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ORIGINAL ARTICLE

New Zealand bicycle helmet law—do the costs outweigh the benefits?

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Objectives: This paper examines the cost effectiveness of the compulsory bicycle helmet wearing law (HWL) introduced in New Zealand on 1 January 1994. The societal perspective of costs is used for the purchase of helmets and the value of injuries averted. This is augmented with healthcare costs averted from reduced head injuries.
Methods: Three age groups were examined: cyclists aged 5–12 years, 13–18 years, and ⩾19 years. The number of head and non-head injuries averted were obtained from epidemiological studies. Estimates of the numbers of cyclists and the costs of helmets are used to derive the total spending on new bicycle helmets. Healthcare costs were obtained from national hospitalisation database, and the value of injuries averted was obtained directly from a willingness-to-pay survey undertaken by the Land Transport Safety Authority. Cost effectiveness ratios, benefit:cost ratios, and the value of net benefits were estimated.
Results: The net benefit (benefit:cost ratios) of the HWL for the 5–12, 13–18, and ⩾19 year age groups was \$0.3m (2.6), –\$0.2m (0.8), and –\$1.5m (0.7) (in NZ \$, 2000 prices; NZ \$1.00 = US \$0.47 = UK £0.31 approx). These results were most sensitive to the cost and life of helmets, helmet wearing rates before the HWL, and the effectiveness of helmets in preventing head injuries.
Conclusions: The HWL was cost saving in the youngest age group but large costs from the law were imposed on adult (⩾19 years) cyclists.

A recent New Zealand study showed that the New Zealand bicycle helmet wearing law (HWL), introduced on 1 January 1994, was effective at reducing head injuries to cyclists admitted to hospital.[1] However, the implementation of the HWL also resulted in a number of costs, including the purchasing of bicycle helmet by unhelmeted cyclists. Although the benefits of bicycle helmet wearing have been extensively covered and debated in the literature,[2–14] less focus has been placed on the costs.[15–18] This study evaluates, *ex post*, the costs, cost effectiveness, and cost benefit of the New Zealand bicycle helmet law for three age groups: 5–12 years, 13–18 years, and adults (19 years and above).

METHODS

Our approach to cost effectiveness, cost benefit, and net benefit costs follows standard practice in economic evaluations.[19 20] In the absence of evidence on the effectiveness of the HWL in preventing death, this analysis is limited to evaluating the costs of the HWL with respect to hospital admissions averted. The model was constructed in an Excel spreadsheet.

Benefits of the HWL

In the first three years, the HWL was shown to prevent an annual average of 4.0 (90% confidence interval (CI) 0 to 10), 10.3 (90% CI 7 to 14), and 28.3 (90% CI 22 to 35) cyclists admitted to hospital with head injuries in the 5–12 years, 13–18 years, and adults respectively.[1] These benefits were extrapolated over the life of a helmet (five years).[21]

Value of the HWL benefits

The value of these head injuries averted was estimated from the societal perspective. The social value was derived from a willingness-to-pay survey to avoid injury requiring short stay hospital treatment less than seven days, and long stay hospital treatment seven days or more.[22]

The willingness-to-pay values included indirect costs (loss of productive output due to temporary incapacitation and permanent disability), property damage, legal/court costs, and medical costs (including emergency treatment). We revised the costs for hospital inpatient treatment with the estimates described below. These willingness-to-pay values applied to all age groups for all traffic related injuries. We assumed the percentage of head injuries requiring more than seven days hospital treatment was constant in the pre-HWL and post-HWL periods.

Direct medical costs for cyclists admitted to hospital were estimated from diagnostic related groupings recorded by the New Zealand Health Information Service (NZHIS). Diagnostic related groupings are based on the resources associated with the primary diagnosis, complications, comorbidities, age, and gender.[23] From this data we calculated the average cost of a head injury for each of the three age groups (table 1).

