Changes in Motorcycle-Related Head Injury Deaths, Hospitalizations, and Hospital Charges Following Repeal of Pennsylvania's Mandatory Motorcycle Helmet Law

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To evaluate the 2003 repeal of Pennsylvania's motorcycle helmet law, we assessed changes in helmet use and compared motorcycle-related head injuries with nonhead injuries from 2001–2002 to 2004–2005. Helmet use among riders in crashes decreased from 82% to 58%. Head injury deaths increased 66%; nonhead injury deaths increased 25%. Motorcycle-related head injury hospitalizations increased 78% compared with 28% for nonhead injury hospitalizations. Helmet law repeals jeopardize motorcycle riders. Until repeals are reversed, states need voluntary strategies to increase helmet use. (*Am J Public Health.* 2008;98:1464–1467. doi:10.2105/AJPH.2007.123299)

In 1975, Congress stopped requiring states to enact mandatory, universal motorcycle

helmet use laws as a condition for receipt of federal highway construction funds. By 1980, 27 states had repealed mandatory helmet laws. Despite consistent evidence that repeals led to increases in motorcycle-related deaths and injuries,[1] several more states followed suit in the late 1990s and early 2000s. Most recently, in 2003, Pennsylvania repealed its universal helmet law, now requiring helmets only for riders younger than 21 years or those with fewer than 2 years of riding experience who have not completed a safety program.

In 2006, the Pennsylvania Legislative Budget and Finance Committee released a report describing a 33% increase in trauma center admission rates for motorcycle-related head injuries from calendar years 2001–2002 to 2004–2005,[2] but only an 11% increase in motorcycle–related death rates. Media coverage focused on the small post-repeal change in death rates rather than the full injury picture. To supplement the report, we examined statewide motorcycle crash, hospitalization, and death data. To better control for nonhelmet factors affecting the number of motorcycle–related injuries, such as changes in general motorcycle use, miles traveled, and weather, we compared changes in head injury rates with changes in nonhead injury rates, assuming that nonhelmet factors affect head and nonhead injuries equally.

TABLE 1—Number of Motorcycle Registrations, Motorcycle Riders in Reportable Crashes, Motorcycle-Related Deaths and Hospitalizations, and Corresponding Rates per 10 000 Motorcycle Registrations, by Year: Pennsylvania, 2001–2005

Year	Motorcycle Registrations	Riders in Crashes	Riders in Crashes per 10 000 Registrations	Deaths	Deaths per 10 000 Registrations	Motorcycle Injury Hospitalizations	Hospitalizations per 10 000 Registrations
2001	237 276	3 364	141.8	106	4.5	1 226	51.7
2002	248 775	3 455	138.9	116	4.7	1 319	53.0
2003	267 826	3 513	131.2	138	5.2	1 354	50.6
2004	291 015	4 133	142.0	133	4.6	1 645	56.5
2005	318 283	4 625	145.3	177	5.6	1 986	62.4

METHODS

The number of Pennsylvania motorcycle registrations and the number of motorcycle riders, including drivers and passengers, involved in "reportable" crashes were obtained from the Pennsylvania Department of Transportation (PennDOT) for 2001 to 2005 (Tables 1 and 2). "Reportable" crashes included those involving an injury or those in which at least 1 vehicle was towed. We determined helmet status for riders in crashes, categorized as "used," "used improperly," "none," or "unknown." Our use of *motorcycle* included motorized pedacycles and motor-driven cycles.

The number of in-state motorcycle traffic–related deaths among Pennsylvania residents was obtained from the Pennsylvania Department of Health (DOH). Death certificate data include causes of death coded according to the *International Classification of Diseases, 10th Revision* (*ICD-10*).[3] Motorcycle traffic–related deaths were defined as those with *ICD-10* codes V20–V28 (.3–.9) or V29.4–V29.9 as underlying causes of death on the death certificate.[4] Motorcycle–related deaths were categorized as head injuries if 1 of the cause-of-death codes included a traumatic brain injury diagnosis code.[5]

