Bicycle helmet use in Canada: The need for legislation to reduce the risk of head injury

Brent E Hagel, Natalie L Yanchar; Canadian Paediatric Society, Injury Prevention Committee
Paediatr Child Health 2013;18(9):475-80
Posted: Nov 1 2013

Abstract
Bicycling is a popular activity and a healthy, environmentally friendly form of transportation. However, it is also a leading cause of sport and recreational injury in children and adolescents. Head injuries are among the most severe injuries sustained while bicycling, justifying the implementation of bicycle helmet legislation by many provinces. There is evidence that bicycle helmet legislation increases helmet use and reduces head injury risk. Evidence for unintended consequences of helmet legislation, such as reduced bicycling and greater risk-taking, is weak and conflicting. Both research evidence to date and recognition of the substantial impact of traumatic brain injuries support the recommendation for all-ages bicycle helmet legislation.

Key Words: Bicycle helmet; Head injuries; Legislation

Bicycling is a popular activity and form of transportation in Canada for children, adolescents and adults. The percentage of children that have ridden a bicycle at least once in the past 12 months is 91% for children five to 12 years of age and 77% for youth 13 to 17 years of age.[1] While the physical activity associated with riding a bicycle can have significant health benefits, injuries can and do occur.

Bicycling injuries
Bicycling-related injuries among Canadian children and youth account for approximately 4% of all injuries encountered in the emergency department (ED),[2][3] 7% of all hospital admissions for unintentional injury for those younger than 15 years of age,[4] and are the fifth-leading cause of child and youth hospitalization (2079 in 2001/2002).[5] In terms of mortality, they comprise 5% of all deaths due to unintentional injury for children younger than 15 years of age in Canada.[4] Between 30%[6] and 53% of bicycling fatalities occur in children and youth, with most resulting from collisions with motor vehicles.[7]

There are large variations in population-based rates of bicycling-related injuries due to several factors. Adolescents, particularly males, have the highest rates of bicycling-related injuries involving motor vehicle collisions, ranging from 28 to 56 per 100,000 population.[6][9] Rates of hospitalization for children and youth range from 33.9 injuries per 100,000 in urban areas to 50 injuries per 100,000 in rural areas.[10] Overall death rates in Canada are estimated to be 0.27 per 100,000 population.[6]

Bicycling-related head injuries
Head injuries rank among the most severe injuries in bicyclists, representing 20% to 40% of all bicycling injuries encountered in Canadian EDs.[2][3][7][14] Considering only hospital admissions, head injuries represent approximately one-half of all bicycling injuries in children and youth.[11][15] Ultimately, head injuries account for 45% to 100% of child and youth bicycling deaths.[16][20] Therefore, head injuries represent the most severe injuries that occur among child and youth bicyclists and, as such, are an important target for injury prevention.

Helmet use and head injury risk
Two systematic reviews have demonstrated that helmets reduce the risk of head injuries while cycling.
In one Cochrane review, helmets were estimated to reduce the risk of head and brain injuries by 69%, severe brain injuries by 74% and facial injuries by 65%, with similar effects for cyclists in collisions with motor vehicles and across all age groups. Another study found that helmets reduced head injury risk by 60%, brain injury risk by 58%, facial injuries by 47% and fatal injury by 73%. The latter study did note an indication of greater risk of neck injuries among helmet users (OR 1.36 [95% CI 1.0 to 1.86]), which “…may not be applicable to the lighter helmets currently in use.” Investigators concluded that their results were “applicable to riders of all ages, both in less severe crashes, and in collisions with motor vehicles.” A reanalysis of this study in 2011, which included more recent studies and adjustment for potential sources of bias, confirmed the protective effect of helmets on head injuries and facial injuries, although the effects were attenuated.

**Helmet legislation and helmet use**

Systematic reviews have also demonstrated that legislation increases the use of helmets in children and youth. One review showed that bicycle helmet use increased postlegislation, with more than one-half of the included studies demonstrating an increase of at least 30%. The odds of helmet use more than quadrupled with legislation, and this effect was consistent for areas with legislation for riders younger than 16 years of age and in areas where all-ages legislation was in place. Similarly, a Cochrane systematic review of child and youth bicycle helmet legislation found a significant increase in helmet use both postlegislation and with enforcement of existing legislation.