Costs of the HWL

The HWL imposed a cost on cyclists, who had not purchased a helmet before the HWL, equal to the minimum cost of a new helmet (that is, NZ \$19.95, personal communication, Pacific Helmets, New Zealand Ltd). The cost to society of a helmet is this price less 12.5% goods and services tax (that is, NZ \$17.73 per helmet). This cost was multiplied by the numbers of unhelmeted cyclists before the law. The helmet wearing rate was recorded by the Land Transport Safety Authority and the numbers of unhelmeted cyclists were estimated in a previous study.[15] Data on the costs of enforcing the HWL were not available; however, these costs were likely to be small because enforcing the HWL is part of general traffic enforcement

Abbreviations: CI, confidence interval; HWL, helmet wearing law; NZHIS, New Zealand Health Information Service

Table 1 Age group specific parameters used in the model

	Age 5–12	Age 13–18	Adults
Number of cyclists (1993)	85702	202985	596808
Helmet wearing rate in September 1993 (%)	86.8	55.9	38.9
Helmet wearing rate in March 1994 (%)	98.6	97.1	92.9
Mean hospital treatment costs for cyclists head injuries ($)*	1569	1607	1351
Mean hospital stay in head injured cyclists (bed days)†	2.8	3.2	4.2
⩾7 days stay in head injured cyclists (%)	6.4	7.1	10.7

*Mean hospital treatment costs for non-head injured cyclists: $1919 5–12 years, $2909 13–18 years, and $2849 adults.
†Percentage ⩾7 days stay (non-head injured cyclists): 16.2% 5–12 years, 19.8% 13–18 years, and 25.3% adults.

Table 2 Global parameters used in the model and sensitivity analysis. All costs are in NZ $ for 2000 (NZ $1.00 = US $0.45, UK £0.31, €0.50)

	Base value	Maximum value	Minimum value
Cost of helmet (all age groups) ($)	17.73	44.44	8.89
Life of helmet (years)	5	7	3
Discount rate (%)	5	10	0
Social costs of injury with <7 days hospital treatment ($)*[22]	13309	15970	10647
Social costs of injury with ⩾7 days hospital treatment ($)*[22]	196360	235632	157088
Law enforcement costs ($)†	Nil	200000	Nil
Head injuries averted per year due to the HWL			
5–12 years	4.0	10.0	Nil
13–18 years	10.3	14.0	6.7
Adults	28.3	35.0	22.0
Number of cyclists quitting			
5–12 years	Nil	5870	–
13–18 years	Nil	47173	–
Adults	Nil	82890	–
Costs of quitting cycling ($)	0.00	19.95‡	–

*The social cost of a fatality was $2280000 in December 2000 currency. From the willingness-to-pay survey, preventing one permanently disabling head injury was at least as important as preventing one fatality.[24]
†In the first year of the law (1994) we assumed law enforcement costs would be double the costs of subsequent years (that is, $400000). This cost was pro rated over the percentage of cyclists in each age group (table 1).
‡Also, including an additional $30 "other" costs of quitting cycling.

without use of additional police resources. We address this point in the sensitivity analysis.

Cost effectiveness, cost benefit, and net benefit

Cost effectiveness was calculated as the additional costs per head injury averted from the HWL compared with a no law policy, where costs appearing in the numerator are the costs of the HWL (that is, cost of helmets) and the benefits (denominator) are the number of serious head injuries averted over the life of a helmet (five years).

A cost benefit analysis was undertaken to indicate the rate of return on the investment. The benefit:cost ratio indicates the expected benefits if the same policy was implemented in other countries. The numerator (benefits) is the value in monetary units of head injuries averted. The cost is as above. We also calculated the net benefit (benefits minus costs) of the HWL.

A discount rate of 5% has been used for costs and outcomes. All money values are reported in New Zealand dollars (NZ $) converted to 2000 prices using the New Zealand Consumer Price Index (NZ $1.00 = US $0.45, UK £0.31, €0.50).

Sensitivity analysis and "quitters"

A one way sensitivity analysis was performed to determine the robustness of the results with respect to changes in parameter values (table 2).[19] Helmet effectiveness was varied between the upper and lower 90% confidence intervals reported by Scuffham *et al*.[1] Nominal costs for law enforcement were pro rated based on the numbers of cyclists in each age group (table 1), and in the first year of the law we assumed law enforcement costs would be double the costs of subsequent years.

In addition, we undertook an analysis with the assumption that some cyclists might have quit cycling due to the HWL rather than purchase a helmet ("quitters"). In this event, there would be a reduction in the number of both head and non-head injuries due to the reduction in number of cyclists. The number of quitters is the reduction in number of cyclists between the years 1993 and 1994 (when the law was introduced), estimated as the same percentage reduction in non-head injuries in that period. Injury data for head and non-head injuries, obtained from the NZHIS, is described elsewhere.[1] We analysed three scenarios: (i) there were no costs associated with quitting; (ii) a cost of quitting equal to the price of a helmet ($19.95) where quitters value cycling at no more than this amount otherwise they would purchase a helmet; and (iii) an additional $30 societal cost on top of the $19.95 to account for additional costs from reduced exercise and increased motorcar use. This cost was incurred when the HWL was introduced, but the benefits (injuries averted) observed throughout the time horizon of the study.

