The human cost of allowing unhelmeted motorcycling in the United States

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Contents

Abstract

Introduction: This study's objective was to estimate the number of motorcyclist fatalities attributable to laws that allow unhelmeted riding in the United States since 1976.

Method: Counts of helmeted and unhelmeted motorcyclist fatalities were used to estimate population-level helmet use under all-rider helmet laws and in the absence of such laws. The number of lives that could have been saved if helmet use in states that allowed unhelmeted riding was equal to helmet use in states with all-rider helmet laws was estimated for each year and summed over the study years.

Results: If all states had all-rider helmet laws throughout the 1976–2022 study period, 22,058 fewer motorcyclists would have died in crashes. This represents 11% of all motorcyclist fatalities during these years. The number of motorcyclists killed in 2022 would have been 10% lower. Currently, 17 states and the District of Columbia have an all-rider helmet law in place.

Conclusion: Requiring helmets for all motorcyclists is a straightforward rule of the road that has the potential to reduce annual motorcyclist fatalities, which are at record-high levels of over 6,000 per year, by 10%. All-rider helmet laws are a fundamental component of a Safe System for motorcycling.

Practical Applications: States should consider the human cost of not having all-rider helmet laws and use this tool to reduce the number of riders killed in crashes.

1. Introduction

It is not news that riding a motorcycle involves more risk than traveling in a passenger vehicle and that no single countermeasure can eliminate every crash, injury, or fatality. However, that elevated risk can be reduced with the implementation of multiple effective countermeasures and by recognizing that humans make mistakes—two fundamental pillars of a line of thinking known as the Safe System approach. Motorcycling in a Safe System would involve measures that reduce the likelihood of crashing as well as measures that protect riders who do crash, and it would involve prioritizing measures that are the most effective. Unfortunately, however, the safety of motorcyclists traveling on our nation's roads has not been prioritized. The number of motorcyclist fatalities in the United States has reached a record-high for the third year in a row (Insurance Institute for Highway Safety, 2024a), despite relatively stable numbers of registered motorcycles over the past decade (Teoh, 2023b).

Wearing a helmet is one of the most fundamental countermeasures for motorcyclist fatalities. Deutermann (2004) found that helmets reduce riders' risk of dying in a crash by 37% , and other studies have shown similar benefits (Liu et al., 2004; Norvell & Cummings, 2002). Helmets also reduce the risk of traumatic brain injury by two-thirds (National Highway Traffic Safety Administration, 2008). Helmets that cover more of the face are generally more effective than those covering only the top of the head (Yu et al., 2011) and helmets that do not meet federal performance standards (specifically, 49 CFR 571.218), also known as "novelty helmets," do not provide effective protection (Rice et al., 2017). While there have been claims that wearing a helmet increases the risk of neck injury, this has been refuted by about a dozen studies (e.g., Crompton et al., 2011; Orsay et al., 1994). Similarly, claims that motorcycle helmets reduce riders' visibility and hearing have also been debunked (McKnight & McKnight, 1994).

Of course, helmets only protect riders if riders wear them, and the most effective way of increasing helmet use is with a straightforward traffic rule requiring all motorcyclists to wear a helmet while riding. State laws that impose such a rule are known as universal or all-rider helmet laws. The first all-rider helmet law in the United States was enacted in 1966 (Kirley et al., 2023) and by 1975, 47 states

and the District of Columbia had enacted all-rider helmet laws (Figure 1). The spread of such laws was a direct result of federal policy: The 1966 National Highway Safety Act made state eligibility for certain highway safety and construction funding contingent on such laws. This eligibility requirement was removed in 1976 (Federal-Aid Highway Act of 1976). Subsequently, many states repealed their all-rider helmet laws or, more typically, weakened them by making them apply only to riders under a certain age (usually 21). By 1978, only 22 states and DC required all riders to be helmeted; as of 2024, 17 states and DC have this requirement (Figure 1). In 2022, the latest year of available data, 93% of motorcyclists observed in states with all-rider helmet laws were helmeted, in contrast to 64% of motorcyclists in states without such laws (National Highway Traffic Safety Administration, 2023).