Many of the studies examining the association between helmet use and bicycle helmet legislation in Canada have found increases in the postlaw period (Table 1). One Ontario study noted a 20% increase in helmet use among children five to 14 years of age two years after passage of helmet legislation covering riders younger than 18 years of age, demonstrating larger increases in low- and middle-income areas. A follow-up study found that helmet prevalence fell to prelegislation levels for low- and middle-income areas while remaining elevated in high-income areas six years postlegislation. After the introduction of all-ages bicycle helmet legislation in 1996 in British Columbia, helmet use increased 18% among children younger than six years of age and 26% among riders six to 15 years of age. Another study found that helmet use increased 35% among children, 41% among adolescents and 50% among adults after all-ages legislation passed in Nova Scotia. Helmet use increased from 72% to 95% among children younger than 13 years of age and more than doubled among adolescents after helmet legislation covering riders younger than 18 years of age came into effect in Alberta. Based on national Canadian Community Health Survey self-report data, a recent study has found the likelihood of helmet use to be greatest in provinces with all-ages legislation, followed by regions with laws covering riders younger than 18 years of age, and lowest where there is no helmet legislation; these trends were evident for both adolescents and adults.
<table>
<thead>
<tr>
<th>Author [reference], year</th>
<th>Age group covered</th>
<th>Year implemented</th>
<th>User prevalence Prelegislation</th>
<th>Postlegislation</th>
<th>Postlaw increase</th>
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<td>Prelegislation</td>
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<td>Total: 46% in 1995</td>
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<td>Total: 20% (1997)</td>
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<td>Parkin et al [26], 2003</td>
<td>&lt;18 years of age</td>
<td>1995</td>
<td>LI: 5–14 years of age:</td>
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<td>Total: 66% in 1997</td>
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<td>Macpherson et al [27], 2006</td>
<td>&lt;18 years of age</td>
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<td>LI: 33% in 1995</td>
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<td>HI: 84.5% in 2001</td>
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<td>Total: 46% in 1995</td>
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<td>5–14 years of age:</td>
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<td>HI: 11.4%</td>
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<td>All ages</td>
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<td>1–5 years of age:</td>
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<td>60% in 1995</td>
<td>78% in 1999</td>
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<td>6–15 years of age:</td>
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<td>35% in 1995</td>
<td>61% in 1999</td>
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<td>16–30 years of age:</td>
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<td>47% in 1995</td>
<td>69% in 1999</td>
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<td>Adolescent: 29% in 1995/1996</td>
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<td>Child: 84% in 1998/1999</td>
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<td>Adolescent: 70% in 1998/1999</td>
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<td>Karkhaneh et al [30], 2011</td>
<td>&lt;18 years of age</td>
<td>2002</td>
<td>&lt;13 years of age:</td>
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<td>72% in 2000</td>
<td>95% in 2006</td>
<td>23%</td>
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<td>13–17 years of age:</td>
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<td>30% in 2000</td>
<td>63% in 2006</td>
<td>33%</td>
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LI Low income; HI High income; MI Middle income

**Helmet legislation and head injuries**

Of the three studies included in a systematic review examining changes in head injury risk pre- and postlegislation, two indicated a statistically significant reduction in risk and one a nonstatistically significant reduction in risk.[32] A Canadian study compared time trends in head injury rates among children and adolescents five to 19 years of age between provinces that had introduced legislation with those that had not. While their head injury rates were similar before legislation (approximately 18 per 100,000 population), these rates fell by 45% in provinces that introduced helmet legislation compared with only 27% in provinces that did not.[32] An Australian study investigating the long-term effects of all-ages bicycle helmet legislation on head and arm injuries in riders younger than 16 years of age[33] found a decline in
rates of hospitalization for bicycle- versus motor vehicle-related head injuries in children postlegislation (3.1% per year), with no evidence of a decline in arm injury hospitalizations. The rate of non-motor vehicle-related child cyclist head injuries was estimated to decrease as well (1.2% per year), a result that was not statistically significant.

