

# Repeal of the Michigan helmet law: the evolving clinical impact

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## Abstract

**BACKGROUND:** Michigan repealed a 35-year mandatory helmet law in April 2012. We examined the impact of this legislation on a level 1 trauma center.

**METHODS:** A retrospective cohort study comparing the 7-month period before and the 3 motorcycle seasons after the helmet law repeal.

**RESULTS:** A total of 345 patients were included in the study. Nonhelmeted riders increased from 7% to 28% after the repeal. Nonhelmeted crash scene fatalities were higher after the repeal (14% vs 68%). The nonhelmeted cohort had significantly higher in-patient mortality (10% vs 3%), injury severity score (19 vs 14.5) and abbreviated injury scale head (2.2 vs 1.3). Non-helmeted riders also had increased alcohol use, intensive care unit length of stay and need for mechanical ventilation. The median hospital cost for the non-helmeted cohort was higher ( $P < .05$ ).

**CONCLUSIONS:** The impact of the Michigan helmet law repeal continues to evolve. Three years after this legislative change, we are now observing increased injury severity score, higher in-patient mortality, and worse neurologic injury.

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On April 13th, 2012, the State of Michigan (MI) repealed a 35-year mandatory motorcycle helmet law. This allows riders who are over the age of 21, who have had a valid

motorcycle license for at least 2 years or completed a motorcycle safety course and have acquired at least \$20,000 in additional medical insurance to ride without a helmet.

One year after the repeal, we published the early clinical impact of this legislative change. Motorcyclists not wearing helmets quadrupled after the repeal. Although hospital mortality was unchanged, nonhelmeted motorcyclists (NHMs) more frequently died on the scene. Furthermore, the NHMs had a longer intensive care unit (ICU) length of stay (LOS) and mechanical ventilation time, increased hospital costs, and higher rates of alcohol intoxication.<sup>1</sup>

Today, the helmet law repeal remains controversial, despite an established body of evidence that demonstrates a

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clear safety benefit of motorcycle helmets. Multiple studies have shown that NHMs have a higher mortality rate than helmeted motorcyclists (HMs).<sup>2-4</sup> Other investigators have found that NHMs have a higher rate of lethal and nonlethal head injuries.<sup>3-5</sup>

The purpose of this study is to examine the ongoing clinical impact of the motorcycle helmet law repeal in the State of MI, now 3 years into its implementation.

## Methods

### Study design

Spectrum Health Butterworth Hospital is an 815-bed tertiary care center serving 13 counties in West Michigan. It is the only level 1 trauma center serving region 6, 1 of 7 regions in Michigan. After obtaining institutional review board approval, we retrospectively reviewed the medical records of all trauma patients admitted to the trauma service that were involved in a motorcycle crash during each motorcycle season from 2011 to 2014. We examined patient records during a 7-month period before the helmet law repeals (April 10, 2011 to November 10, 2011) and compared this to the same 7-month period each year after the repeal (2012 to 2014). Patients with an unknown helmet status were excluded from the study. Patient data from 2011 to 2012 have been reported previously.<sup>1</sup>

Data collected included age, sex, helmet status, mortality, injury severity score (ISS), abbreviated injury scale (AIS) head, ICU LOS, hospital LOS, mechanical ventilation time, admission Glasgow coma scale (GCS), hospital cost, alcohol intoxication (blood alcohol content >.08%), and disposition. Data were also collected from the Michigan State Department of Transportation to determine crash scene fatalities for region 6.

### Statistical analysis

Data were analyzed using IBM SPSS Statistics version 21 (Armonk, NY). Nominal data were compared using the chi-square or Fisher's exact test where applicable. Nominal values are expressed as percentages. Quantitative data were compared using the *t*-test or Mann-Whitney *U* test. Quantitative data are reported as mean  $\pm$  standard deviation. Multivariate regression analyses were performed. Outcome variables included LOS, ICU LOS, vent days, death, and ICU admission. Independent variables were ethanol above the legal limit, age, and sex, as well as either helmet status (yes vs no) or group (prelaw vs postlaw) as the final independent variable. Significance was assessed at  $P < .05$ .

## Results

A total of 345 patients were involved in a motorcycle crash and admitted to the trauma service during the study period. There were 296 men (86%), and the average age

was 44. Seventy-nine riders presented from April 10, 2011 to November 10, 2011, before the helmet law repeal and 266 riders presented in the after 3 motorcycle seasons, from April 10 to November 10 2012 to 2014.

Demographic and clinical data for the prelaw and postlaw change groups are shown in Table 1. When comparing these 2 cohorts, age and sex were no different. However, when comparing helmet status, significantly more riders were NHMs in 2012 to 2014, compared with 2011 ( $P < .001$ ). NHMs crash scene fatalities were more than 4 times higher in 2012 to 2014 compared with 2011, which was significantly different.

