ORIGINAL ARTICLE

Economic disparity in bicycle helmet use by children six years after the introduction of legislation

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Background: Studies evaluating the effectiveness of bicycle helmet legislation often focus on short term outcomes. The long term effect of helmet legislation on bicycle helmet use is unknown.
Objective: To examine bicycle helmet use by children six years after the introduction of the law, and the influence of area level family income on helmet use.
Methods: The East York (Toronto) health district (population 107 822) was divided into income areas (designated as low, mid, and high) based on census tract data from Statistics Canada. Child cyclists were observed at 111 preselected sites (schools, parks, residential streets, and major intersections) from April to October in the years 1995–1997, 1999, and 2001. The frequency of helmet use was determined by year, income area, location, and sex. Stratified analysis was used to quantify the relation between income area and helmet use, after controlling for sex and bicycling location.
Results: Bicycle helmet use in the study population increased from a pre-legislation level of 45% in 1995 to 68% in 1997, then decreased to 46% by 2001. Helmet use increased in all three income areas from 1995 to 1997, and remained above pre-legislation rates in high income areas (85% in 2001). In 2001, six years post-legislation, the proportion of helmeted cyclists in mid and low income areas had returned to pre-legislation levels (50% and 33%, respectively). After adjusting for sex and location, children riding in high income areas were significantly more likely to ride helmeted than children in low income areas across all years (relative risk = 3.4 (95% confidence interval, 2.7 to 4.3)).
Conclusion: Over the long term, the effectiveness of bicycle helmet legislation varies by income area. Alternative, concurrent, or ongoing strategies may be necessary to sustain bicycle helmet use among children in mid and low income areas following legislation.

Bicycling is an important physical and recreational activity for children. Efforts to prevent bicycle related injuries are driven by the goal of promoting healthy and safe physical activity. Each year in Canada 2200 children are admitted to hospital because of a cycling related injury.[1] Bicycle related injuries are the most common cause of hospital admissions for sports and recreation injuries among Canadian children.[2] Among injured child cyclists, about 39% of hospital admissions are for head injuries.[3] In the province of Ontario, in the years before the initiation of specific prevention strategies, the bicycle related mortality rate was approximately 0.8 per 100 000 per year for children aged 0 to 15 years[4] and the hospital admission rate was 16.25 per 100 000 per year for children aged 5 to 19.[3]

A meta-analysis of 16 observational studies and a Cochrane systematic review of five case–control studies both concluded that bicycle helmets reduce bicycle related head and facial injuries.[5 6] Studies from Australia, the USA, and Canada have shown that helmet legislation increases the frequency of helmet use by children.[7–10] Only a few studies have focused on the impact of helmet legislation following its introduction, and none longer than three years afterwards.[11 12] Furthermore, population based studies from New Zealand and Canada have shown that helmet legislation is associated with a reduction in the incidence of bicycle related head injuries.[3 13]

Several province-wide and community specific non-legislative initiatives were undertaken in Ontario in the early 1990s, several of which have been evaluated.[14–18] Legislation mandating bicycle helmet use by all children younger than 18 years was introduced in the province of Ontario in October 1995. The objective of this study was to examine bicycle helmet use by children six years after the introduction of the law and to examine the influence of area level family income on helmet use.

METHODS

This study was part of a longitudinal observational survey initiated in 1990 and conducted in the community of East York, in collaboration with the local public health unit. East York is a health district within the city of Toronto, located in the south central region of the province of Ontario with a total population of 107 822, and a school age population of 11 340 (1996 census data).

Details of the bicycle helmet observational survey and area profiles have previously been described.[14 15] For census purposes, the community of East York was divided into 21 census tracts for which sociodemographic data were available from Statistics Canada. These tracts were grouped into seven areas that were geographically distinct in that their boundaries (expressways, ravines, railway tracts, and hydroelectric power lines) were natural barriers to travel. These natural barriers helped to minimize misclassification—that is, classifying a cyclist in an area in which they did not reside. The seven areas were labeled 1 to 7 and ranked according to average family income. For the purposes of analysis, the areas were grouped into low income (areas 1 to 4), mid income (area 5), and high income (areas 6 and 7). The observational survey was conducted yearly prior to legislation to evaluate non-legislative interventions; yearly for two years following legislation (1996 and 1997) to evaluate the short term effects of legislation; and every two years twice (1999 and 2001) to evaluate the longer term effects of legislation.