Because they increase helmet use, all-rider helmet laws are associated with lower motorcyclist fatality rates, head injury rates, and medical costs. For instance, in studies controlling for state-to-state differences such as average temperature, precipitation, residential density, per capita income, speed limits, and alcohol laws, all-rider helmet laws were associated with lower motorcyclist fatality rates per population, number of registered motorcycles, and vehicle miles traveled than states that allowed unhelmeted motorcycling (Branas & Knudson, 2001; French et al., 2009; Houston & Richardson, 2008, 2007; Sosin & Sacks, 1992). Laws that apply only to younger riders have not been effective at improving safety for those that are covered (Weiss et al., 2010), presumably because they are difficult to enforce.

The changes to state helmet laws enabled researchers to conduct many before–after studies of safety-related outcomes and medical costs. For example, when Florida weakened its all-rider helmet law in 2000, the fatality rate per 1,000 crash involvements increased 35% (Kyrychenko & McCartt, 2006). When Kentucky and Louisiana weakened their all-rider helmet laws in the late 1990s, rider fatalities increased 50% and 100%, respectively (Ulmer & Preusser, 2003). Both times that Texas weakened its all-rider helmet law—in 1977 and in 1997—motorcyclist fatalities increased, 35% and 31% (Preusser et al., 2000; Watson et al., 1980). Watson et al. studied repeals of all-rider helmet laws in 22 states and found rider fatalities rose more than expected in 20 of the 22 states. More recently, Michigan was an outlier,

with no change in fatalities after weakening its all-rider helmet law in 2012 (Carter et al., 2017). Similarly, rates of serious head injuries also increased after helmet law repeals (e.g., Carter et al., 2017; Mounce et al., 1992; Muelleman et al., 1992; Ulmer & Preusser, 2003). Unsurprisingly, given these results, studies show that helmeted riders and all-rider helmet laws are associated with lower medical costs, which in many cases are covered by the public (Bach & Wyman, 1986; Bray et al., 1985; Highway Loss Data Institute, 2017; Lawrence et al., 2002; Max et al., 1998; Muelleman et al., 1992; National Highway Traffic Safety Administration, 1996; Rivara et al., 1988; Ulmer & Northrup, 2005). On the other hand, when California required all riders to be helmeted in 1992, motorcyclist fatalities decreased by 37% (Kraus et al., 1994). Overall, with rare exception, enacting all-rider helmet laws reduces fatality and head injury rates as well as medical costs, and weakening all-rider helmet laws increases these outcomes.

The purpose of this study was to estimate how many fewer motorcyclists would have died in crashes in the United States if every state had an all-rider helmet law from 1976 through 2022. This is a direct measure of the human cost of the policy of allowing unhelmeted motorcycling in some jurisdictions.

2. Method

The overall approach was to estimate helmet use for two groups within each year: motorcyclist fatalities in states (plus DC) that had all-rider helmet laws and in states that allowed unhelmeted motorcycling. This allows for variation over time in the population-level rate of helmet use during the study period. Then the number of lives that would have been saved each year had all-rider helmet laws been in place everywhere (i.e., if the helmet use rate in states that allow unhelmeted motorcycling was equal to the rate in jurisdictions with all-rider helmet laws) was estimated based on helmet effectiveness. Results were summed across years.

Population-level helmet use rate, which is conceptualized as the proportion of vehicle miles traveled (VMT) involving the rider being helmeted, can be estimated from effectiveness and the numbers of helmeted and unhelmeted motorcyclist fatalities as follows. This derivation assumes that helmeted and unhelmeted riders' crash fatality rates per VMT differ only by helmet effectiveness. The derivation follows similar lines of thinking as found in Deutermann (2005) and Glassbrenner and Starnes (2009). Effectiveness was taken as 37% (Deutermann, 2004) for the current study.

