Bicycle Helmet Use After the Introduction of All Ages Helmet Legislation in an Urban Community in Alberta, Canada

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ABSTRACT

Background: Bicycle trauma is a common cause of recreational death and disability and helmets have been shown to reduce fatal and non-fatal head and face injuries. This study evaluated the effect of mandatory bicycle helmet legislation for all ages in St. Albert, Alberta.

Methods: We observed bicyclists from June to September of 2006 in St. Albert, a community subject to both provincial (<18 years old) and municipal (all ages) helmet legislation, and compared our results with observations taken in 2000 when no legislation existed. Helmet wearing and rider characteristics were recorded by trained observers. Poisson regression analysis was used to obtain helmet prevalence (HP) and prevalence ratio (PR) estimates.

Results: HP increased from 45% to 92% (PR=2.03; 95% CI: 1.72-2.39) post-legislation. Controlling for other covariates, children were 53% (PR=1.53; 95% CI: 1.34-1.74) and adolescents greater than 6 times (PR=6.57; 95% CI: 1.39-31.0) more likely to wear helmets; however, adults (PR=1.26; 95% CI: 0.96-1.66) did not show a statistically significant change post-legislation. Restricting the analysis to high socio-economic status areas, adult helmet prevalence increased in St. Albert from 58% to 73% post-legislation compared with a 52% to 57% change across the province; this effect was not statistically significant.

Conclusions: Helmet legislation in St. Albert was associated with a significant increase in helmet use among child and adolescent cyclists. A larger increase in HP was observed for adults in St. Albert than in other areas of the province; however, this difference was not statistically significant, which may reflect the small sample size or insufficient time passage after bylaw enactment.

Key words: Bicycling; head protective device; legislation; prevalence

La traduction du résumé se trouve à la fin de l'article.

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Bicycle riding is a popular recreational and transportation activity in Canada;¹ however, injuries do occur and may result in emergency department (ED) visits, hospitalizations²⁻⁵ and even deaths.^{6,7} Approximately 20% of bicyclist ED visits result from head injuries,⁸ though the proportion can rise to over 75% for those fatally injured.⁷ Evidence from two systematic reviews suggests helmets reduce the risk of head, brain and severe brain injury by between 58% and 88% among bicyclists of all ages.^{9,10}

Given the effectiveness of helmets in preventing head injuries, efforts to increase helmet use while bicycling have been undertaken in many countries. A systematic review has shown that promotional activities such as education, media campaigns, and community incentives may increase short-term use.¹¹ Some jurisdictions have implemented mandatory helmet use legislation – some for all ages¹²⁻¹⁵ and some for cyclists under 18 years of age.¹⁶ Two systematic reviews indicated that bicycle helmet legislation can increase helmet use from 5% to 54%¹⁷ as well as decrease head injury rates;¹⁸ however, due to variations in the target age group and compliance, there is a need for more research in this area.

A comprehensive roadside survey in two major cities (Edmonton and Calgary) and eight smaller communities in Alberta in 2000 demonstrated a helmet use rate of 55% among all age groups.¹⁹ On May 1, 2002, Alberta passed a provincial law requiring all bicyclists less than 18 years of age to wear helmets.²⁰ Two years after provincial legislation, an observational survey repeated in Edmonton revealed that helmet use among bicyclists <18 increased from 28%

to 83% with little associated change for helmet use for cyclists 18 and over (≥18).²¹ In February 2006, the City Council of St. Albert (a suburban community northwest of Edmonton with a population of 57,000, reported by Statistics Canada 2006) passed a traffic bylaw (February 2006) amending the provincial helmet legislation to include all age groups effective from July 1, 2006 (personal communication with John Younie, Manager, Major Projects and Park Planning, City of St. Albert, May 1, 2009).

To evaluate the effect of this legislation change, we conducted a follow-up observational survey in the summer of 2006.

METHODS

Pre- and post-legislation observational surveys were conducted in St. Albert as part of a larger province-wide survey two years before (in 2000) and four years after provincial helmet legislation (in 2006). All observations were made between June and September in each of 2000 and 2006.