Each year observations were made at the same 111 selected sites in East York, including the schoolyards of all elementary and middle schools (Kindergarten to grade 8), all parks, and

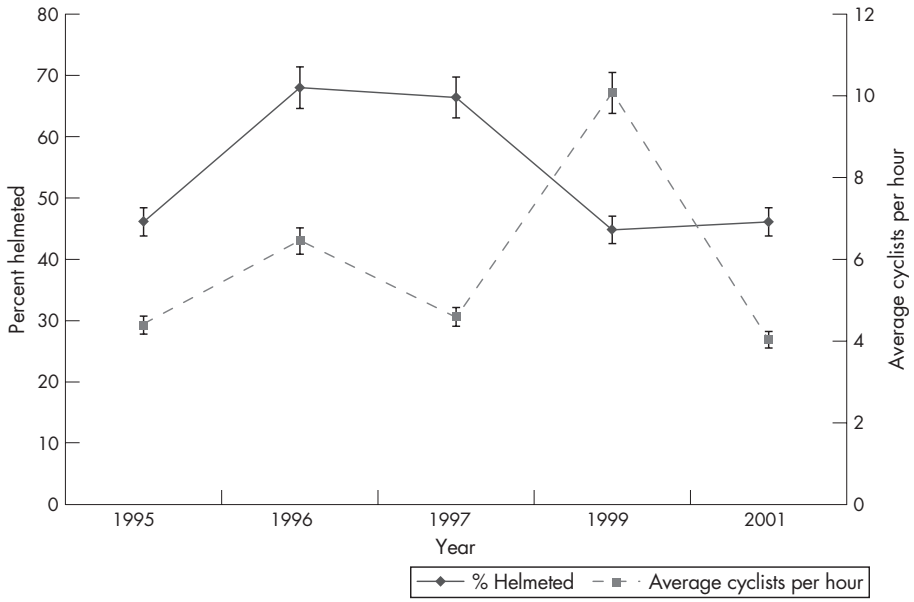

Figure 1 Child bicyclists: average number and percent helmeted.

a random selection of residential streets and major intersections. Observations were conducted between April and October. Each site was observed at least once each year. Observers remained at the site for one hour.

Trained observers used a standardized data collection form to gather information. Data gathered by the observers included sex (male or female), location (school, park, residential street, major intersection), and income area (high, mid, low). Children were included if they were estimated to be between the ages of 5 and 14 years (based on their ability to ride a two wheeled bicycle unaided and their observed prepubertal appearance) and were riding a two wheeled bicycle. The observers counted the number of child cyclists during the one hour observation period, and noted whether or not each cyclist was helmeted. The questionnaire and observer training methods have been shown to be reliable, including a high inter-rater reliability of 0.96.[19]

For the current study, data from the years 1995 (pre-legislation) 1996, 1997, 1999, and 2001 (post-legislation) were analyzed. (Data from 1990 to 1994 have been reported in previous publications.[14 15]) The proportions of helmeted cyclists by year and income area (high, mid, and low) were calculated. The relative likelihood of helmet use by income area (low income as reference) for each year of the study period was estimated, along with 95% confidence intervals. Stratified analysis using the Mantel–Haenszel method was used to estimate the relative risk of helmet use by income area, after adjusting for sex (male or female) and location