RESULTS

The costs of the HWL cost for 5–12 year old children was relatively low because relatively few helmets for this age group were required (helmet wearing rates were 87% before the HWL) (table 3). In contrast, the cost of the law for adult

Table 3 Cost effectiveness estimates by age group (five year outcomes and costs in NZ$ for 2000)

	Age 5–12	Age 13–18	Adults
Number of helmets required	10195	84999	328162
Cost of helmets (a) ($)	180792	1507312	5819397
Head injuries averted			
Short stay hospital inpatient	16.9	43.4	114.4
Long stay hospital inpatient	1.2	3.3	13.8
Total head injuries averted	18.1	46.8	128.2
Total healthcare costs averted ($)	28387	75110	173158
Total societal costs averted (b) ($)	471920	1279050	4289602
Cost per head injury averted ($)	9990	32241	45396
Benefit:cost ratio (b/a)	2.610	0.849	0.737
Net benefit (societal perspective; b–a) ($)	291128	–228262	–1529796

Table 4 Results of sensitivity analysis: costs, benefits, and benefit:cost ratios (BCR)

	Age 5–12			Age 13–18			Adults		
	Costs of law ($)	Value of benefits ($)	BCR	Costs of law ($)	Value of benefits ($)	BCR	Costs of law ($)	Value of benefits ($)	BCR
Base case*	180792	471920	2.61	1507312	1279050	0.85	5819397	4289602	0.74
Cost of helmet: $50.00	453769	471920	1.04	3761912	1279050	0.34	14791731	4289602	0.29
Cost of helmet: $10.00	90580	471920	5.21	756834	1279050	1.69	2918097	4289602	1.47
Life of helmet: 7 years	180792	629156	3.48	1507312	1703263	1.13	5819397	5703009	0.98
Life of helmet: 3 years	180792	298307	1.65	1507312	813948	0.54	5819397	2735117	0.47
Law enforcement costs	287727	471920	1.64	1760586	1279050	0.73	6564065	4289602	0.65
Discount rate: 10%	180792	426669	2.36	1507312	1160630	0.77	5819397	3898996	0.67
Discount rate: 0%	180792	522489	2.89	1507312	1416873	0.94	5819397	4771906	0.82
Head injuries averted: upper CI	180792	1180572	6.53	1507312	1733409	1.15	5819397	5295651	0.91
Head injuries averted: lower CI	180792	0	0	1507312	829022	0.55	5819397	3317056	0.57
Costs of head injury increase 20%	180792	565879	3.13	1507312	1537458	1.02	5819397	5179263	0.89
Costs of head injury decrease 20%	180792	377855	2.09	1507312	1024972	0.68	5819397	3433444	0.59
Numbers of quitters	76697	2445747	31.89	670778	8887908	13.25	4349481	15258505	3.51
Cost of quitting: $19.95	193803	2445747	12.62	1611879	8887908	5.51	6003137	15258505	2.54
Cost of quitting: $49.95	369903	2445747	6.61	3027069	8887908	2.94	8489837	15258505	1.80

*Base case: cost of helmet = $19.95; life of helmet = 5 years; discount rate = 5%; no quitters; head injuries averted per year: 4.0 5–12 years, 10.3 13–18 years, 28.8 adults; treatment costs: $1569 5–12 years, $1607 13–18 years, $1351 adults; societal cost of serious head injury = $196360; societal cost of minor head injury = $13309.

cyclists was large due to the relatively large number of helmets required under the law (39% pre-law wearing rate).

The helmet wearing law was most cost effective for 5–12 year olds and least cost effective for adults. The benefit:cost ratio was greater than one for the 5–12 year age group only with a return of $2.61 for each $1 invested in helmets. For the 13–18 years and adults, the return on $1 was $0.85 and $0.74 respectively. Hospital inpatient costs averted were small, accounting for 15.7%, 5.0%, and 3.0% of the costs of helmets in the 5–12, 13–18, and adults respectively.