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Table 1. Number of Sites and Cyclists Observed in the Two Studies in St. Albert, Alberta, Canada

Location	2000		2006	
	Site	Observations	Site	Observations
School	3	49	4	136
Park	2	11	4	16
Residential	2	2	5	12
Cycling path	2	63	3	51
Commuter route	2	17	2	10
Total	11	142	18	225

A total of five trained observers collected information on cyclists at selected sites among five strata consisting of residential areas, schools, parks, commuter routes, and designated cycling paths. A list of schools and parks were obtained from municipal websites. For residential areas, commuter routes and designated cycling paths, we used standard road maps divided by alphanumeric zones. From the lists, we randomly selected observation sites. As the number of sites in the provincial survey was based on the population of each area, 11 sites from a total of 136 were selected for the observations in St. Albert.¹⁹ In 2006, the original sites in 2000 were resurveyed and seven additional sites from all new and existing potential sites (n=138) were randomly selected. Our observations among revisited sites were at the same days and times as in 2000. Other methods for collecting demographics and environmental conditions were detailed in another provincial study and are available upon request.²² Data were collected on age, sex, helmet use, location, and companionship for each bicyclist.

Contact was made with Edmonton and Calgary Police Services as well as the Royal Canadian Mounted Police (RCMP) to estimate police enforcement of the helmet law by means of documented ticket citations during the study period.

Analysis

Data were analyzed using Stata/SE version 10.²³ We compared the prevalence of helmet use between 2000 and 2006 by important factors including: age, sex, location type, weather conditions (dry, wet), and temperature (low: <10°C; moderate: 10-20°C; high: ≥20°C). Weather and temperature data were obtained from an archive on the Environment Canada website.²⁴

Given that our outcome was a count variable (number of bicyclists who wore a helmet), we used Poisson regression analysis with cluster adjustment for site for univariate and multiple regression analysis with the robust (sandwich or Huber-White) estimator to correct the standard error of the estimates.²⁵ We report HP (%), with 95% confidence intervals [CI] and prevalence ratios (PRs, 95% CI)^{26,27} comparing the post- to the pre-legislation period.²⁷

Examining the means and variances of our main outcome (helmet use) in all three age groups demonstrated that data were not over- but under-dispersed; consequently, Poisson was preferred over negative binomial regression modeling. If variances are smaller than the means, it would imply less variability in helmet use than estimated with the Poisson distribution, leading to wider CI and more conservative estimates (i.e., less likely to be statistically significant).²⁷ As age was previously shown to be an effect modifier for the relationship between bicycle helmet legislation and HP,²¹ in the multiple Poisson regression analysis, we incorporated the interaction of year (2000, 2006) with age (children <13; adolescents 13-17; adults ≥18), allowing the effect of year of survey to vary depending on age group.

To compare adult helmet use in St. Albert (with universal helmet legislation) to that in the rest of Alberta (with a helmet law for those under 18), we selected that part of the Alberta population with a high SES (i.e., 3rd, 4th, and 5th quintile of neighbourhood median income level) and compared adult HP with the corresponding HP in St. Albert.

RESULTS

Sampling

The sites of observation for St. Albert are shown in Table 1. Of the 11 sites in 2000, one had zero observations, and from the 18 sites in 2006, two had zero observations; these sites were not part of the analysis. Inter-observer reliability in capturing cyclist characteristics was examined in a parallel study in Alberta and showed that disagreements between two observers at the same site were less than 6% in recording bicyclists' characteristics.²²

Univariate analysis

Overall HP increased from 45% to 92% (PR=2.03; 95% CI: 1.72-2.39) post-legislation. Subgroup analysis showed that HP among children increased from 63% to 100% (PR=1.59; 95% CI: 1.38-1.82). Adolescent HP increased from 10% to 76% (PR=8.00; 95% CI: 1.60-39.9), and adult HP increased from 58% to 73% (PR=1.26; 95% CI: 0.93-1.70) (Table 2). HP increased in males and females, at schools and on cycling paths and regardless of companion helmet use (Table 2).

In Calgary and Edmonton, 188 tickets were issued between 2003-2008, targeting only children and adolescents (personal communication with Allison Bouthillier, Edmonton Police Services and Allison Miller, Calgary Police Services). In St. Albert, 130 tickets were issued during 2006-2008, targeting cyclists of all ages (personal communication with Corporal Don Murray, St. Albert RCMP).

Multiple Poisson Regression analysis

From the full model with all covariates and the interaction of age with year, HP among children (PR=1.53; 95% CI: 1.34-1.74) increased 53% from 2000 to 2006 (Table 3). Adolescents (PR=6.57; 95% CI: 1.39-31.0) demonstrated a sixfold increase in HP from 2000 to 2006. Adults did not show a statistically significant increase in HP over time after adjustment for covariates (PR=1.26; 95% CI: 0.96-1.66). In 2000, HP among adolescents (PR=0.20; 95% CI: 0.04-0.87) was 80% lower than among adults; however, children (PR=1.14; 95% CI: 0.85-1.49) did not show a statistically significant difference compared with adults. In 2006, HP among children (PR=1.38; 95% CI: 1.17-1.63) was 38% higher than among adults, but adolescent helmet use was similar to that in adults (PR=1.02; 95% CI: 0.76-1.38) (Table 3). Controlling other covariates, HP among females was 12% greater compared with males (PR=1.12; 95% CI: 1.02-1.22) (Table 3). Locations did not show a significant relation to HP. Those riding with anyone who had a helmet (child, adolescent or adult) demonstrated 17% greater HP than those riding alone (PR=1.17; 95% CI: 1.02-1.33). After adjustment for other covariates, weather conditions and temperature had little effect on helmet use (Table 3).

