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Impact of North Carolina's Motorcycle Helmet Law on Hospital Admissions and Charges for Care of Traumatic Brain Injury

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Abstract

Background: North Carolina (NC) requires motorcyclists of all ages to wear federally-approved safety helmets. The purpose of this paper was to estimate the impact of this state law in terms of hospital admissions for traumatic brain injury (TBI) and associated hospital charges.

Methods: Hospital admissions of NC motorcyclists with TBIs and associated hospital charges in 2011 were extracted from the NC Hospital Discharge Data system. Projected hospital admissions and charges for the same year, under the counterfactual condition of NC without a universal motorcycle helmet law, were estimated using various substitutes (Florida, Pennsylvania, and South Carolina residents treated in NC).

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Results: NC's universal helmet law prevented at least 190 hospital admissions of NC motorcyclists with TBI in 2011. Averted hospital charges involving taxpayer-funded sources (i.e., government and public charges) were at least \$9.5 million for 2011, and total averted hospital charges for 2011 were at least \$25.3 million.

Limitations: Cost estimates are limited to inpatients during the initial period of hospital care. This study was unable to capture long-term healthcare costs and productivity losses involving NC TBI patients and their caregivers.

Conclusions: NC's universal motorcycle helmet law generates health and economic benefits for the state and its taxpayers.

Introduction

Motorcycling is a popular and fuel-efficient means of commuter transportation, and provides a social focus for communities of recreational motorcyclists. However, from a traffic safety perspective, motorcyclists are a high-risk population of road users. Relative to passenger car occupants, motorcyclists are more than 26 times as likely to be killed and five times as likely to be nonfatally injured, per vehicle mile traveled [1]. A variety of factors contribute to this disparity. Motorcycles are less conspicuous than passenger vehicles [2, 3] and are thus more likely to be involved in traffic crashes; motorcycles provide less protection from crash forces because of their open design; and motorcyclists are over-represented in alcohol-related and speed-related fatal crashes [1].

Traumatic brain injuries (TBIs) are a leading cause of motorcycle-related death and are among the most severe and costly of nonfatal motorcyclist injuries [4, 5]. Non-fatal TBIs consume significant medical resources in the acute phase of treatment and may require extensive rehabilitation [4]. Helmets that meet federal safety standards are the most effective way to reduce the risk of head trauma in a motorcycle crash [6]. Helmets are estimated to be 42% effective at preventing death and 69% effective at preventing head injury when a crash occurs [7].

Universal helmet laws, defined as laws that require all motorcycle riders to wear a helmet, are effective at sustaining high levels of helmet use [8, 9]. Currently, 19 states and the District of Columbia have universal helmet laws [10]. Among the remainder, 3 states have no helmet law and 28 have partial helmet laws. Partial helmet laws require only certain subgroups to wear a helmet, usually those under the age of 18 or 21. Multiple studies have reported that when states weaken or repeal their universal helmet law to a partial helmet law or no helmet law, helmet use decreases and motorcycle-related deaths and head injuries increase [9, 11–14].

The purpose of this study was to estimate the impact of North Carolina's (NC) universal motorcycle helmet law on the incidence and burden of motorcycle-related TBI to NC residents. NC has high helmet use and has motorcycle injury and death rates below those of other southeastern states without universal helmet laws, such as South Carolina (SC) and Florida [15–17]. However, an analysis of the impact of NC's universal helmet law has not

previously been conducted. This study focused on hospital admissions and charges for the initial period of care for NC motorcyclists with TBI treated as inpatients in NC hospitals.

Methods

Overview:

This study examined hospital charges for NC residents admitted to NC hospitals in calendar year 2011 (1/1/2011 to 12/31/2011). We quantified the healthcare impact of the state's universal helmet law by comparing the observed (actual) incidence and charges for these patients to a hypothetical (counterfactual) NC with no universal helmet law in 2011. We used discharge data from NC hospitals, combined with results from published evaluations from other states that have weakened or repealed helmet laws [9, 12, 13].

Actual Inpatient Incidence and Hospital Charges for 2011 (Universal Helmet Law in Effect):

Data on motor vehicle traffic-related injuries sustained by NC motorcyclists admitted to NC hospitals in 2011 were abstracted from the NC Hospital Discharge Data (HDD) system. HDD are abstracted from hospital administrative claim forms used to bill payers. Hospitalized motorcyclists were identified using International Classification, 9th Revision, Clinical Modification (ICD-9-CM) External Cause of Injury codes (codes in the range E810–E819 with a fourth digit of .2 or .3). Among these discharge records, motorcyclists suffering a TBI were identified using ICD-9-CM Diagnosis codes (800.0–810.9, 803.0–804.9, 850–854.19, 950.1–950.3, 959.01, 995.55, consistent with the Centers for Disease Control and Prevention's (CDC) TBI definition). Total hospital charges included routine, ICU/CCU, surgery, lab, pharmacy, radiology, respiratory, therapy, supplies, and other charges during the initial period of care.