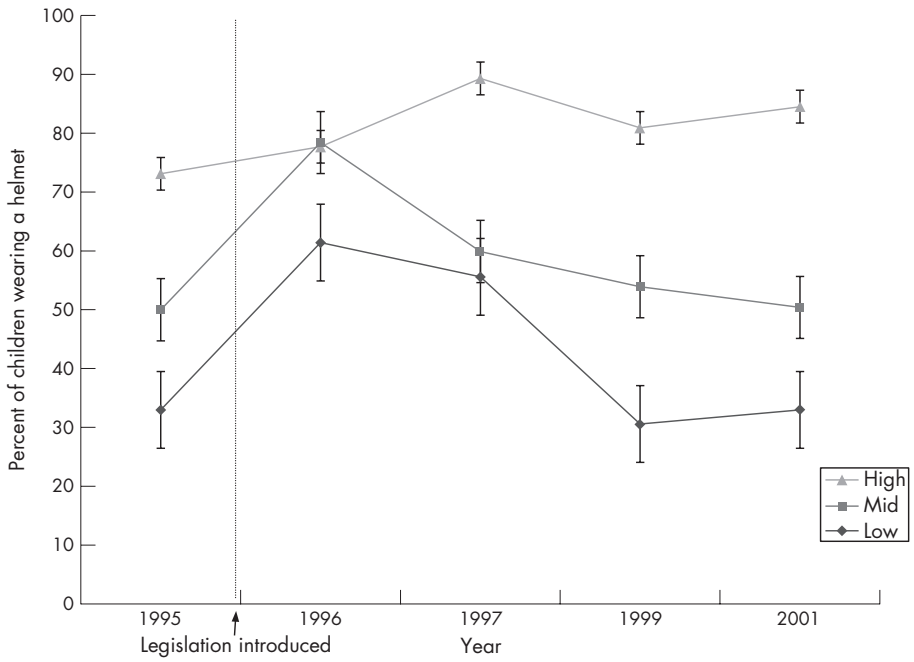

Figure 2 Helmet use by income area by year, East York 1995–2001.

Table 1 Relative likelihoods of bicycle helmet use by children (5–14 years) in East York by income area and year

Income area	1995 Pre-legislation		1996, 1 year post-legislation		1997, 2 years post-legislation		1999, 4 years post-legislation		2001, 6 years post-legislation	
	% use	RL (95% CI)	% use	RL (95% CI)	% use	RL (95% CI)	% use	RL (95% CI)	% use	RL (95% CI)
High	73.1	2.2 (1.9 to 2.5)	77.7	1.2 (1.1 to 1.3)	89.3	1.6 (1.5 to 1.8)	80.9	2.6 (2.2 to 3.0)	84.5	2.6 (2.2 to 3.0)
Mid	50.0	1.5 (1.2 to 1.7)	78.4	1.2 (1.1 to 1.3)	59.9	1.1 (0.9 to 1.2)	53.9	1.8 (1.5 to 2.1)	50.4	1.5 (1.2 to 1.9)
Low	33.0	*reference*	61.4	*reference*	55.6	*reference*	30.8	*reference*	33.0	*reference*

CI, confidence interval; RL, relative likelihood.

(school, park, residential street, major intersection).[20] The average number of cyclists per hour of observation had been previously calculated for 1995, 1996, 1997, and 1999.[21] For the purposes of the current analysis, the calculation was also made for 2001. A χ^2 test was used to compare cyclists per hour by income area. All analyses were carried out using the Statistical Analysis System (SAS®) software.[22]

RESULTS

Over the five year study period, observers counted 4999 children (2860 high, 1042 mid, and 1097 low income areas), during 885 hours of observation, for an average number of cyclists per hour of 5.6. Figure 1 shows the proportion of children wearing a bicycle helmet by year. Helmet use was 45% in 1995, the year before the legislation, with an immediate increase in the two years following legislation (68% and 66% of children rode helmeted in 1996 and 1997, respectively). There was a subsequent decline in helmet use by children, however, to 45% in 1999 and 46% in 2001.

Figure 2 shows the change in helmet use over time by income area. Before the legislation, children in high income areas were more likely to be helmeted (73%) than those in mid and low income areas (50% and 33%, respectively). Helmet use increased in all three income areas in the first year after the introduction of legislation. In subsequent years, helmet use remained above pre-legislation rates in high income areas, but declined in both the mid and low income areas. In 2001, six years post-legislation, the proportion of helmeted cyclists in high income areas was 85%; in mid and low income areas the proportion of helmeted cyclists had returned to pre-legislation levels (50% and 33%, respectively).