Table 2 shows comparisons between HMs and NHMs. Again, there were no differences in gender or age. The non-helmeted group had a significantly higher hospital mortality rate compared with the helmeted group. ISS, AIS head, GCS, ICU stay, and the need for mechanical ventilation were all significantly higher in the nonhelmeted group as well. The nonhelmeted group had a higher median hospital cost (\$27,760 vs \$20,967,  $P = .03$ ). This group was also more likely to be intoxicated on arrival ( $P < .001$ ).

Multivariate analyses were used to determine predictors for the dependent variables LOS, ICU LOS, vent days, death, and ICU admission. Although alcohol intoxication was significantly related to helmet status in the univariate analysis, it was not a significant predictor for any of the dependent variables. Furthermore, none of the other independent variables tested were significant predictors.

## Comments

Motorcycle helmet laws have generated controversy for several decades. The National Highway Safety Act, implemented in 1966, required that states mandate helmet use to receive federal highway safety and construction funds. This requirement was rescinded in 1976, when Congress revoked the authority of the US Department of Transportation to withhold state funds for helmet law noncompliance. A dramatic increase in motorcycle deaths was observed in the year after this legislative change. Despite this negative impact, many states weakened or rescinded their motorcycle helmet laws. Today, only 19 states and the District of Columbia maintain a universal helmet law. Partial helmet laws, requiring only certain riders (usually those younger than 18 or 21 years) to wear a helmet, are present in 28 states. Illinois, Iowa, and New Hampshire are the only states without a helmet law.<sup>2</sup> Michigan maintained its universal helmet law for 35 years until April 13th, 2012 when it was repealed, and a partial helmet law was approved in our State. We reported the clinical impact of this legislative change in the American Journal of Surgery 1 year after the repeal.

We found that motorcyclists not wearing helmets quadrupled in the first year after the repeal. Although hospital mortality was unchanged, NHMs more frequently died on the scene (14% vs 77%,  $P = .007$ ). Furthermore,

**Table 1** Comparisons of demographic and clinical variables between years 2011 (prelaw change) and 2012–2014 (postlaw change)

| Variables                              | 2011       | 2012–2014    | <i>P</i> value |
|--|------------|--------------|----------------|
| Age (years)*                           | 42 ± 15    | 45 ± 15      | .15            |
| Males (%)                              | 68/79 (86) | 228/266 (86) | .94            |
| Nonhelmeted riders (%)                 | 6/79 (8)   | 76/266 (29)  | <.001          |
| Hospital mortality (%)                 | 2/79 (3)   | 15/266 (6)   | .38            |
| Nonhelmeted crash scene fatalities (%) | 1/7 (14)   | 22/35 (63)   | .03            |

\*Mean ± standard deviation.

the NHMs had a longer ICU LOS and mechanical ventilation time, increased hospital costs, and higher rates of alcohol intoxication. It was initially surprising that hospital mortality was not higher in the NHMs cohort. However, when we compared the 2 cohorts, the ISS and the AIS head were the same. We hypothesized that the most severely injured patients were dying on the scene.<sup>1</sup> We also recognized that our study was limited by time. This has prompted an ongoing analysis of our motorcycle crash patients.

States that enforce a universal helmet law report up to 94% helmet law compliance. Helmet use is significantly lower in those states with partial and no helmet laws where as few as 50% of riders choose to wear a helmet.<sup>2,4,5</sup> In the year before the MI helmet law repeal, 93% of our motorcycle crash patients wore a helmet. In the 3 years after the repeal, this has dropped to 72% ( $P < .001$ ). This

phenomenon has been observed in other states. Investigators in Florida found that helmet use dropped from 80% to 33% after their helmet law repeal.<sup>6</sup> A similar decrease was reported in Arkansas and Texas.<sup>7,8</sup> Although our study only documents the helmet status of those admitted to the hospital, a recent observational study of Michigan riders revealed that only 73% of riders on the street are wearing helmets.<sup>9</sup> This is a major concern, especially given our increased rate of crash scene mortalities among NHMs after the repeal.

In the year before the helmet law repeal, only 1 NHM crash scene fatality was reported in region 6 of MI. In the 3 years after the repeal, there have been 22 NHM crash scene fatalities in our region. This represents a 4-fold increase in crash scene mortality since the repeal: 14% vs 63% ( $P = .03$ ). This is one of the first reports of prehospital fatalities among NHMs. Our findings highlight the importance of injury prevention. This has also been recognized by surgeons in Florida, who suggest that efforts to lower speed limits, improve rider education, monitor licensing, and enforce higher visibility clothing may be worthwhile.<sup>6</sup>

