle had the headset mounted back to front. Thus the handlebars were inserted incorrectly. Both these bicycles had been assembled from kit sets.

Sixty (29%) of the 205 bicycles had badly underinflated tyres.

Of the 200 children for whom there was usable questionnaire data, 91% knew the correct hand signal for a left or right turn. 43% knew the hand signal for stopping. 42% knew both the signals for turning and stopping. 8% (mostly 8 and 9 year olds) did not know any of the hand signals.

Cycling to school

Of the 133 children who said they usually rode their bicycles to school, we have data for 127 as to whether or not their bicycle was considered roadworthy and their helmet judged 'safe' by the cycle shop staff member who carried out the assessment. Of these:

- 75 (59.1%) had either a bicycle that was not considered roadworthy or a helmet that was judged 'unsafe'
- 47 (37.0%) had a bicycle that was not considered roadworthy
- 52 (40.9%) had helmets that were either damaged, not fitted and/or not worn correctly
- 24 (18.9%) had both a bicycle that was not considered roadworthy and a helmet that was judged 'unsafe'.

As regards the ability of the children to complete the practical assessment, 11- and 12-year-olds were significantly better than those aged 8-10 ($p<0.0001$).

In this sample, 40.9% of the 127 children aged 8-12 who usually ride to school are wearing helmets that are unsafe because of damage, or potentially ineffective because of the way they are being worn. 37% are doing so on bicycles that have problems that cycle shop staff consider render the cycle 'not roadworthy'. The single biggest reason was brake pads that were worn to the extent that they would impede the child's ability to make an emergency stop. It is therefore recommended that parents regularly check that both their child's helmet and bicycle are 'fit for purpose'.

There are a number of organisations that either deliver programmes through schools or advice to parents designed to enable children to cycle safely. For example, Transport for Christchurch offer schools a Child Safe programme (http://www.tfc.govt.nz/travel-by/bike/cycle-safe-programme-schools/). This targets Year 6 students and the programme includes:

- Cycle maintenance
- Correct fitting of helmets
- Basic cycling skills.

Others include Bikes In Schools – a programme provided by The Bike On New Zealand Charitable Trust (http://bikeon.org.nz/bikesinschools.html), Bike Wise (www.bikewise.co.nz/resources/resources-schools), which provides links to resources for teachers and guidance for parents on their website, and Cycling New Zealand (www.cyclingnewzealand.nz).

At present the New Zealand Police and New Zealand Transport Agency recommend that "children under 10 years old cycle on the road only when accompanied by a competent adult rider" (it is not clear how this age was arrived at). While this does not state that 10-year-olds can be allowed to cycle unsupervised, it is not unreasonable for a parent to draw this conclusion. In this study one in four 10-year-olds were not able the practical assessment without losing control of their bicycles or veering out of the cycle lane. This number dropped to one in ten of 11-year-olds.

The findings of this study suggest that there is no specific age at which it can said a young child can be allowed to ride unaccompanied on public roads. Enrolment in cycle skills courses is recommended where these are available. However, parents should not solely rely on these as 'proof' of their child's competence. They should check a few simple things for themselves to help inform their decision. Firstly, does the child know the various hand signals required for safe cycling, and do they understand when and for how long to perform these? Secondly, can the child maintain control of their bicycle and remain within a cycle lane while performing these required hand signals, and then when checking over their shoulder for traffic approaching from behind? There were a few 11 and 12-year-olds who were unable to do so.

Why I did it

While cycling is encouraged among New Zealand children to prevent and reduce childhood obesity, it is not without its dangers. Between 2000 and 2012, 37 children died in cycling related incidents, with 9,192 cyclists between the ages of 0 and 14 being hospitalised for non-fatal injuries between 2000 and 2014 [2]. In 2014, children aged 10-14 made up the highest proportion of cycling injuries/deaths [3]. This age group start cycling alone more frequently, and for a greater distance than before, and thus are at greater risk of an accident. There are approximately 30 cyclist deaths/injuries for all ages reported per million hours cycling, more than double the amount of death/injuries reported when using a large vehicle. The number of cycling accidents has stayed fairly constant since the 1990s [4].

Several factors contribute to a child cyclist's risk of having, or being injured in the event of, an accident.

While child cyclists are required by law to wear a standards approved helmet, for them to be effective they should be of the right size and worn properly. A child's risk of an accident is also increased if their bicycle is not roadworthy, e.g. ineffective brakes from worn brake pads.

Advice is available regarding the theoretical requirements for safe cycling by children [5]. However, there is a lack of information as to when children can physically cope with the practicalities required under current road rules and regulations. There is also little data published about children's knowledge about these rules and regulations.