The relative likelihoods of helmet use by income area are presented in table 1. In general, children in high income areas were significantly more likely to ride helmeted than those in low income areas. The magnitude of the difference, however, changed over time. For example, before the legislation, children in high income areas were 2.2 times (95% confidence interval (CI), 1.9 to 2.5) more likely to ride helmeted than children in low income areas. In the year immediately following the legislation, children riding in high income areas were only 1.2 times (1.1 to 1.3) more likely to ride helmeted than children in low income areas. By 2001, children in high income areas were again more than twice as likely to be helmeted (relative risk = 2.6 (95% CI, 2.2 to 3.0)) as children in low income areas.

The adjusted analysis showed similar results. After taking into account sex (male or female) and location (school, park, residential street, major intersection), children in high income areas were 3.4 times more likely to ride their bicycle helmeted compared with children in low income areas, across all years (95% CI, 2.7 to 4.3).

As shown in fig 1, the average number of child cyclists per hour was 4.32 in 1995, 6.84 in 1996, 4.57 in 1997, 10.07 in 1999, and 4.03 in 2001. There was no significant association between average cyclist per hour and introduction of legislation over the period studied. Figure 3 shows the average number of child cyclists per hour by income area. There was no significant difference in cyclists per hour by income area ($p = 0.32$). Throughout the study period, girls were more likely to wear helmets than boys (overall RR = 1.7 (95% CI, 1.5 to 1.8)).

DISCUSSION

The introduction of bicycle helmet legislation in East York, Toronto was associated with an initial increase in helmet use among all children.[23] This increase was sustained over six

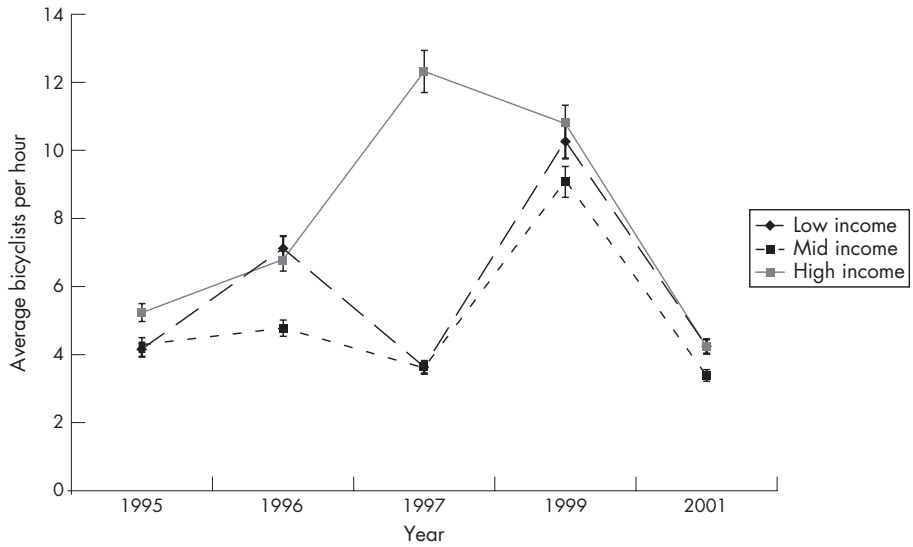

Figure 3 Average number of child cyclists per hour by income area.

years only among children bicycling in high income areas. Children riding in mid and low income areas had an increase in helmet use immediately after the law was passed. However, four to six years later, helmet use in these areas had declined to pre-legislation levels. This strong income gradient resulted in an apparent decline in helmet use at a population level.

A main strength of the study was the examination of the effectiveness of helmet legislation on bicycle helmet use by children over the long term. In addition, helmet use was observed, rather than reported, and the observation methods have been shown to be reliable. Finally, the large sample size allowed for stratified analysis, which took into account potentially confounding variables (sex and location).

There were several limitations to our study. First, income was measured at the neighbourhood rather than at the individual level. Therefore, children observed bicycling may not have had the socioeconomic attributes of their neighborhood, leading to potential misclassification bias. However, Mustard *et al* studied a representative sample of households in a Canadian province and found evidence for the use of ecologic level measures of socioeconomic status as proxies for individual level measures.[24] Second, this study was conducted in one health district in Ontario; therefore, the results may not be generalisable to other populations in Canada or elsewhere. However, the demographics of East York resemble those of Canadian urban centers—for example, the average family income in Canada is $54 583, while in East York it is $58 196.[25] Finally, the role of law enforcement was not studied; therefore its impact could not be assessed. Further, many non-legislative factors influence helmet use. The contribution of these strategies (education, health promotion) were not evaluated in the current study. The joint effects of non-legislative and legislative factors are likely to be complex.

