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Downstream Medical Cost of Repealing Universal Motorcycle Helmet Laws

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Brief Title: Motorcycle Helmet Law Cost

Background: While repeal of universal motorcycle helmet laws has been linked to increased crash-related morbidity, prior work evaluating the impact of repeal on crash-related costs is primarily limited to pre-post differences that neglect to account for underlying temporal trends. In this context, we sought to evaluate the impact of universal motorcycle helmet law repeal on crash-related costs using multiple-group interrupted time series methods.

Study Design: We evaluated the impact of Michigan's universal motorcycle helmet law repeal on inflation-adjusted inpatient costs associated with motorcycle crashes. We used data from the Healthcare Cost and Utilization Project State Inpatient Databases from 2009 to 2015. Michigan's repeal occurred in April 2012. We performed a multiple-group interrupted time series analysis comparing Michigan and four control states chosen for geographic and sociodemographic similarity.

Results: 19,685 patients age ≥21 years were identified, of whom 5,280 were from Michigan. Universal motorcycle helmet law repeal was associated with a $5,785 (95% CI $3,022-8,548, p<0.001) increase in inpatient costs per motorcycle crash patient in Michigan. This corresponded to a 26% increase in average cost per patient and $4.5 million/year excess annual expenditure over the study period. There was no association between repeal and cost change in the control group ($47, 95% CI -$1,094-1187, p=0.9).

Conclusions: Universal motorcycle helmet law repeal is associated with a 26% increase in crash-related inpatient costs. As policy repeal has occurred in 33 US states, a substantial portion of nationwide medical costs associated with motorcycle crashes may be potentially preventable.

Keywords: motorcycle, helmet, policy, law, costs

Introduction

Many US states have repealed longstanding universal motorcycle helmet legislation despite evidence linking repeal to worse crash-related clinical outcomes, including injury severity, intensive care utilization, and mortality.[1–4] Repeal proponents argue for individual autonomy regarding the decision to assume higher injury risk by not wearing a helmet. Although injuries are personally borne by the rider, higher costs of medical care associated with helmet nonuse are not typically paid by the individual.[5,6] Shared public funding covers motorcycle crash expenses through various mechanisms, including third-party or government medical insurance and catastrophic claims programs.[7] Furthermore, higher costs of care may impact trauma systems, as uninsured patients and inadequate reimbursement may exacerbate ongoing financial challenges faced by US trauma centers.[8,9] Despite direct relevance to policymakers and trauma networks, prior studies evaluating the impact of universal motorcycle helmet law repeal on crash-related costs are primarily limited to pre-post measures and do not account for preexisting trends over time.[10–12]

In this context, we performed a policy evaluation of universal motorcycle helmet law repeal on crash-related inpatient costs, using Michigan as an exemplar. We hypothesized that repeal would be associated with increased cost per patient.

Methods

We performed a multiple-group interrupted time series study evaluating patients age ≥21 years admitted for motorcycle-related traumatic injury using data from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases from January 2009 to September 2015. We evaluated patients from Michigan and four control states chosen for sociodemographic and geographic similarity: Wisconsin, Minnesota, Kansas, and Colorado. We identified patients using inpatient admission codes from the *International Classification of Diseases, Ninth Revision*

(ICD-9) E-codes: E810-819, fourth digit 2 or 3. Michigan's helmet law repeal took effect April 13, 2012. Our primary outcome was average inflation-adjusted inpatient costs.

First, we used bivariate statistics to compare patient characteristics between repeal and non-repeal states. Next, we evaluated change in mean annual inpatient cost associated with policy repeal using interrupted time series analysis (ITSA) for Michigan and the control states. We performed ITSA using segmented ordinary least squares regression methods incorporating Newey-West standard errors. Autocorrelation and seasonality were evaluated using the Cumby-Huizinga test and autocorrelation and partial autocorrelation function plots. To evaluate confounding, patient characteristics were evaluated in relation to the outcome using descriptive statistics and time series plots. We calculated excess annual costs associated with repeal by dividing mean cost increase per crash by mean number of annual motorcycle admissions. To evaluate potential outlier influences, we repeated the analysis using mean log-transformed cost. The IRB deemed this study exempt. We followed STROBE reporting guidelines.

Results

We identified 19,685 patients, of whom 5,280 were from Michigan. Table 1 describes patient characteristics. Policy repeal was associated with a $5,785 (95% CI $3,022-8,548, $p<0.001$) increase in inpatient costs per motorcycle crash patient (Figure 1). This represents a 26% increase in average cost, corresponding to $4.5 million/year excess expenditures in Michigan post-repeal. This association remained significant in log-transformed analysis ($p=0.02$). Repeal was not associated with cost change in the control group ($47, 95% CI -$1,094-1187, $p=0.9$). Injury severity scale estimations using ICD-9 codes demonstrated increased scores in both Michigan and control states after repeal ($p<0.01$), though the magnitude was larger in Michigan.