Two recently published studies reported different conclusions regarding the association between helmet legislation and head injuries. One compared the population-based rate and proportion of ED and hospitalized head injuries for bicyclists and pedestrians three years before, and four years after, bicycle helmet legislation in Alberta.\[^{34}\] They found significant declines in the proportion of children younger than 13 years of age seen in the ED, and of adolescents (13 to 17 years of age) and adults (≥18 years of age) hospitalized for head injuries, with no declines in the proportion of head injuries for a control group of pedestrians. Another study examined hospitalizations for bicycle-related head injuries Canada-wide from 1994 to 2008.\[^{35}\] Comparing the population-based rate and proportion of head injuries in Canadian provinces that did or did not implement helmet legislation, they were unable to demonstrate a significant association between legislation alone (all ages or children only) and a decline in head injuries, with rates of helmet use and head injuries generally declining in all jurisdiction regardless of legislation status.

Importantly, none of the studies evaluating the effect of bicycle helmet legislation identify whether a helmet was being worn by injured bicyclists. Because it is largely unknown whether cases sustaining head injuries wore a helmet, these studies are weaker than other case-control studies that have firmly established bicycle helmet effectiveness. Also, studies that simply compare jurisdictions with and without helmet legislation are probably affected by other factors associated with helmet legislation, such as educational programs or incentives. Certainly the strongest evaluation of the effect of helmet legislation is whether it affects helmet-use prevalence, with the downstream effect being a reduction in the number and severity of head injuries manifesting from greater helmet use.

**Helmet use and risk compensation**

Debate continues on the general topic of risk compensation (ie, risk homeostasis) in relation to bicycle helmet use.\[^{36}\][^37] The theory suggests that everyone has a target level of risk. Its proponents argue that if an individual's environment is altered to increase safety, they will respond by acting more dangerously to meet their own target level of risk.\[^{38}\] However, the theory also suggests that people often take risks to optimize benefits (eg, gaining time by speeding).\[^{39}\] The evidence for risk compensation and bicycle helmet use among children is mixed. In some studies, parents report they would allow children wearing safety gear, including a helmet, to take more risks.\[^{40}\][^41] Other studies measuring risk tolerance in children suggest a greater willingness to take risks when using safety gear while bicycling.\[^{42}\] Still others have found no relationship between safety gear use and risk tolerance.\[^{43}\]

A crossover trial of an obstacle course comparing conditions involving safety gear and no safety gear found that “children went more quickly and behaved more recklessly when wearing safety gear than when not wearing gear, providing evidence of risk compensation”.\[^{44}\] Adult-based studies have been conflicting, showing that helmeted cyclists tend to be more cautious\[^{45}\] or less cautious\[^{46}\] than nonhelmeted cyclists.

One ED-based study found no evidence of a relationship between use of safety equipment and reported bicycling behaviour (cycling fast, taking chances) or injury severity among children injured in a variety of activities, including bicycling.\[^{46}\] Another found that helmeted bicyclists experienced less severe nonhead and non-neck injuries.\[^{47}\] Injury outcome-based studies involving all age groups have found that helmeted bicyclists experienced more frequent and severe nonhead injuries compared with nonhelmeted bicyclists.\[^{48}\] However, one European study found no relationship between bicyclist commission of a traffic violation and helmet use.\[^{49}\] The issue of risk compensation remains unresolved.\[^{23}\]