A public health perspective that promotes healthy physical activity and safety must be applied to common childhood activities such as walking and bicycling. Public health priority setting depends in part upon burden but also on the effectiveness of preventive interventions.[26] The burden of child pedestrian and bicycling injuries remains significant, as measured by deaths, hospital admissions, and emergency department visits. In the province of Ontario (2001/2002), 73 child pedestrians (5 to 14 years) and 104 child cyclists were admitted to hospital with head injuries, with 97% and 22% resulting from motor vehicle traffic, respectively.[1] Evidence suggests that strategies for the prevention of pedestrian injuries such as traffic calming and safety education are promising but require further investigation.[27 28] Two decades of empirical research supports the effectiveness of helmets in the prevention of bicycle related head injury at both the individual and population level.[3 5 6 13] However, it is acknowledged that controversy remains.[29–32]

Some investigators have argued that there may be unintended negative consequences of helmet promotion, notably risk compensation, and a reduction in rates of cycling. Risk compensation theory suggests that the protective effect of bicycle helmets may be negated by a change in cyclist behavior.[33] It has been argued that the ability to establish, refute or measure risk compensation is difficult, and that a systematic review of the evidence for risk homeostasis should be conducted.[34 35] The potential for helmet use to encourage risk taking among cycling children remains undetermined. Conversely, the possibility that helmet legislation removes a barrier to participation in cycling among risk averse children and their parents should also be explored.

A relation between helmet legislation and a reduction in cycling rates has been postulated.[36 37] We examined the trends in children's cycling rates in East York, Toronto before and after the introduction of helmet legislation and were unable to identify any association.[21] We hypothesize that the year to year variation in cycling rates is more likely to be associated with other factors such as the weather or random variation in bicycling, rather than legislation. Further, in the current study, we have identified an income gradient for helmet use four to six years following helmet legislation. A corresponding income gradient is not apparent for cycling rates. This would suggest that an association between cycling rates and helmet legislation is unlikely. Our longitudinal observational survey has focused on children aged 5 to 14 years. Whether such an association exists for individuals older than 14 years warrants further study.

Implications for prevention

The difference in helmet use four to six years post-legislation between children in high and low income areas bears further consideration. Studies from the UK have shown a two- to fivefold social class gradient for injury and death rates in children of low versus high socioeconomic status.[38 39] Previous studies in East York, Toronto have shown a similar income gradient in the effectiveness of non-legislative strategies to increase children's helmet use.[14 15] Observations in the immediate post-legislation period suggested that the legislative effect was most powerful among children residing in low income areas.[23] Taken together, these findings suggest that alternative, concurrent, or ongoing strategies are necessary to sustain bicycle helmet use after legislation, particularly among children in mid and low income areas.

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Key messages

- Previous studies have shown an income gradient in the effectiveness of non-legislative strategies to increase children's helmet use.
- Immediately after legislation mandating the use of helmets, the legislative effect appeared most powerful among children residing in low income areas.
- Over the longer term, the effectiveness of bicycle helmet legislation was sustained in children in high income areas but waned in children in low income areas.
- Alternative, concurrent, or ongoing strategies are necessary to sustain bicycle helmet use after legislation, particularly among children in mid and low income areas.

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LACUNAE

Buckled up for safety

A 44 year old woman escaped serious injury from a gunshot Sunday thanks to her seat belt and a thick bra strap, authorities said. Robin Key, 44, of Riverview, Fla., was shot through the windshield of the car she was riding in Sunday. She said she felt a searing pain in her shoulder. Hillsborough County sheriff's deputies said a .38-caliber bullet smashed through the windshield then bounced off Key's shoulder—thanks to a seat belt and a thick bra strap. The copper jacketed slug landed in her lap. ''It's a big bullet, but you had all those forces acting against it,'' Hillsborough sheriff's spokesman J D Callaway told the St Petersburg Times. ''It's very rare that something like that occurs. She's very lucky. You know, we're just glad she came out OK.''
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