This study aimed to explore these various factors.

What I did

Primary schools in Alexandra (2), Omakau (1) and Clyde (1) were contacted to gauge interest in taking part in the study. They all agreed to participate. All schools run from Year 0 to Year 8. Each principal was visited at their school to determine the best location to execute the study, and to address any questions or concerns. They were provided with information about the proposed study to include in a newsletter and principals obtained parental consent.

The police were approached by the researchers and agreed to assist and provide traffic management at each site. They also made available details about the content of their cycle safety visits to schools.

Central Otago has a large cycling industry due to its links with the Otago Central Rail Trail. Two cycling companies agreed to come and perform the bicycle checks for the trial: SheBikesHeBikes from Omakau and BikeItNow from Clyde.

The study focussed on children aged 8-12. Initially the age range was from 6 to 12, however after a pilot run at Omakau School it was decided that age 8 was a more appropriate age at which to start the study.

At each school, children were assigned a number in order to match data from different recordings. At Omakau, The Terrace and Clyde Schools this was as a sticker; at Alexandra Primary school this was pre-designated and most children had their numbers written on their hands. Children and their bicycles were evaluated according to a questionnaire, a helmet and cycle check and a practical assessment.

Questionnaire

Conducting the questionnaire at Clyde School

Children were individually asked a questionnaire with the following questions:

- Their age: at Omakau School this was recorded as 6-8, 9-10, 11-12; at the other schools individual ages were recorded and the lower cut-off changed to 8 years of age. Children aged 13 were allowed to participate but results were not counted
- Whether they are left or right handed
- How often they ride their bicycle: every day, several times a week, less than that, or hardly ever
- Whether or not they usually ride their bicycle to school

- Whether they most commonly ride their bicycle alone, with other children, or accompanied by adults
- Whether or not the bicycle they were riding on the day was their own bicycle: some children borrowed bicycles from classmates or family members[i]
- To select which out of three options (shown below) is the correct way to wear a helmet



- Whether or not they should usually ride their bicycle on the footpath
- How to indicate to a driver that they are turning a corner, or stopping, and how long to perform these signals for
- Whether or not they should turn in front of cars or other cyclists.

Measures were taken to ensure children did not hear each other's answers, including having children being 'moved' to the questionnaire spot one at a time. The questionnaire was also always administered to each child prior to practical assessment, as children were asked to perform hand signals in the practical and this might have artificially boosted the number of correct responses to said questions. At Alexandra Primary School this questionnaire was completed electronically through Google Forms as opposed to manually on the day.

Cycle and helmet check


Checking a bicycle at The Terrace School

A helmet check at Clyde School

Children's bicycles were assessed by cycle shop staff members from SheBikesHeBikes and BikeItNow to see how fit they were to be ridden. At Omakau School, bicycles were assessed as to type – BMX, mountain bike or other – and as being the correct size, too big or too small. They were also assessed as to whether or not they were roadworthy. Since the reasons for the decision were not recorded, and, strictly speaking, a missing rear reflector (which is legally required) means a bicycle is 'not road safe', these results were excluded from the final analysis. For the other 3 schools, bicycle type, size, and the individual components of the bicycles were

[i] At Alexandra School, this question was asked as part of the cycle check due the questionnaire having been administered online beforehand.

recorded as being acceptable or not: seat, handlebars, headset, grips, brakes, wheels, pedals, chain, reflectors, tyre pressure, bell, and gears. For the purposes of the study a bicycle was classified as 'not roadworthy' if:

- The brake pads were worn to the extent that they would impede the cyclist's ability to make an emergency stop
- There was a problem with the headset
- The handlebars were wrongly positioned for the type of bicycle.

Badly underinflated tyres did not of themselves result in a 'not roadworthy' classification though they adversely affect the handling of a bicycle.

It was decided, if bicycle seats or handlebar heights needed adjusting, that this would not be done prior to practical assessment, as it may have made the children less familiar with the feel of their bicycle and affected their riding.

At these 3 schools, helmets were also assessed regarding structural soundness, fit and if worn correctly.

Practical Assessment

A cycle lane (70 metres long and 1.2 metres wide – the minimum legal required width) was painted on a road adjacent to each school by Fulton Hogan, with permission from the Council. Each was on a sealed road section with little to no traffic throughout the school day to ensure safety, while also providing as realistic a road-biking situation as possible. Children were then tested one at a time riding along this model cycle lane (cycle way).