In St. Albert, HP for adults increased from 58.1% (95% CI: 46.3-72.8) in 2000 to 73.1% (95% CI: 63.6-84.0) in 2006; while in other

Table 2. Prevalence of Helmet Use and Prevalence Ratio 2006 Versus 2000 in St. Albert, Alberta, Canada

Variable	2000		2006		Prevalence Ratio (95% CI), Cluster Adjusted†
	n/N	% (95% CI)	n/N	% (95% CI)	
Overall	64/142	45 (40-51)	206/225	92 (86-98)	2.03* (1.72 to 2.39)
Age (years)					
<13	39/62	63 (55-73)	152/152	100 (NA)	1.59* (1.38 to 1.82)
13-17	4/42	10 (2-44)	16/21	76 (59-99)	8.00* (1.60 to 39.9)
≥18	18/31	58 (46-73)	38/52	73 (64-84)	1.26 (0.93 to 1.70)
Missing data§	3/7		0/0		
Gender					
Male	41/98	42 (36-48)	139/155	90 (84-96)	2.14* (1.80 to 2.55)
Female	21/41	51 (40-65)	67/70	96 (91-100) ‡	1.87* (1.41 to 2.47)
Missing data	2/3		0/0		
Location					
Park/residential/commuter route	17/30	57 (45-72)	30/38	79 (62-100) ‡	1.39 (0.91 to 2.13)
School	21/49	43 (42-44)	132/136	97 (94-100) ‡	2.26* (2.19 to 2.34)
Cycling path	26/63	41 (35-48)	44/51	86 (81-92)	2.09* (1.78 to 2.46)
Companion helmet use					
Alone	48/107	45 (38-54)	152/171	89 (81-98)	1.98* (1.61 to 2.43)
Riding with anyone helmeted	12/17	71 (53-94)	54/54	100 (NA)	1.42* (1.07 to 1.87)
Riding with anyone non-helmeted	3/15	20 (8-52)	0/0	NA	NA
Missing	1/3		0/0	NA	NA
Weather condition¶					
Dry	64/142	45 (40-51)	153/171	89 (83-96)	1.99* (1.66 to 2.37)
Wet	0/0	NA	53/54	98 (93-100) ‡	NA
Temperature**					
High	41/93	44 (37-53)	103/115	90 (82-98)	2.03* (1.62 to 2.56)
Moderate	20/42	48 (38-60)	83/89	93 (83-100) ‡	1.96* (1.47 to 2.61)
Low	3/7	43 (17-100) ‡	20/21	95 (86-100) ‡	2.22 (0.92 to 5.34)

* Statistically significant; (NA) not applicable

† Prevalence ratio of helmet use 2006 versus 2000; clusters were sites of observation

‡ % greater than 100 for upper limit was cut off to 100

§ Missing was not listed if there were no missing data

|| Riding with at least one adult or child companion

¶ Any rain ≥1 mm was considered wet; otherwise defined as dry based on Environments Canada National Climate Archive Data

** Low = <10, Moderate = 10-20, and High = ≥20 degrees Celsius

Table 3. Adjusted Prevalence Ratio of Helmet Use 2006 Versus 2000 in St. Albert, Alberta, Canada

Variable	Prevalence Ratio (95% CI), Cluster Adjusted
Age (years)	
<13	
2000	1.0 (ref)
2006	1.53* (1.34 to 1.74)
13-17	
2000	1.0 (ref)
2006	6.57* (1.39 to 31.0)
≥18	
2000	1.0 (ref)
2006	1.26 (0.96 to 1.66)
Year	
2000	
<13	1.14 (0.89 to 1.45)
13-17	0.20* (0.04 to 0.87)
≥18	1.0 (ref)
2006	
<13	1.38* (1.17 to 1.63)
13-17	1.02 (0.76 to 1.36)
≥18	1.0 (ref)
Gender	
Male	1.0
Female	1.12* (1.02 to 1.22)
Location	
Park/residential/commuter route	1.00
School	0.93 (0.84 to 1.04)
Cycling path	0.96 (0.87 to 1.06)
Companion helmet use	
Alone	1.00
Riding with anyone helmeted †	1.17* (1.02 to 1.33)
Riding with anyone non-helmeted †	0.60 (0.28 to 1.28)
Temperature ‡	
High	1.00
Moderate	1.07 (0.99 to 1.14)
Low	1.09 (0.97 to 1.22)