**Helmet use and ridership**

A number of reports and studies have examined the argument that helmet legislation may reduce ridership among children and adolescents, thereby contributing to problems associated with decreased physical activity. One Australian study indicated a decline in bicycling associated with helmet legislation implemented in 1990 in all age groups. However, the rates for adults approached prelaw levels after two years, while the decline for children reflected a pre-existing downward trend. The rate for adolescents remained below prelaw levels two years postlegislation.\[^{50}\] Another study noted small but statistically significant declines in youth cycling after
legislation in various states in the United States, based on parent- and youth-reported bicycling behaviour.\[51\] However, an observational Ontario study found no evidence of a decline in cycling activity among children five to 14 years of age after introduction of bicycle helmet legislation.\[52\] While there was significant year-to-year variability in the rate of bicycling at different locations, none could be attributed to the adoption of bicycle helmet legislation. A follow-up study showed the same rate of bicycling prelegislation and six years postlegislation.\[27\] Similarly, Canadian survey data indicate no evidence of a decline in adolescent bicycling in relation to bicycle helmet legislation.\[51\] A decline in the number of observed child and adult – but not adolescent – bicyclists associated with helmet legislation was observed in one Alberta study.\[53\] This inconsistent effect across age groups suggests that other factors aside from the helmet law may be responsible for changes in bicycling.

A related issue is whether all-ages bicycle helmet legislation would negatively influence the implementation of urban community, low-cost bicycle rental or bikeshare programs. Increasing bicycle use is desirable from an individual and societal perspective. However, not having easy access to a helmet may be a deterrent to renting a bicycle for short trips in urban areas, especially where helmet use is mandatory. Investigators in Canada and the United States have shown that the prevalence of helmet use was lower among users of a bikeshare program relative to those using personal bicycles.\[54\]\[55\] However, some bikeshare rental companies offer helmet dispensing stations (http://sandvault.com/sandvault-announces-helmetstation/). Their effect on helmet use is not yet known.

In summary, the evidence of a reduction in bicycling among children and adolescents following helmet legislation is mixed, and few studies have adequately accounted for existing bicycling trends independent of a helmet law. While some individuals may avoid bicycling due to helmet legislation, it would need to be shown that they do not replace it with other physical activities for helmet legislation to be considered to have a negative effect on overall health.

Helmet use and enforcement

One single county-based study conducted in the United States noted a change in helmet prevalence of 43% after helmet legislation, a substantial increase that occurred with almost no enforcement.\[56\] However, another study found that negligible helmet use in a rural Georgia community with helmet legislation covering young riders increased significantly after a combined helmet promotion, giveaway and enforcement program.\[57\] Systematic review of the effect of bicycle helmet legislation has suggested significant increases in helmet use even with limited enforcement.\[24\] Canadian studies appear to support this,\[30\] reporting high postlegislation bicycle helmet use rates with moderate enforcement activities.\[29\] One Ontario study showed that negligible enforcement (in terms of citations) may have contributed to bicycle helmet use returning to prelegislation levels for low- and middle-income children and youth six years after the helmet law came into effect, while remaining above prelegislation levels for children in high-income areas.\[27\] Therefore, available evidence suggests that bicycle helmet legislation can increase use even without significant enforcement, at least for a few years after implementation. This finding speaks volumes for the ‘education effect’, although the sustained effectiveness of bicycle helmet legislation likely requires ongoing promotion and enforcement.

Helmet use and nonlegislated interventions

There is growing evidence that a multifaceted approach to behaviour change is more successful than isolated interventions. Several studies have demonstrated the efficacy of nonlegislated interventions in increasing bicycle helmet use among children.\[68\] However, the effect of social marketing in increasing helmet use among teens and adults has not been clearly established. Also, the effects of nonlegislated interventions alongside legislation are not fully understood, but it is likely that combined synergies between two approaches would be more successful than either one by itself. Alongside education and policy implementation would be environment- or engineering-based injury prevention efforts.\[59\]\[60\] and public health strategies such as sales tax rebates and children’s tax credits for the purchase of protective helmets.\[61\]\[62\] Although this statement focuses on the promotion of bicycle helmet use to reduce injuries through legislative interventions, the importance of a multifaceted approach, concurrent with education and enforcement, cannot be underestimated.

Recommendations for policy

There is strong evidence that bicycle helmet legislation increases bicycle helmet use. There is also ample research indicating that legislation reduces risk of bicycle-related head injury. Evidence of the potential
negative effects of bicycle helmet legislation, such as reduced bicycling, is mixed, and a direct cause-and-effect relationship has not been demonstrated. Based on current evidence, bicycle helmet legislation is recommended to both increase helmet use and reduce head injury risk for children and adolescents. While legislation has positive effects on helmet use, these are further compounded by enforcement and education. All of these policies, however, should be implemented in context with wider road safety initiatives such as traffic calming and the separation of cyclists from motor vehicles.