Counterfactual Inpatient Incidence and Hospital Charges:

The counterfactual of interest is the hypothetical condition of NC in 2011 with no universal helmet law. In states in which the universal helmet law has been repealed or weakened to a partial helmet law, there are two effects: 1) an increase in the number of motorcyclists with TBIs and an 2) increase in the average cost of care per motorcyclist with a TBI [12, 13]. Our analyses therefore estimated both an incidence increase and an average cost increase. We estimated these parameters using data from other states. Because there is uncertainty in utilizing data from other states as a substitute for the counterfactual NC, we used three different populations to estimate the increase in incidence and average cost and presented a range of estimates:

1. Pre-repeal and post-repeal data from Florida [13]
2. Pre-repeal and post-repeal data from Pennsylvania [12]
3. Results of universal helmet law repeal impacts from the Community Preventive Services Task Force [9] and data on hospital charges to SC residents treated for motorcycle crash-related TBI in NC hospitals

Florida and Pennsylvania were selected because these states are approximately comparable to NC in terms of factors that influence motorcyclist behaviors and exposures (e.g. length of

riding season, road environment), and well-conducted evaluation studies of universal helmet law repeal were available for these states. SC residents treated in NC hospitals were selected because they provided a comparison group treated in the same hospitals as NC residents. Like the data on NC residents, these data were obtained from the NC HDD system.

In the Florida study, Ulmer & Northrup [13] examined acute care hospital-admitted motorcyclists with a principal diagnosis of head/brain/skull injury before and after the January 2000 repeal of Florida's universal helmet law. Comparing the 30 months pre-law to the 30 months post-law they found cases increased from 602 to 1097, an 82% increase. Adjusted for inflation, total acute care costs for these injuries averaged \$34,518 per case in the 30 months pre-law, and \$39,877 per case in the 30 months after the law change, an increase of 16%.

In the Pennsylvania study, Mertz & Weiss [12] examined motorcycle-related hospitalizations with head injuries (classified as having a TBI code, based on the CDC definition of TBI, listed as one of the first five ICD-9CM diagnosis codes). The authors examined hospitalizations two years before (2001–2002) and after (2004–2005) the September 2003 repeal of Pennsylvania's universal helmet law. They found motorcycle-related head injury hospitalizations increased 78% during this time, and the percentage increase in the mean charge per motorcycle-related head injury hospitalization was 32%.

Motorcyclists who were residents of SC, a state without a universal helmet law, and treated in NC hospitals provided a third estimate of expected average hospital charges in the counterfactual condition. The average charge for SC inpatients with motorcycle-related TBI was extracted from the NC HDD system. The criteria used to define motorcycle-related TBI for SC patients were identical to those used for NC patients. For some areas of SC, the nearest trauma hospital is located in NC. We assumed that many of the SC motorcyclist injuries treated in NC hospitals were involved in crashes in SC near the border of the two states and that the helmet use and TBI severity distribution of these SC residents was representative of all SC residents admitted to hospitals with TBIs in 2011. These patients had a mean charge of \$104,814, compared to \$83,428 for NC residents, an increase of 26%.

Because the NC HDD system could not be used to estimate the expected incidence increase in NC hospital admissions for NC motorcyclists with TBIs without a universal helmet law (counterfactual condition), we used an estimate from a recent systematic review from the Community Preventive Services Task Force [9]. The review estimated a 69% increase in nonfatal head injuries when a state changes from a universal helmet law to a partial helmet law or no helmet law.

Total Charges and Payer Source:

To estimate total hospital charges, the expected mean charge per admitted motorcyclist was multiplied by the expected number of admitted motorcyclists. Annual averted hospital charges were calculated as the difference between the actual charges in 2011 and the estimated charges obtained from each of the three substitute populations discussed above. To estimate expected charges billed to each source of payment, we obtained data on expected sources of payment for hospitalized motorcyclists with TBIs from 2011 NC HDD claims.

Expected sources of payment were categorized as government or other public sources (e.g., Medicaid, Medicare, and hereafter referred to as “taxpayer sources”), private insurance (e.g., Blue Cross Blue Shield of North Carolina) and other forms of payment, and self-payment. The percentage of all charges billed to each source of payment was multiplied by the total expected charges to estimate the total expected charges for each source of payment.