* Statistically significant

† Riding with at least one adult or child companion

‡ Low = <10, Moderate = 10-20, and High = ≥20 degrees Celsius

Figure 1. Trends of helmet prevalence (overall % of use) for adults (≥18) in St. Albert vs. Alberta, Canada pre- and post-legislation

little practical or statistical change (Including June HP=1.26; 95% CI: 0.72-2.20 vs. Excluding June HP=1.24; 95% CI: 0.69-2.22; $p=0.47$).

DISCUSSION

This study evaluated bicycle helmet use four years after the introduction of provincial bicycle helmet legislation targeting those under age 18 in St. Albert, Alberta, a municipality that elected to adopt a universal helmet use bylaw in 2006. Overall, the results suggest that helmet use increased 53% among children, more than sixfold among adolescents, and had no statistically significant change among adults (Table 3). There was no statistically signifi-

high SES areas of Alberta (see methods), HP changed from 51.7% (95% CI: 48.3-55.2) in 2000 to 56.8% (95% CI: 51.8-62.2) in 2006 (Figure 1). The results of a sensitivity analysis comparing the HP post- to pre-legislation ratio among adults in St. Albert in 2006 by excluding the month of June (before the city bylaw) demonstrated

cant difference between helmet use among children and adults pre-legislation in 2000; however, after legislation, it is estimated that child helmet use was 39% greater than use in adults.

The results from the provincial survey showed that HP increased post-legislation by 29% among children, 112% among adolescents and 14% among adults.²² HP trends in St. Albert demonstrate a greater, though not statistically significant, increase from pre- to post-legislation compared with a much more modest increase at other Alberta sites (Figure 1). One explanation for this trend in St. Albert for adults may be the limited time post-legislation for people to adhere to the new city bylaw; nevertheless, the rising adult HP in this community is encouraging.

Evaluation of British Columbia's universal helmet legislation showed that HP among all age groups increased between 18% and 28% four years after legislation from 1995 to 1999.¹³ HP in Nova Scotia, a province that implemented all-ages bicycle helmet legislation in 1997, increased substantially from 1995/96 to 1998/99 among all age groups (children: 49% to 84%; adolescents: 29% to 70%; adults: 36% to 86%).¹² In our study, HP increased from 63% to 100%, 10% to 76%, and 58% to 73% among children, adolescents and adults, respectively. We controlled for other covariates in a multiple regression analysis demonstrating that HP improved significantly among children and adolescents, but not among adults (Table 3).

An examination of four cycles of Canadian Community Health Surveys between 2001 and 2007 has shown that helmet use was much higher in a province with universal helmet legislation (youth=77.5%, adults=71.4%) than a province with helmet legislation targeting only those under 18 (youth=46.7%, adults=38.9%).²⁸

In 1990, Victoria, Australia became the first jurisdiction in the world to introduce compulsory bicycle helmet use for all age groups following a decade of promotional helmet use activities that started in 1980. HP estimates the year before legislation for metropolitan primary school students, secondary school students, and adults were 76.8%, 18.4%, and 47%, respectively. One year after legislation, HP increased for all age groups to 92.2%, 44.2%, and 92%, respectively.²⁹ This shows that implementing all-age helmet legislation can increase helmet use in children, adolescents and adults.

Two studies in Ontario demonstrated that HP among higher-income areas was greater at baseline than in lower-income areas. These areas were observed to have a smaller percentage increase after implementing helmet legislation.^{16,30} Given that the sites observed in St. Albert were generally of high SES, we would then suggest that the increase in adult HP from 58% to 73% was a promising finding.

Limitations and strengths

Our study is not without limitations. Our observers did not stop cyclists to obtain demographic information; however, they used their best estimate for age category, sex and other variables, a strategy which has been used in many other similar investigations.^{12,13,16} This approach may result in some misclassification; however, we would consider that these errors were likely not systematically related to helmet use or year of the study. Although the number of observations in this study was small and not evenly distributed among different age groups, the results are practically and statistically significant for children and adolescents.