The model cycle lane at Omakau School

On the first run through, children were asked to first attempt to perform a left-hand turning signal for at least 3 seconds, followed by a stop hand signal for at least 3 seconds, as in accordance with the rules of the Official New Zealand Code for Cyclists [6]. Children were not explicitly told they had to stay within the cycle lane, only that they should 'bike down the cycle lane' – this was to check whether or not children knew and were able to keep within the 1.2m width strip. Both hand signals were demonstrated to the children, and both with the left hand, though it should be noted that the right hand is also used for stop signals and may be more easily seen by traffic. Children had been instructed to return to the start for a second run through after completion of the first run.

Signalling a stop at Clyde School

For the second run through, children were asked first of all to, after passing a researcher, look over their right shoulder at them and correctly identify a sign held up by the researcher. (At Omakau and Alexandra schools these were pictures of different vehicles; at The Terrace and Clyde these were cards of different colours. Both the pictures and colours were changed around after each child.) After looking over their shoulder, they continued cycling and attempted to perform a right-hand turning signal for at least 3 seconds.

g from behind
turn

During these runs, children were being assessed on their ability to start biking, to perform left-hand, right-hand and stop turning signals for at least 3 seconds, and to look over their right shoulder and identify a potential hazard, all while maintaining control of their bicycles and without deviating outside the lines of the cycle way.

Oops!

It should be noted that often the phrase ‘for at least 3 seconds’ was not used, as it became apparent that children underestimated how long 3 seconds was. The most effective phrase was to tell them to ‘hold their arm out for a good while and keep going’, or similar words to that effect.

As mentioned earlier, the first school – Omakau – was used as a de facto pilot. Resulting from this a minor change was also made to the practical component of the study. The observer stood further from the start so the cyclist could achieve a faster speed before having to look over their shoulder. To standardise the observation results across all 4 schools the practical portion of the study was repeated at Omakau some weeks later and the results from the first visited discarded. In order to minimise school disruption, bicycle checks etc. were not repeated. Thus it was not possible to match the results of the practical portion of the study with the remainder of the data from that school.

What I found

Two hundred and ninety-three 8-12-year-old children participated in one or more parts the study. Complete data – bicycle check, helmet check, questionnaire information and observations from the practical test – was available from 190 subjects.

Helmet check

Of the 214 helmets that were checked, 41% (87) were deemed 'unsafe' because either the helmet was damaged, worn incorrectly, or there were problems with the straps being either too loose and/or wrongly positioned. In any of these situations the helmet is unlikely to effectively protect the head in the event of an accident.

Bicycle check

Eighty-five of the 205 bicycles checked (41%) were not considered roadworthy by the cycle shop staff member carrying out the assessment. 75% of these (31% of all bicycles) were so classified because of worn brake pads (a number of these bicycles had other issues also). One bicycle had brakes fitted but the brake cables were not attached. One bicycle had the headset mounted back to front. Thus the handlebars were inserted incorrectly. Both these bicycles had been assembled from kit sets.

Sixty (29%) of the 205 bicycles had badly underinflated tyres.

Questionnaire data

Of the 200 children for whom there was usable questionnaire data, 91% knew the correct hand signal for a left or right turn. 43% knew the hand signal for stopping. 42% knew both the signals for turning and stopping. 8% (mostly 8 and 9 year olds) did not know any of the hand signals.

Only 4% of the children knew the correct amount of time a hand signal should be performed for – as stipulated in the Road Code. In answer to this question many children answered 'until I have completed the turn' or 'until I have stopped'.

86% of children said they should not ride their bicycles on the footpath.

3% of children said they were allowed to turn in front of cars or other cyclists.

From the 3 illustrations of helmet wearing, 95% identified the correct option. 4% picked the illustration showing the helmet tipped over the forehead and 1% the helmet shown tipped over the back of the head.

Cycling to school

133 (66.5%) of the children said they usually rode their bicycles to school[ii]. There was no significant difference between the different ages.

Of the 133 children, we have data for 127 as to whether or not their bicycle was considered roadworthy and their helmet judged 'safe' by the cycle shop staff member who carried out the assessment. Of these:

- 75 (59.1%) had either a bicycle that was not considered roadworthy or a helmet that was judged 'unsafe'
- 47 (37.0%) had a bicycle that was not considered roadworthy
- 52 (40.9%) had helmets that were either damaged, not fitted and/or not worn correctly
- 24 (18.9%) had both a bicycle that was not considered roadworthy and a helmet that was judged 'unsafe'.

[ii] For three of the schools, every child who had access to a bicycle was asked to bring it to school on the day of the assessment. Unfortunately, at the fourth school, owing to a mix-up in communication, only the children who had ridden their bicycle to school as usual were available for testing that day.

Nine of the 75 (12%) had an unsafe helmet, a bicycle that was not roadworthy and were cycling on badly underinflated tyres. This group made up 7.1% of the children who usually ride to school.