Results

In 2011, there were 275 hospital admissions of NC motorcyclists with TBIs (Table 1). The mean hospital charge per case was approximately \$83,400 with total charges for all cases of \$22.9 million. If NC’s universal helmet law had been weakened or repealed in 2011 (counterfactual condition), the expected number of NC hospital admissions for NC motorcyclists with TBIs would have increased to between 465 and 501 cases. This range is the actual number of motorcycle-related TBI admissions (n=275), multiplied by the expected incidence increase for each of the three substitute populations (FL: 82%, PA: 78%, SC: 69%). Additionally, the expected mean charges per injured NC motorcyclist with a TBI would have increased to between \$96,400 and \$110,100. This range is the actual average charge per motorcycle-related TBI admission (\$83,428) multiplied by the expected average charge increase in each of the three substitute populations (FL: 16%, PA: 32%, SC: 26%). Combining expected incidences and expected mean charges per injured NC motorcyclist with a TBI yielded total expected charges of \$48.3 million to \$53.9 million in the counterfactual condition of a weakened or repealed universal helmet law in 2011, more than double the actual charges. Thus, by maintaining a universal helmet law, between \$25.3 million and \$31.0 million in hospital charges were averted (expected charges minus actual charges) in 2011.

Charges to taxpayer sources for the treatment of NC motorcyclists in NC hospitals were approximately \$8.6 million in 2011, or 38% of total charges (Table 1). Applying this proportion to total expected charges if NC’s universal helmet law had been weakened or repealed in 2011 (counterfactual condition), we found that expected hospital charges to taxpayer sources would have increased to between \$18.2 million and \$20.3 million. Therefore, by maintaining a universal helmet law, between \$9.5 million and \$11.6 million in hospital charges to taxpayer sources were averted. Averted charges for private sources were \$12.6 million to \$15.4 million, and \$3.2 million to \$3.9 million for self-payment.

Discussion

Universal helmet laws increase helmet use, prevent injuries and deaths, and reduce costs [9, 18–23]. Similarly, weakening or repealing these laws has been shown to decrease helmet use, result in increased injuries and deaths, and increase costs [9, 11–14]. By maintaining NC’s universal helmet law, there were at least 190 fewer NC hospital admissions of NC motorcyclists with TBIs in 2011 than if the state had not had a universal helmet law. Additionally, we estimated that total hospital charges for admitted NC motorcyclists with TBIs were approximately half what they would have been without a universal helmet law. Our estimates of averted charges by payer source indicated that approximately \$9.5 million to \$11.6 million in NC hospital charges for the treatment of NC motorcyclists to taxpayer-

based payer sources were averted. However, the proportion of averted charges to taxpayer-based payer sources may be an underestimate. Lawrence et al. [24] noted that some motorcyclists designated as “self-pay” on billing records will likely have some proportion of their costs shifted to government sources, e.g., if they become unable to pay all of their bills due to the costly nature of their injuries.

It is important to note that this study was focused on the initial period of care only. Initial care is typically only a small proportion of the care provided (and total costs generated) during the treatment and recovery of TBI. CDC reported that while lifetime medical costs associated with nonfatal hospitalized TBIs averaged about \$79,000 per patient in 2010 dollars, lifetime work loss costs averaged an additional \$179,000 per patient [16]. Additionally, Whiteneck et al. [25] found that about one-third of adults hospitalized with TBI from all causes still required help with daily activities one year after their discharge. Miller et al. [26] documented major employment impacts for motorcyclists with TBIs, with employment dropping from just over 80% to 45% one year post-injury and unemployment tripling (11% to 32%). In addition to personal productivity losses, there are significant losses associated with caregiver burden and reduced quality of life [4, 24].

The results of this study confirm a previous study reporting that universal helmet laws produce economic benefits [27]. The previous study reported that states with universal helmet laws save, on average, nearly four times the costs per registered motorcycle compared to states without a universal helmet law. Moreover, that study found that NC led the nation in terms of both lives saved and costs saved by helmet use per registered motorcycle. NC was estimated to save \$163 million in medical and productivity costs due to helmet use per 100,000 registered motorcycles in 2010. For comparison, southeastern states without universal helmet laws, such as SC and Florida were estimated to save \$27 million and \$38 million per 100,000 registered motorcycles, respectively [6, 27].

Some states that have weakened their universal helmet law to a partial helmet law have attempted to address the costly nature of these injuries by requiring that unhelmeted motorcyclists carry a minimal amount of insurance to cover medical costs associated with a crash [10]. However, research has shown these legislative provisions are typically insufficient to cover the increased costs associated with these injuries, and many of the costs are paid for by taxpayer-funded sources [13]. Florida weakened its motorcycle helmet law from a universal to a partial helmet law that required only riders under the age of 21 and riders with less than \$10,000 of medical insurance to wear a helmet. However, post-law less than a quarter of hospitalized motorcyclists with TBIs had medical costs that were less than \$10,000 with a mean cost per case of nearly \$40,000 (in 1998 dollars) [13]. Additionally, only 63% of those admitted with head injuries were covered by private insurance, with the remainder having their treatment classified as self-pay or billed to charitable or public sources [13].