Although it is well known that hospital mortality is higher among NHMs than HMs, we did not report this finding after the first year of the MI repeal. This was not consistent with national or state data. A study of more than 70,000 patients from the National Trauma Databank revealed that mortality among HMs was 3.8% whereas mortality among NHMs was 6.7%. Those states with partial and no helmet laws had significantly higher mortality than those with universal helmet laws.<sup>2</sup> A cross-sectional study analyzing national discharge data found that patients hospitalized in states without universal helmet laws are more likely to die during their hospitalization.<sup>5</sup> These mortality findings have also been replicated in individual states where helmet laws have been repealed.<sup>6–8,10</sup>

Unfortunately, 3 years after the MI helmet law repeal, we are now reporting an increased mortality rate among NHMs in our region (10% vs 3%,  $P = .036$ ). Although these findings are disappointing, it is encouraging that other states have reversed this mortality impact. In California, there was a 38% absolute reduction in mortality the first year after initiating a universal helmet law.<sup>10</sup> In Nebraska, there was a decline from 13 to 8 mortalities per 10,000 registrations 1 year after the reenactment of a helmet law.<sup>10</sup> We suspect that the increased mortality rate in MI is likely secondary to the fact that our NHMs are presenting more seriously injured (ISS 19 vs 14.5) and have more severe neurologic injury, than before the repeal.

Traumatic brain injury is the major contributing factor to mortality in NHMs. In our new analysis, the NHMs have a lower presenting GCS and higher AIS head. In Pennsylvania, traumatic brain injury death increased by 37% after the repeal of their universal helmet law.<sup>3</sup> Neurosurgeons at the University of Miami encountered a significantly increased number and severity of brain injuries admitted to their trauma center after the repeal of a mandatory helmet law.<sup>6</sup> It is this evidence that has led EAST to issue a level

**Table 2** Comparisons of demographic and clinical variables between helmeted and nonhelmeted riders

| Variables              | Helmeted     | Nonhelmeted | <i>P</i> value |
|------------------------|--------------|-------------|----------------|
| Age (years)*           | 44 ± 15      | 45 ± 13     | .38            |
| Males (%)              | 223/263 (85) | 73/82 (89)  | .34            |
| Hospital mortality (%) | 9/263 (3)    | 8/82 (10)   | .04            |
| ISS                    | 15 ± 9.2     | 19 ± 13.0   | .004           |
| AIS head               | 1.3 ± 1.4    | 2.2 ± 1.9   | <.001          |
| GCS                    | 14 ± 3.2     | 12.6 ± 4.5  | .009           |
| Hospital LOS           | 5.3 ± 5.7    | 6.0 ± 6.4   | .40            |
| ICU (%)                | 65/211 (31)  | 35/64 (55)  | .001           |
| ICU LOS (days)         | 6.1 ± 7.3    | 5.9 ± 7.4   | 0.9            |
| Ventilator (%)         | 31/253 (12)  | 18/75 (24)  | .01            |
| Ventilator time (days) | 5.7 ± 7.1    | 6.8 ± 8.0   | .59            |
| EtOH (>.08)            | 19/136 (14)  | 26/53 (49)  | <.001          |
| Hospital cost          | \$20,967     | \$27,760    | .049           |

AIS = abbreviated injury scale; EtOH = ethanol; GCS = Glasgow coma scale; ICU = intensive care unit; ISS = injury severity score; LOS = length of stay.

\*Mean ± standard deviation.

1 recommendation that “all motorcyclists should wear a helmet...to reduce the incidence of head injury”.<sup>10</sup>

It is not surprising that NHMs are more likely to require critical care and spend more time on the ventilator. This acuity of care is more costly. In our study, the NHMs incur about \$7,000 more in hospital cost than the HMs ( $P < .05$ ). This figure does not include the cost of readmissions, rehabilitation, or losses in productivity. The Centers for Disease Control and Prevention estimate that medical and productivity costs saved from helmet use are \$1,212,800 per fatality and \$171,753 per serious injury.<sup>11</sup> The costs of providing health care to a motorcyclist after a crash is largely borne by society, as most of these expenses are paid for by public funds.<sup>12</sup> Moving forward, it is clear that we must consider both the clinical and financial ramifications of partial and no helmet laws, before making legislative changes.

There are several limitations of this study, including its retrospective design, local geographic boundaries, and unknown etiology of crash scene mortalities. Although it was previously suggested that higher rates of intoxication among NHMs is a confounding factor, a multivariate analysis does not support this thought. Alcohol intoxication was not an independent predictor for any measured outcome.