There was one 9-year-old child who had an unsafe helmet, rode a bicycle with more than one feature that rendered it not roadworthy and had badly underinflated tyres.

102 (51%) said they rode their bicycle every day. 27% reported riding 2-3 times a week, 15% less often than that and the remaining 9% said they hardly ever rode their bicycle.

Cycling ability

The ability of the children to complete the practical assessment by age is shown in Table 1.

Table 1. Practical assessment by age

Age	**8**	**9**	**10**	**11**	**12**
Total no.	43	49	43	44	45
No. completing assessment safely	32	33	33	40	42
%	74.4%	67.3%	76.7%	90.9%	93.3%

A chi-squared analysis found the strongest significant correlation was between the children aged 8-10 years and those 11-12 years old ($p<0.0001$). 8 and 9 year olds compared to 10-12 year olds was also significant ($p=0.0023$).

Children who rode their own bicycles (176) were significantly better at performing the practical assessment than those on borrowed bicycles (48) – 85.2% vs 62.5% ($p=0.0009$).

Children who usually rode to school (133) were significantly better at performing the practical assessment than those who did not (67) – 91.0% vs 67.2% ($p<0.0001$). Nevertheless 12 children (9.0%) of those who usually bicycle to school were unable to perform the practical assessment without losing control of their bicycles or veering out of the cycle lane.

Children who rode their bicycles every day were significantly more able to perform the practical assessment compared to those who rode their bicycles a few times a week or less (82.8% vs. 55%, $p<0.0001$).

There was no statistically significant difference between left- and right-handed children at performing the assessment. When breaking down the assessment into ability to perform a left-handed or a right-handed turn, again no statistical difference was found between left- and right-handed children. Both sets of children were better able to perform the hand signal components of the test than to bicycle safely while looking over their shoulder.

Children at all four schools receive cycle safety and riding lessons. These are delivered by a local police officer who is the area school community officer and a dual trained level 2/3 cycle instructor. He advised that the lessons were provided “dependent on local needs assessments”.

What it means

40.9% of the 127 children aged 8-12 who usually ride to school are wearing helmets that are unsafe because of damage, or potentially ineffective because of the way they are being worn. In the majority of cases the problem was that that straps were too loose and/or did not form a V under the ears. In a study by Hagel et. al (2010) [7] it was found that 20% of children aged under 13 years wore their helmets incorrectly. Their most frequently observed error was the helmet sitting too far back on the head. A case control study by Romanow et. al (2012) into cyclist head and facial injury risk in relation to helmet fit concluded that an incorrectly worn or fitted helmet had an increased odds ratio of head injury of 3.38 [8].

A simple video that shows the correct way to fit a child cycle helmet is available from SafeKids Worldwide (http://www.safekids.org/video/bike-helmet-fit-test).

A fit test sheet is also provided. See Appendix A.
[http://www.safekids.org/sites/default/files/documents/Helmet%20Fit%20Test%202013.pdf]

Two New Zealand studies have looked at the safety benefits of wearing a helmet [9,10]. In these studies, the proportion of head injuries to non-head injuries over time was examined against the observed rate of helmet use. Both studies used Land Transport Safety Authority (LTSA) data which was obtained from observation studies of children cycling to school. The assumption was made that the helmets worn were the correct size, and properly fitted and worn. The findings of our study – that around 40% of children wore helmets that would not provide maximum protection in the event of an accident – would suggest that such studies have underestimated the safety benefits.

Cycle helmet wearing rates based on observation have also been used to calculate potential cost-benefits [11]. In that study, the cost of the lifetime provision of helmets for the cycling population was compared to the potential savings, as a result of helmet wearing, in hospital costs of treating skull fractures and intracranial injuries. The number of events expected to be prevented was estimated according to the findings of two overseas studies [12,13]. The first – a population wide survey – compared increase in helmet use over time with the decrease in the number or serious head injuries. The second – a case control study – compared the risk of a serious head injury to a cyclist wearing a cycle helmet with that of a non-helmet wearing cyclist. Again each study assumed that the helmets were 'safely' worn, thus leading to an underestimation of the potential savings in the cost-benefit analysis.

In our study, 37% of the 8-12-year-old children who usually ride to school are doing so on bicycles that have problems that cycle shop staff consider render the cycle 'not roadworthy'. The single biggest reason was brake pads that were worn to the extent that they would impede the child's ability to make an emergency stop. The U.K. Royal Society for the Prevention of Accidents [14] reviewed cycle accidents occurring in 2014. Common causes were a motorist emerging into, or turning across, the path of a cyclist. Both events would require an emergency stop on the part of the cyclist. The fact that 29% of the bicycles tested had badly underinflated tyres – which reduce manoeuvrability – would increase the risk in the above situations.