The number of Pennsylvania residents hospitalized at acute care hospitals in Pennsylvania for motorcycle traffic–related injuries was obtained from DOH using data compiled by the Pennsylvania Health Care Cost Containment Council. The hospital discharge database includes diagnoses coded according to the *International Classification of Diseases, 9th Revision, Clinical Modification* (*ICD-9-CM*).[6] Inpatient records with *ICD-9-CM* codes E810–E819 (.2, .3) were selected.[7] Motorcycle-related hospitalizations were classified as head injuries if 1 of the first 5 *ICD-9-CM* diagnosis codes included a traumatic brain injury code.[5] DOH also provided aggregate hospital charges and summary disposition information for motorcycle-related hospitalizations. Drivers and riders of all ages were included

TABLE 2—Number of Head Injury and Nonhead Injury Motorcycle-Related Deaths, Hospitalizations, and Corresponding Rates per 10 000 Motorcycle Registrations, by Year: Pennsylvania, 2001–2005

Year	Motorcycle Registrations	Motorcycle Head Injury Deaths	Motorcycle Head Injury Deaths per 10 000 Registrations	Motorcycle Nonhead Injury Deaths	Motorcycle Nonhead Injury Deaths per 10 000 Registrations	Motorcycle Head Injury Hospitalizations	Motorcycle Head Injury Hospitalizations per 10 000 Registrations	Nonhead Injury Hospitalizations	Nonhead Injury Hospitalizations per 10 000 Registrations
2001	237 276	31	1.3	75	3.2	354	14.9	872	36.8
2002	248 775	48	1.9	68	2.7	393	15.8	926	37.2
2003	267 826	44	1.6	94	3.5	439	16.4	915	34.2
2004	291 015	51	1.8	82	2.8	602	20.7	1 043	35.8
2005	318 283	80	2.5	97	3.0	730	22.9	1 256	39.5

TABLE 3—Number of Motorcycle Registrations, Motorcycle Riders in Reportable Crashes, Motorcycle-Related Deaths and Hospitalizations, and Corresponding Rates per 10 000 Motorcycle Registrations, by Study Period: Pennsylvania, 2001–2002 and 2004–2005

	Study Period			
	2001–2002	2004–2005	% Change	*P*[a]
Registrations	486 051	609 298	25.4	
Riders in crashes	6 819	8 758	28.4	
Riders in crashes per 10 000 registrations	140.3	143.7	2.5	.133
Deaths	222	310	39.6	
Deaths per 10 000 registrations	4.6	5.1	11.4	.217
Injury hospitalizations	2 545	3 631	42.7	
Hospitalizations per 10 000 registrations	52.4	59.6	13.8	<.001

[a]*z* statistic (2-sided) for the difference in rates in 2004–2005 and 2001–2002.

in the analyses to evaluate the overall effect of the repeal.

The number of riders in motorcycle crashes per 10 000 motorcycle registrations was calculated for the 2 years before (2001–2002) and after (2004–2005) the September 2003 repeal. The number of motorcycle-related fatalities and hospitalizations per 10 000 motorcycle registrations was calculated for the same 2 time periods. Hospital charges were converted to 2005 dollars using the Consumer Price Index for "hospital and related services."[8] The percentage change from 2001–2002 to 2004–2005 was calculated for all injury indices. Differences in rates, assessed with the *z* statistic, were considered statistically significant at the 0.05 level.[9] The pre- and postrepeal difference in the percentage of helmet wearers, defined as those categorized as "used" divided by those with known helmet status, was assessed using the χ^2 test.

RESULTS

Helmet use by motorcycle riders involved in reportable crashes in Pennsylvania declined from 82% in 2001–2002 to 58% after the repeal (2004–2005; $P<.001$).

Both the number of motorcycle registrations and the number of motorcycle riders in reportable crashes increased from 2001–2002 to 2004–2005 (Table 3). The number of riders in reportable crashes per 10 000 registrations, however, did not change significantly (Table 3).