Population-level helmet use rate

$$= \frac{\text{VMT}_{\text{helmeted}}}{\text{VMT}_{\text{helmeted}} + \text{VMT}_{\text{unhelmeted}}}$$

$$= \frac{\frac{\text{Fatalites}_{\text{helmeted}}}{\text{Rate}_{\text{helmeted}}}}{\frac{\text{Fatalities}_{\text{helmeted}}}{\text{Rate}_{\text{helmeted}}} + \frac{\text{Fatalities}_{\text{unhelmeted}}}{\text{Rate}_{\text{unhelmeted}}}}, \text{ where rate = fatalities/VMT}$$

$$= \frac{\frac{\text{Fatalites}_{\text{helmeted}}}{\text{Rate}_{\text{helmeted}}}}{\frac{\text{Fatalities}_{\text{helmeted}}}{\text{Rate}_{\text{helmeted}}} + (1 - \text{Effectiveness})\frac{\text{Fatalities}_{\text{unhelmeted}}}{\text{Rate}_{\text{helmeted}}}}, \text{ since we assume } \text{Rate}_{\text{helmeted}} = (1 - \text{Effectiveness}) \times \text{Rate}_{\text{unhelmeted}}$$

$$= \frac{1}{1 + \frac{\text{Fatalities}_{\text{unhelmeted}}}{\text{Fatalities}_{\text{helmeted}}}(1 - \text{Effectiveness})}$$

The other fundamental calculation is estimating how many fatalities would have occurred if the population-level helmet use rate was higher. NHTSA periodically estimated lives saved if helmet use was 100% (e.g., Deutermann, 2005; National Highway Traffic Safety Administration, 2018) as did another study

(Dee, 2009), but helmet use clearly is less than 100% in all-rider helmet law states, so a slightly different estimate formula is needed for the current study. The general formula below or similar ones are found in other studies as well (e.g., Blincoe, 1994; Dee, 2009; Evans, 1987).

Fatalities prevented if population-level helmet use rate was 100 × $\text{Helmetuse}_{\text{new}}$%, instead of 100 × $\text{Helmetuse}_{\text{actual}}$%

$$= \frac{\text{Fatalities}_{\text{actual}} \times \text{Effectiveness} \times (\text{Helmetuse}_{\text{new}} - \text{Helmetuse}_{\text{actual}})}{1 - \text{Effectivenss} \times \text{Helmetuse}_{\text{actual}}}$$

To derive this formula, first consider the relationship between $\text{Fatalities}_{\text{actual}}$ (or F_{actual} for brevity), the number of fatalities that were actually observed and that arose from a population-level helmet use rate of 100 × $\text{Helmetuse}_{\text{actual}}$ % (estimated with the formula derived above), and F_{zero}, the number of fatalities we would have if there were no helmet use (i.e., if the use rate was zero). This is given by the formula below, which shows the number of unhelmeted fatalities and helmeted fatalities weighted by actual helmet use rate. Specifically, the number of unhelmeted fatalities is simply the nonuse rate times F_{zero}, and the number of helmeted fatalities is the product of the use rate, F_{zero}, and 1-effectiveness since helmets prevent some crash involvements from becoming fatalities per the definition of effectiveness.

$$F_{\text{actual}} = (1 - \text{Helmetuse}_{\text{actual}}) \times F_{\text{zero}} + \text{Helmetuse}_{\text{actual}} \times (1 - \text{Effectiveness}) \times F_{\text{zero}}$$

$$\text{Or } F_{\text{zero}} = \frac{F_{\text{actual}}}{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{actual}}}$$ note: F_{actual}, $\text{Helmetuse}_{\text{actual}}$, Effectiveness are all known.