The net benefits of the HWL were positive for the youngest age group only; for the 13–18 age group and adults, the costs of the HWL exceeded the benefits. The total net cost to society of the HWL for adults was more than $1.5 million over five years.

Sensitivity analysis

The results were most sensitive to the cost of a helmet, the life of a helmet, the number of head injuries averted, and quitting cycling (table 4). If helmets were significantly cheaper, the HWL would be cost saving for all age groups. The break even helmet prices (excluding tax) were $46.30, $15.05, and $13.07 for the 5–12, 13–18, and adults. The HWL was cost saving for the 5–12 and 13–18 age groups if helmet life was greater than seven years, if the upper bound for helmet effectiveness was used[1] or if the societal cost of head injuries is increased by 20%. The inclusion of law enforcement costs did not affect the findings.

A key parameter was the number of cyclists who quit cycling (table 4). Increased numbers of quitters reduced the numbers of both head and non-head injuries and, because fewer cyclists purchase helmets, the costs of the HWL decreased. Even when other costs of quitting were included at a substantially higher cost than a helmet, the HWL continued to be cost saving for all age groups.

DISCUSSION

This study shows that the costs associated with the HWL were far greater for adults than for children, and the HWL was cost saving in the youngest age group. The reasons were that more adults than children were required to purchase a bicycle helmet due to the law (table 3) and relatively fewer head injuries were averted in adults than children.

The important factors affecting cost effectiveness of a HWL were the cost and life of helmets (recommended replacement every five years),[21] the effectiveness of helmets, helmet wearing rates before the HWL was introduced, and the effect on cyclist participation (quitting). However, the estimates from "quitters" may be overstated because of a general downward trend in cycling, both in New Zealand and internationally.[25]

Because the costs of helmet promotion, publicity campaigns, passing legislation through parliament, and enforcing the HWL were not included in this analysis, the estimates understate the true costs of the HWL. However, these costs will

Key points

- The New Zealand bicycle helmet wearing law, introduced on 1 January 1994, was an effective mechanism to increase helmet wearing rates, and has resulted in a reduction in head injuries of 18 for ages 5–12, 47 for ages 13–18, and 128 for ⩾19 years of age over the five year life of a helmet.
- The costs incurred over five years due to purchasing helmets were NZ $180 792 for those aged 5–12 years, $1 507 312 for those aged 13–18 years, and $5 819 397 for those ⩾19 years of age.
- From a societal view, the law results in a net benefit (benefit:cost ratio) of $291 128 (2.61) for ages 5–12 years, and net losses of –$228 262 (0.85) for ages 13–18, and –$1 529 796 (0.74) for ⩾19 years.
- If people choosing to quit cycling rather than purchase a helmet are included in the study, the net benefits (benefit:cost ratio) were $2 369 050 (31.89) for ages 5–12, $8 217 130 (13.25) for ages 13–18, and $10 909 024 (3.51) for ⩾19 years.
- The findings are most sensitive to the cost and life of helmets, the helmet wearing rates before the law, and the effectiveness of helmets in preventing head injury.

not affect the marginal costs of the HWL. In contrast, the social costs saved due to fewer head injuries are likely to understate the true costs—especially for cases involving fatality or neurobehavioural damage (where costs are incurred for potentially the rest of life). Preventing one permanently disabling head injury is at least as important as preventing one fatality.[24] Consequently, the minimum value of preventing a permanently disabling head injury is $2 million—the value of preventing one fatality.[24] In this case, our estimates of the net benefit from helmet wearing are likely to be understated. Similarly, there are many other benefits of helmet wearing that were not included, such as the value of averting minor injuries, increased visibility to other road users, and increased (or reduced) cyclist caution.[26]

Mandatory bicycle helmet wearing laws do go some way in reducing injuries to cyclists. However, bicycle helmets do have some limitations. For example, the effectiveness of helmets is reduced where collision forces are greater than 30 km per hour. Consequently, additional methods to reduce injuries to cyclists (and not only head injuries), such as cycle paths to separate cyclists from other traffic, require evaluation, including economic evaluation.

We have found that the introduction of the 1994 bicycle helmet law in New Zealand has been more cost effective when aimed at those cyclists in a younger age group. The cost effectiveness ratios between age groups differ substantially, and therefore, it is important that any future mandatory helmet wearing policies in other countries consider the costs and cost effectiveness of implementing the law to specific age groups before legislation is made.

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