The number of Pennsylvania residents dying in Pennsylvania from motorcycle-related injuries increased 40% after the helmet law was repealed (Table 3). The number of head injury deaths increased 66%, whereas the number of nonhead injury deaths increased 25% (Table 4). The rate of motorcycle-related head injury deaths per 10 000 registrations increased 32% (borderline significance; $P=.045$), but there was no significant change (–0.1%) in nonhead injury deaths per 10 000 registrations (Table 4).

The number of acute-care motorcycle-related hospitalizations for Pennsylvania residents increased 43% from 2001–2002 to 2004–2005 (Table 3). Motorcycle-related head injury hospitalizations increased 78%, whereas nonhead injury hospitalizations increased 28% (Table 4). The hospitalization rate per 10 000 registrations increased significantly (42%) for head injuries but not for nonhead injuries (2%; Table 4).

Total acute care hospital charges (in 2005 dollars) for motorcycle-related head injuries increased 132%, from $53 501 923 in 2001–2002 to $124 236 056 in 2004–2005, compared with a 69% increase for nonhead injuries. The percentage increase in the mean charge per motorcycle-related hospitalization was nearly identical for head and nonhead injuries (32% and 31%, respectively). The larger percentage increase in total charges for head injuries compared with nonhead injuries reflects the larger percentage increase in the number of head injury hospitalizations. The number of head injured hospitalized motorcyclists requiring further care at other

TABLE 4—Number of Head Injury and Nonhead Injury Motorcycle-Related Deaths, Hospitalizations, and Corresponding Rates per 10 000 Motorcycle Registrations, by Study Period: Pennsylvania, 2001–2002 and 2004–2005

	Study Period			
	2001–2002	2004–2005	% Change	*P*[a]
Registrations	486 051	609 298	25.4	
Head injury deaths	79	131	65.8	
Head injury deaths per 10 000 registrations	1.6	2.2	32.3	.045
Nonhead injury deaths	143	179	25.2	
Nonhead injury deaths per 10 000 registrations	2.9	2.9	-0.1	.990
Head injury hospitalizations	747	1 332	78.3	
Head injury hospitalizations per 10 000 registrations	15.4	21.9	42.2	<.001
Nonhead injury hospitalizations	1 798	2 299	27.9	
Nonhead injury hospitalizations per 10 000 registrations	37.0	37.7	2.0	.529

[a]*z* statistic (2-sided) for the difference in rates in 2004–2005 and 2001–2002.

facilities, largely for rehabilitation and long-term care, increased 87% (165 patients in 2001–2002; 309 in 2004–2005), compared with a 16% increase for nonhead injured hospitalized motorcyclists. Charges for rehabilitation and long-term care were not available.

DISCUSSION

As in many states, the number of motorcycle registrations and the number of reported crashes increased in Pennsylvania following repeal of the mandatory helmet law. The rate of crashes per 10 000 registrations, however, did not change significantly, indicating little change in driving habits, road conditions, or risk behavior of motorcyclists. Consistent with other studies, our analysis shows increases in the number and rate of deaths and serious injuries following the repeal of a mandatory universal motorcycle helmet law.[10–18]

Our study is important for 2 main reasons. First, we used population-based hospital-discharge data compiled from all acute care hospitals in the state, whereas most previous studies of postrepeal changes in motorcycle-related hospitalizations include data only from selected trauma centers. Second, we attempt to control for nonhelmet factors by comparing changes in head injuries to nonhead injuries, assuming that nonhelmet factors, such as miles traveled, weather, and driving practices, generally affect both head and nonhead injuries equally. The large postrepeal increases in head injuries relative to nonhead injuries, both for statewide deaths and hospital discharges, indicate that lower helmet use was most likely responsible.

Limitations

To identify head injuries, we used *ICD* codes on death certificates and hospital discharge data, but these are not routinely assessed for validity and reliability. We assumed that coding practices did not change during the study period and that trends were not affected. Also, vital statistics data have been shown to underestimate the number of motorcycle deaths;[19] again, we assumed trends were not affected.

The hospital charges presented here have 2 shortcomings: (1) they are not equivalent to costs, and (2) they do not include physician costs, rehabilitation costs, or nonmedical costs including loss of productivity, and as such, they greatly underestimate the financial burden of motorcycle-related injuries.