Legislation that requires all bicyclists to wear helmets — regardless of age — has a number of potential benefits. All cyclists are at risk for head injury, and the protective effect of bicycle helmets has been well established for every age group. In addition, children are far more likely to use helmets in the presence of adults wearing helmets. Legislation that is Canada-wide in scope and effects is preferable to an age/location restrictions or another segmented approach. Table 2 lists current Canadian provincial/territorial bicycle helmet legislation status along with CPS recommendations from its status report, *Are We Doing Enough?*

**TABLE 2**
The status of bicycle helmet legislation in all provinces/territories, with Canadian Paediatric Society (CPS) recommendations*

<table>
<thead>
<tr>
<th>Province/Territory</th>
<th>2011 status†</th>
<th>Recommended actions</th>
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<tbody>
<tr>
<td>British Columbia</td>
<td>Excellent</td>
<td>Meets all CPS recommendations</td>
</tr>
<tr>
<td>Alberta</td>
<td>Good</td>
<td>Amend current legislation to include all age groups</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets. Some education programs are available</td>
</tr>
<tr>
<td>Manitoba</td>
<td>Good**</td>
<td>Amend current legislation to include all age groups</td>
</tr>
<tr>
<td>Ontario</td>
<td>Good</td>
<td>Amend current legislation to include all age groups</td>
</tr>
<tr>
<td>Quebec</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets. Some education programs are available</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>Excellent</td>
<td>Meets all CPS recommendations</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>Excellent</td>
<td>Meets all CPS recommendations</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>Excellent</td>
<td>Meets all CPS recommendations</td>
</tr>
<tr>
<td>Newfoundland and Labrador</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets</td>
</tr>
<tr>
<td>Yukon</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets</td>
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<tr>
<td>Northwest Territories</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets</td>
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<tr>
<td>Nunavut</td>
<td>Poor</td>
<td>Enact legislation that requires all age groups to wear helmets</td>
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</tbody>
</table>

*Adapted from reference [65]. †Excellent: Province/territory has legislation requiring all cyclists to wear helmets, with financial penalties for noncompliance. Parents are responsible for ensuring their child wears a helmet; Good: Province/territory has legislation requiring all cyclists younger than 18 years of age to wear a helmet; Poor: Province/territory has no legislation on bike helmets

**Legislation effective May 2013**

**Recommendations**

Based on current evidence and the importance of preventing head injuries in children and youth, the
CPS makes the following recommendations:

- All jurisdictions in Canada should legislate and enforce bicycle helmet use for all ages.
- Legislation should be rolled out using social marketing and education to raise awareness of bicycle helmet efficacy, accessibility and importance.
- Other strategies to prevent bicycling injuries, such as separating riders from motor traffic with bicycle lanes, pathways for commuting and recreational cycling, and community safety programs should be implemented concurrently.
- Physicians should counsel families about the importance of wearing bicycle helmets. Where all-ages legislation does not exist, parents should wear a bicycle helmet to model good behaviour and protect themselves.
- Sales tax exemptions or rebates and federal tax credits to make the purchase of bicycle helmets less expensive should be adopted.

Future research should explore both the intended and potential unintended effects of bicycle helmet legislation, with focus on:

- Long-term follow-up to assess the effects of bicycle helmet legislation on compliance, prevalence and head injury rates, with appropriate control for trends in other traffic safety initiatives.
- How enforcement activities influence helmet compliance and prevalence.
- The level of bicycling activity after implementation of helmet legislation, with appropriate control for independent and pre-existing trends in bicycling.

Acknowledgements

This position statement was reviewed by the Community Paediatrics, Adolescent Health, and Healthy Active Living and Sports Medicine Committees, and by the Emergency Paediatrics Section, of the Canadian Paediatric Society.

References


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