## Conclusions

The clinical impact of the repeal of the mandatory MI helmet law is evolving. One year after the change, we reported decreased helmet use, increased crash scene mortalities, and higher medical costs. ICU length of stay and mechanical ventilation time was also longer. Now, 3 years after the implementation of this legislation, we report that the initial impact of the law is sustained and worsening. We have now demonstrated that NHMs have increased injury severity, worse neurologic injury, and a higher rate of hospital mortality. Although these results are not surprising and reflect existing literature on the subject, there have been several reports of fewer fatalities and fewer head injuries in those states that have reenacted mandatory helmet laws.<sup>10</sup> The MI legislature should seriously consider reenacting its mandatory helmet law, as the clinical and financial impact of their decision to repeal the law is now very clear.

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## Discussion

### Discussant

**Dr. Roxie M. Albrecht (Oklahoma City, OK):** You may know that I just finished my 6th 500 mile bike ride across Iowa. The first one was in 1980, and I and many of the riders did not wear helmets. This year there was about 20,000 riders. I saw 1 person in 7 days with no helmet on. So, its interesting the dichotomy of the people who ride bikes as opposed to those who ride motorcycles. And this study is very important and timely to potentially reverse the trend of additional states rescinding or modifying their laws.

I do have a couple questions. If you look over the 5-year periods of your prior study and this study, did you find that the percentage of unhelmeted riders continues to rise, or is there steadily increase on a yearly basis? Do you have any data on developing any injury prevention strategies or advocacy or public service announcements in your region to help reverse this trend of increasing helmet nonuse?

And then, finally, do you have any information on discharged disposition of the unhelmeted riders? What percentage of them was going to inpatient rehab, nursing homes, skilled-nursing facilities, or long-term care.

And then as part of that, you said that they had—they were required to have an additional \$20,000 of health care insurance. Did that policy include rehabilitation services?

**Dr. Striker:** To address your first question whether the unhelmeted percentages worsened over time, we did not specifically break down that over the first 3 years; however, the percentage published in our first article was the exact same as it was now, which is 29 percent. So, I think that



is relatively sustained. However, throughout the literature throughout the nation, those numbers do continue to decrease normally steady somewhere around 60% to 70% in states with a partial helmet law, and about 50% in states with a no helmet law.

In response to your second question, if we are working toward anything with injury prevention, we have presented our articles yearly at the Michigan traffic safety summit. That is, we work with many different researchers that deal with epidemiologic data across the state, as well as their motorcycle advocates there, and many injury prevention task forces. There is also law enforcement that attends that meeting and people who can help with the legislative aspect.

So, we have formed some good bonds and have started to coalesce our research together to form more of an idea of where to take this in the future. So, I think that is one of the most important things that we are looking toward next is how to continue this throughout the rest of the state and not just looking at western Michigan, and then to take in those other factors as well from the other points of view.

And in response to your third question. We did not find a significant difference between where they were discharged to; however, that data is relatively sparse. And so, we would like to look farther into whether they are getting discharged to an acute rehab facility, to a subacute or to a long-term acute care center. And I think that will have larger clinical impacts as well, because the monetary difference between those patients that are requiring long-term rehab stays would be significant as well as the potential loss of productivity.

**Dr. Jeffrey Claridge (Cleveland, OH):** I think one of the things that I would be interested in, and I think your health policy people would be, is the cost. As you said, the state decided that tourism costs benefit outweighed the loss of lives. And I think all of us in this room would disagree with that. Do you have any idea on the cost to this and potential downstream revenue and loss of work and those kind of things?

**Dr. Striker:** Yes. So the original thought that the potential loss of tourism actually came from a study from the American Bikers Aiming Toward Education (ABATE) group, which is a motorcycle advocates group that quoted that there was a potential of about \$54 million that could be lost from tourism. And while I do not have anything specific for the State of Michigan. The CDC did estimate that the medical and productivity costs saved from helmet use were anywhere between \$1.2 million for a fatal accident and about \$171,000 per serious injury.

The University of Michigan Transportation Research Institute, as well, has estimated anywhere between \$213 and \$317,000 per crash that we are losing just from the medical aspects of care.

**Dr. James G. Tyburski (Detroit, MI):** Follow-up question to that. I think it is an excellent point that this was originally set up that it would be a loss of tourism. So do you have demographic data on the origin of your victims, ie, are they tourists from Wisconsin riding unhelmeted in Michigan or are they from someplace else or are they native western Michiganders?

**Dr. Striker:** Great question. We do not have that data of where our patients are from. It may be something that we can look into with further data. Thank you.

**Dr. Nicholas J. Zyromski (Indianapolis, IN):** I may have missed this in your presentation, but can you tell us how the motorcycle riders die? Do they die from brain stem herniation? Do they die from long bone fractures when they are not transfused platelets and fresh frozen plasma (FFP) in a timely enough fashion?

**Dr. Striker:** Most of them are from neurologic injuries, but we did not specifically go into that a whole lot deeper.

**Dr. William C. Cirocco (Columbus, OH):** Any information on organ donation from these?

**Dr. Striker:** From these, we have not looked into, but, again, that is something that we are also looking into. Thank you.