This study has some limitations. First, we relied on E-codes to identify hospitalized motorcyclists with a TBI. While NC hospitals have high use of E-codes, it is possible that some motorcyclists with TBIs were not correctly coded as such [28]. Therefore, our results could underestimate the true number of actual injured motorcyclists. Second, we presented a

range of estimated injury incidence and mean charge increases, and each estimate was based on a slightly different injury definition. The Pennsylvania estimate used a similar definition to our study by including motorcyclists with a TBI code as one of the first 5 ICD9-CM diagnosis codes [12]. The Florida estimate included hospital-admitted motorcyclists with a principal diagnosis of a head, brain, or skull injury [13], which is identical to the definition used in our study. While our estimate based on SC residents admitted to NC hospitals used the same injury definition, we assumed that the distribution of TBI severity for these SC residents was representative of what the TBI severity distribution for NC residents would have looked like had the state not had a universal helmet law. This may not be the case if more severe injuries are associated with an increased probability of transfer across state lines. Third, because we do not have information on NC motorcyclists admitted to out-of-state hospitals, total charges associated with hospital admissions for NC motorcyclists with TBIs is likely greater than what we have presented here. Fourth, some of the discharges included here result from transfers between hospitals or readmissions but this is expected to be a small proportion of the overall total discharges. Finally, it is important to note that charges are not equivalent to actual costs. The average charge-to-cost ratio for NC hospitals was approximately 3.2:1 in 2011–2012 [29]. However, because charge-to-cost ratios are an approximation and can vary considerably by hospital and we did not have hospital-specific information, we do not present costs here.

Conclusion:

NC's universal motorcycle helmet law provides key benefits in terms of reduced TBI hospital admissions to NC motorcyclists and averted NC hospital charges. NC hospitals had approximately 190 fewer admissions for NC motorcyclists with TBIs in 2011 than would have been expected in the absence of a universal helmet law. Total charges for NC motorcyclists hospitalized with TBI were approximately half what they would have been without a universal helmet law. At least \$9.5 million in hospital charges to taxpayer-based payer sources were averted because of NC's universal helmet law.

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TABLE 1.

Actual and Projected Incidence and Hospital Inpatient Charges for Motorcyclists with Traumatic Brain Injury (TBI)^d, North Carolina, 2011

| | Source or Substitute Population | Annual Number of Motorcyclist TBI Hospital Admissions | Average Hospital Charge per Motorcyclist TBI Inpatient Admission | Hospital Inpatient Charges for Motorcyclist TBIs | | | |
|--|--|---|--|--|----------------------------------|--------------|----------------------------|
| | | | | Government & Public Sources | Private Sources & Other Payments | Self-Payment | Total Charges, All Sources |
| A. Universal Motorcycle Helmet Law in Effect (Actual) | North Carolina 2011 | 275 | \$83,428 | \$8,624,989 | \$11,430,761 | \$2,886,961 | \$22,942,711 |
| B. No Universal Motorcycle Helmet Law (Counterfactual) | Florida 2000 ^b | 501 | \$96,359 | \$18,150,504 | \$24,054,996 | \$6,075,347 | \$48,280,847 |
| | Pennsylvania 2003 ^c | 490 | \$110,125 | \$20,265,264 | \$26,857,703 | \$6,783,201 | \$53,906,168 |
| C. Averted Losses (B minus A) | South Carolina residents treated in North Carolina Hospitals 2011 ^d | 465 | \$104,814 | \$18,312,705 | \$24,269,962 | \$6,129,639 | \$48,712,307 |
| | Florida 2000 ^b | 226 | \$12,931 | \$9,525,515 | \$12,624,235 | \$3,188,386 | \$25,338,136 |
| | Pennsylvania 2003 ^c | 215 | \$26,697 | \$11,640,275 | \$15,426,942 | \$3,896,240 | \$30,963,457 |
| | South Carolina residents treated in North Carolina Hospitals 2011 ^d | 190 | \$21,386 | \$9,687,716 | \$12,839,201 | \$3,242,678 | \$25,769,596 |

^aHospital inpatient charges for initial period of care, 2011 dollars, for North Carolina residents only.

^bUlmer & Northrup [13] reported an 82% increase in incidence and 16% increase in mean cost following the weakening of Florida's motorcycle helmet law from a universal to a partial law.

^cMertz & Weiss [12] reported a 78% increase in incidence and 32% increase in mean charges following the weakening of Pennsylvania's motorcycle helmet law from a universal to a partial law.

^dSouth Carolina residents with motorcycle crash-related TBI treated in NC hospitals in 2011 had mean charges that were 26% higher than NC residents with motorcycle crash-related TBI. Assumes a 69% increase in incidence based on pooled data from other states [9].