Discussion

Repeal of universal motorcycle helmet legislation was associated with a 26% increase in the average inpatient costs per motorcycle crash admission. Adjusted to 2025 dollars, this corresponds to an estimated $6.4 million/year excess in inpatient costs in Michigan. Given that 33 US states have repealed universal motorcycle helmet laws, these findings have major implications for nationwide costs of care associated with motorcycle crashes. Furthermore, our results limited to inpatient data likely underestimate the total cost increase given that the initial hospitalization accounts for only two-thirds of motorcycle crash-associated acute medical costs.[13] These data are timely as policymakers continue to debate universal motorcycle helmet laws, exemplified by two repeal events since 2020.

Our findings are particularly salient for trauma centers. Increased cost of trauma care is often not offset by higher reimbursement; instead, it may contribute to net-negative margin and financial instability.[14] Hospital profitability may impact resource allocation, quality of care, and the likelihood of hospital closure. Thus, helmet law repeal also has implications for the financial stability of US trauma centers.

Our study should be interpreted in the context of multiple limitations. First, our dataset does not capture motorcyclist helmet use. However, prior studies have demonstrated decreased helmet use in Michigan after repeal.[2] Thus, it is plausible that cost differences associated with policy repeal are related to helmet nonuse. Second, Michigan and controls were not directly compared. However, insignificant change in control states suggests policy repeal may be driving Michigan's observed cost increase. While these methods are inadequate to discern causal relationship, the robustness of our findings is supported by sensitivity analysis for outlier influences and the inclusion of multiple, diverse control states.

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Figure Legend

Figure 1. (A) Multiple-group interrupted time series of average inflation-adjusted inpatient cost surrounding universal helmet law repeal. (B) Multiple-group interrupted time series of average inflation-adjusted log-transformed inpatient costs surrounding universal helmet law repeal.

Precis: Repeal of universal motorcycle helmet legislation was associated with a 26% increase in the average inpatient costs per motorcycle crash admission ($5,849/patient). As 33 US states have repealed these laws, a substantial portion of nationwide costs of care associated with motorcycle crashes may be preventable.

Table 1. Characteristics of the Study Population

Characteristic	Total (N=19,685)	Control state (N=19,685)	Michigan (N=19,685)	p Value
Patients, n (%)	19,685	14,405 (73.2)	5,280 (26.8)	
Age category, n (%)				0.1
21-34 y	4,890 (24.8)	3,519 (24.5)	1,371 (26.0)	
35-44 y	3,679 (18.6)	2,665 (18.5)	1,005 (19.0)	
45-54 y	5,334 (27.1)	3,924 (27.2)	1,410 (26.7)	
55-64 y	4,224 (21.5)	3,128 (21.7)	1,096 (20.8)	
≥65 y	1,567 (8.0)	1,169 (8.1)	398 (7.5)	
Sex, n (%)				<0.001
Male	16,816 (85.4)	12,213 (84.8)	4,603 (87.2)	
Female	2,869 (14.6)	2,191 (15.2)	677 (12.8)	
Race*, n (%)				<0.001
White	13,043 (66.5)	9,637 (67.2)	3,406 (64.6)	
Black	871 (4.4)	338 (2.4)	533 (10.1)	
Hispanic	526 (2.7)	490 (3.4)	36 (0.7)	
Native American	60 (0.3)	46 (0.3)	14 (0.3)	
Other†	369 (1.9)	282 (2.0)	93 (1.8)	
Missing	4,756 (24.2)	3,558 (24.7)	1,198 (22.6)	
Payer, n (%)				<0.001
Private insurance	13,458 (68.4)	9,614 (66.7)	3,844 (72.8)	
Public insurance	2,983 (15.1)	2,159 (15.0)	824 (15.6)	
Uninsured	1,879 (9.5)	1,410 (9.8)	469 (8.9)	
Other	1,237 (6.3)	1,107 (7.7)	130 (2.4)	
Missing	128 (0.7)	115 (0.8)	13 (0.3)	

No. of chronic conditions, n (%)				<0.001
0	4,517 (23.0)	3,873 (23.4)	1,144 (21.7)	
1	4,541 (23.0)	3,369 (23.4)	1,172 (22.2)	
2	3,491 (17.7)	2,554 (17.7)	937 (17.7)	
≥3	7,136 (36.3)	5,109 (35.5)	2,027 (38.4)	

*Race categories were standardized at the federal level by the US Agency for Healthcare Research and Quality, which manages the Healthcare Cost and Utilization Project. Race categories are reported as provided in the dataset. The "Other" category is not further defined.

†Counts <11 not reported due to data use agreement with Healthcare Cost and Utilization Project. "Asian or Pacific Islander" category was merged with "Other" for compliance.

Fig 1