Conclusions

These data strongly suggest that Pennsylvania's mandatory helmet law was effective in preventing traumatic brain injury, given that its repeal led to disproportionate increases in head injuries. Data alone, however, are not sufficient to reverse helmet law repeals; many states maintain repeals despite multiple studies showing increases in deaths, injuries, and costs. Until life-saving mandatory helmet policies are reinstated, voluntary helmet use programs should be developed and evaluated. ■

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Contributors

K.J. Mertz conducted the analyses and drafted the article. H.B. Weiss designed the analyses, conducted preliminary analyses, and revised the article.

Human Participant Protection

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References

1. *Highway Safety: Motorcycle Helmet Laws Save Lives and Reduce Costs to Society.* Washington, DC: US Government Accountability Office; 1991. Report GAO/RCED-91-170.

2. Legislative Budget and Finance Committee. *Motorcyclist Injuries and Fatalities Since the 2003 Repeal of the Mandatory Helmet Law.* Harrisburg: Pennsylvania General Assembly; 2006.

3. *International Classification of Diseases, 10th Revision.* Geneva, Switzerland: World Health Organization; 1990.

4. Centers for Disease Control and Prevention. External cause of injury mortality matrix for ICD-10. Available at: http://www.cdc.gov/nchs/data/ice/icd10_transcode.pdf. Accessed March 15, 2007.

5. Centers for Disease Control and Prevention. Rates of hospitalization related to traumatic brain injury—nine states, 2003. *MMWR Mob Mortal Wkly Rep.* 2007;56:167–170.

6. *International Classification of Diseases, 9th Revision.* Geneva, Switzerland: World Health Organization; 1980.

7. Centers for Disease Control and Prevention. Recommended framework of E-code groupings for presenting injury mortality and morbidity data. Available at: http://www.cdc.gov/ncipc/whatsnew/matrix2.htm. Accessed March 15, 2007.

8. Bureau of Labor Statistics. Archived Consumer Price Index Detailed Report Information. Available at: http://www.bls.gov/cpi/cpi_dr.htm. Last modified January 22, 2008. Accessed November 26, 2007.

9. Hoyert DL, Heron MP, Murphy SL, Kung HC. Deaths: final data for 2003. *Natl Vital Stat Rep.* 2006; 54:1–120.

10. Bledsoe GH, Li G. Trends in Arkansas motorcycle trauma after helmet law repeal. *South Med J.* 2005;98: 436–440.

11. Bledsoe GH, Schexnayder SM, Carey MJ, et al. The negative impact of the repeal of the Arkansas motorcycle helmet law. *J Trauma.* 2002;53:1078–1086.

12. Ho EL, Haydel MJ. Louisiana motorcycle fatalities linked to statewide helmet law repeal. *J La State Med Soc.* 156:151–152.

13. Hotz GA, Cohn SM, Popkin C, et al. The impact of a repealed motorcycle helmet law in Miami-Dade County. *J Trauma.* 2002;52:469–474.

14. Muller A. Florida's motorcycle helmet law repeal and fatality rates. *Am J Public Health.* 2004;94:556–558.

15. Preusser DF, Hedlund JH, Ulmer RG. *Evaluation of Motorcycle Helmet Law Repeal in Arkansas and Texas.* Washington, DC: US Dept of Transportation; 2000. DOT HS 809 131.

16. Ulmer RG, Preusser DF. *Evaluation of the Repeal of Motorcycle Helmet Laws in Kentucky and Louisiana.* Washington, DC: US Dept of Transportation; 2003. DOT HS 809 530.

17. Ulmer RG, Shabanova Northrup V. *Evaluation of the Repeal of the All-Rider Motorcycle Helmet Law in Florida.* Washington, DC: US Dept of Transportation; 2005. DOT HS 509 849.

18. National Highway Traffic Safety Administration. Evaluation of the repeal of motorcycle helmet laws. *Ann Emerg Med.* 2001;37:229–230.

19. Sosin DM, Sacks JJ, Holmgreen P. Head injury-associated deaths from motorcycle crashes: relationship to helmet-use laws. *JAMA.* 1990;264:2395–2399.