A post-hoc power calculation indicates that we had only 29% power to detect a 15% change in HP among adults based on the

total number of adults observed pre- to post-legislation. Therefore, two elements might have played an important role in lower-than-expected HP among adults in St. Albert. First, the short interval between helmet legislation and evaluation may have been insufficient for the intervention to take full effect. Second, the limited number of observations before and after implementation of the bylaw (i.e., the interplay of sample size and magnitude of effect) may have limited our ability to measure this effect.

Finally, it appears that neither Alberta nor St. Albert had any promotional and limited enforcement activities in place for bicycle helmet use before or after the laws were implemented. Whatever enforcement occurred was concentrated in the first year (80% in 2006) in St. Albert and in the second and third year (18% in 2003; 37% in 2004) in Calgary and Edmonton. Therefore, the low HP may be attributable to a general reluctance of adults to change behaviours, low perceived risk of consequences, low perceived risk of head injury, or a combination of these factors.

This study has several strengths. For data collection, we directly observed persons engaged in bicycling rather than relying on self-reports through telephone or questionnaire surveys that may be subject to response bias.²⁸ We used pre-legislation observations as a control period in the same population with consistent observation methods to observe bicyclist characteristics, including helmet use. To address the methodological issues identified by other authors in the evaluation of helmet legislation,³¹ we repeated observations at the same locations, day of week and time of the day as in the pre-legislation study and assessed the effect of legislation four years after implementation of the law. We incorporated interaction terms between age and study year in our multiple regression analysis to allow separate legislation effects for children, adolescents and adults and adjusted for sex, location of observation, companionship, weather conditions and temperature. We also controlled for the potential non-independence of bicycle helmet use at particular data collection sites (i.e., clustered data) in the statistical analysis.

CONCLUSION

Provincial (targeting those <18) and municipal (targeting adults) helmet legislation in St. Albert increased helmet use significantly among children and adolescents. The increase in helmet use among adults in St. Albert was greater than among adults in other areas of the province, though this effect was not statistically significant. The small sample size, insufficient time between legislation and our survey, poor enforcement or lack of influence of the legislation on adults may have influenced the results seen in HP among St. Albert adults. Future research targeting a larger sample size is required to determine the impact of universal helmet legislation on helmet use in all age groups, but in particular among adults subject to the municipal bylaw.

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RÉSUMÉ

Contexte : Les traumatismes dus aux accidents de bicyclette sont une cause courante de mortalité et d'invalidité survenues dans le cadre d'activités de loisirs, et l'on sait que le port du casque réduit les blessures mortelles et non mortelles à la tête et au visage. Nous avons évalué l'effet des lois sur le port obligatoire du casque de cycliste à tout âge à St. Albert, en Alberta.

Méthode : De juin à septembre 2006, nous avons observé des cyclistes à St. Albert, une municipalité assujettie à la fois à la loi provinciale (<18 ans) et à un règlement municipal (tous les âges) sur le port du casque, et nous avons comparé nos résultats aux observations effectuées en 2000, quand il n'existait encore aucune loi. Le port du casque et les caractéristiques des cyclistes ont été notés par des observateurs formés. Au moyen d'analyses de régression de Poisson, nous avons estimé la prévalence du port du casque (PPC) et les ratios de prévalence (RP).

Résultats : La PPC est passée de 45 % à 92 % (RP=2,03; IC de 95 % = 1,72-2,39) après l'adoption des mesures législatives. Si l'on tient compte des effets d'autres covariables, les enfants étaient plus susceptibles dans une proportion de 53 % (RP=1,53; IC de 95 % = 1,34-1,74), et les adolescents plus de 6 fois plus susceptibles (RP=6,57; IC de 95 % = 1,39-31,0) de porter un casque; cependant, la loi ne semble pas avoir eu d'effet significatif sur le port du casque chez les adultes (RP=1,26; IC de 95 % = 0,96-1,66). En limitant notre analyse aux quartiers de statut socioéconomique élevé, la prévalence du port du casque chez les adultes a augmenté à St. Albert, passant de 58 % à 73 % après les mesures législatives; à l'échelle de la province, elle est passée de 52 % à 57 %; cet effet n'était pas statistiquement significatif.

Conclusion : À St. Albert, les mesures législatives sur le port du casque étaient associées à une hausse significative du port du casque de cycliste chez les enfants et les adolescents. Une plus forte hausse de la PPC a été observée chez les adultes de St. Albert que dans d'autres parties de la province, mais cet écart n'était pas significatif, ce qui peut s'expliquer par la petite taille de l'échantillon ou par le fait qu'il ne s'était pas écoulé suffisamment de temps après l'adoption du règlement municipal.

Mots clés : cyclisme; dispositifs de protection de la tête; législation; prévalence