Given the serious deficiencies noted with two bicycles that had been assembled from kit sets, particular care should be taken that assembly instructions are followed carefully. In some cases, the instructions may be incomplete or difficult to understand so it is recommended that in all situations the assembled bicycle be checked by a cycle shop mechanic. 'Bike-in-a-box' bicycles are available throughout New Zealand from The Warehouse at prices ranging from under $100 to over $1000. The Warehouse website provides three videos to aid the assembly of various types of bicycles. Kmart stores also sell kit set bikes ranging from $69-$109. They provide an assembly service for $19.

There are a number of organisations that either deliver programmes through schools or provide advice to parents designed to enable children to cycle safely. For example, Transport for Christchurch offer schools a

Child Safe programme (http://www.tfc.govt.nz/travel-by/bike/cycle-safe-programme-schools/). This targets Year 6 students and the programme includes:

- Cycle maintenance
- Correct fitting of helmets
- Basic cycling skills.

Others include:

- Bikes In Schools – a programme provided by The Bike On New Zealand Charitable Trust (http://bikeon.org.nz/bikesinschools.html)
- Bike Wise (www.bikewise.co.nz/resources/resources-schools), which provides links to resources for teachers and guidance for parents on their website
- Cycling New Zealand (www.cyclingnewzealand.nz).

At present the New Zealand Police and New Zealand Transport Agency recommend that "children under 10 years old cycle on the road only when accompanied by a competent adult rider" [15,16] (it is not clear how this age was arrived at). This recommendation has been picked up by SafeKids [17]. While this does not state that 10-year-olds can be allowed to cycle unsupervised, it is not unreasonable for a parent to draw this conclusion. In this study one in four 10-year-olds were not able to perform the practical assessment without losing control of their bicycles or veering out of the cycle lane. This number dropped to one in ten of 11-year-olds. As expected the more often a child rode their bicycle, so the more competent they were at the assessment. Caution should be exercised when allowing children to ride on public roads on borrowed bicycles since in our study these children were less competent at performing cycling manoeuvres.

The findings of this study suggest that there is no specific age at which it can be said a young child can be allowed to ride unaccompanied on public roads. Enrolment in cycle skills courses is recommended where these are available. However, parents should not solely rely on these as 'proof' of their child's competence. They should check a few simple things for themselves to help inform their decision. Firstly, does the child know the various hand signals required for safe cycling, and do they understand when and for how long to perform these? In our study, the majority of children knew the hand signals for a right and left turn. Less than half knew the correct hand signal for stopping, and only 4% were aware of the length of time the signal should be displayed. Secondly, can the child maintain control of their bicycle and remain within a cycle lane while performing these required hand signals, and then when checking over their shoulder for traffic approaching from behind?[iii] There were a few 11 and 12-year-olds who were unable to do so. Arnberg et. al (1978) tested 144 children between the ages of 5-13 for their ability to perform a number of skills deemed important to ensure safe cycling in traffic situations. They found that it was only the 13-year-olds who could manage all the tests well [18].

[iii] We chose the ability to perform hand signals and to check for traffic approaching from behind as the practical tests since these are basic to safe cycling on public roads [19]. Furthermore, in a comprehensive assessment of the cycling skills of 9- and 10-year-olds, these manoeuvres caused the most difficulty in maintaining control [20].

Conclusions and Recommendations

- It cannot be assumed that simply providing a cycle helmet and ensuring it is worn means a child will have maximum protection in the event of an accident. Parents should check that the helmet is of the proper size, worn correctly, and in good condition.
- Bicycles require regular maintenance. Obvious things such as tyre pressure and brake pads should be frequently checked.
- There is no specific age at which it can be said a young child can be allowed to ride unaccompanied on public roads. Enrolment in cycle skills courses is recommended where these are available. However, parents should not rely solely on these as 'proof' of their child's competence. They should confirm for themselves that their child is aware of and understands the road rules, and is competent at performing the requisite hand signals and other manoeuvres necessary to cycle safely.

Appendix A

SAFE KIDS WORLDWIDE

Does your helmet fit properly?

Take the Helmet Fit Test

1

Eyes: Put the helmet on your head. Look up. You should see the bottom rim of the helmet.

2

Ears: Make sure the straps form a 'V' under your ears when buckled. The straps should be a little tight but comfortable.

3

Mouth: Open your mouth as wide as you can. Does the helmet hug your head? If not, tighten the straps.

Now you're ready to roll!

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