Similarly, for a given new helmet use rate, 100 × $\text{Helmetuse}_{\text{new}}$%, we have

$$F_{\text{new}} = (1 - \text{Helmetuse}_{\text{new}}) \times F_{\text{zero}} + \text{Helmetuse}_{\text{new}} \times (1 - \text{Effectiveness}) \times F_{\text{zero}}$$

And, substituting the formula for F_{zero}, we have

$$F_{\text{new}} = \frac{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{new}}}{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{actual}}} F_{\text{actual}}$$

Then estimated lives saved (since new helmet use rate is higher than actual rate), is given by

$$\text{lives saved} = F_{\text{actual}} - F_{\text{new}}$$

$$= F_{\text{actual}}\left(1 - \frac{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{new}}}{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{actual}}}\right)$$

$$= \frac{F_{\text{actual}} \times \text{Effectiveness} \times (\text{Helmetuse}_{\text{new}} - \text{Helmetuse}_{\text{actual}})}{1 - \text{Effectiveness} \times \text{Helmetuse}_{\text{actual}}}, \text{ which is the formula from above.}$$

Another analysis repeated the calculation within each state to illustrate the cumulative effect of allowing unhelmeted motorcycling. This analysis used the same estimate of all-rider law helmet use rate for each year (i.e., estimated across all jurisdictions with all-rider helmet laws as a group), but estimated each individual state's helmet use rate for states where unhelmeted motorcycling was allowed. The latter involved smaller sample sizes and thus greater variability of the estimates. Results were summed across all study years, and the latest year involving a motorcyclist fatality in the absence of an all-rider helmet law was also noted. Effective dates of helmet law changes were obtained from the IIHS Legal Department from 1975 or earlier through July 1, 2024. Data on motorcyclist fatalities were extracted from the Fatality Analysis Reporting System, a census of fatal crashes maintained by NHTSA, for the period beginning 1976, the year federal incentives for states were removed, through 2022, the latest year of available data at the time of this study. Motorcycles were defined by FARS body type codes 80–89, which cover two- and three-wheel motorcycles, mopeds, dirt bikes, etc. Helmet use, using the FARS restraint use variable for most years and the helmet use variable for later years, included both helmets coded as meeting federal standards as well as novelty helmets because it is unclear that these can be accurately separated in FARS (and were not distinguished in FARS coding until later years). Unknown helmet use was counted as nonuse. Full details on FARS coding are available in the FARS Analytical User's Manual (National Highway Traffic Safety Administration, 2024). Fatalities were disaggregated by all-rider helmet law status by date instead of by state-year, accounting for midyear (or other date) helmet law changes.

3. Results

The primary results of the study are outlined in Table 1. Across all study years, if helmet use in states that allowed unhelmeted motorcycling had been equal to helmet use under all-rider helmet laws, 22,058 fewer motorcyclists would have died in crashes. This amounts to 11% of all motorcyclist fatalities across these years, and 10% for 2022. While estimated population-level helmet use has increased over the years, both for all-rider helmet law states and in states that allow unhelmeted riding, all-rider helmet laws were associated with helmet use rates that were generally 2–3 times as high as in states without such laws. Estimated lives lost due to allowing unhelmeted riding ranged from 182 in 1976, when most states had all-rider laws but helmet use was lower, to 673 in 2021, when helmet use was higher but only 18 states and DC had all-rider helmet laws. Table 2 shows the breakdown of the 22,058 figure by state. Since this involves estimating helmet use within each state, resulting in more variability, these numbers sum to only 22,033. For 12 states and DC, the figure was zero because they had all-rider helmet laws throughout the entire study period. For California, if the state had an all-rider helmet law throughout the 1976–2022 study period, there would have been 2,536 fewer rider fatalities. This was the largest number of any state, likely reflecting high motorcycle exposure during the time. However, California has had an all-rider helmet law since 1992, so this number is not increasing. Thirty-two states lacked all-rider helmet laws and experienced excess rider fatalities in 2022, the latest study year; 33 states lacked all-rider helmet laws at the time of writing this paper, so these numbers will continue to increase.

4. Discussion

The lack of all-rider helmet laws in many states has come at a large cost—the deaths of over 22,000 people in the United States. Helmets provide a necessary layer of protection for motorcyclists when they are involved in crashes, but helmets do not prevent all fatalities and they do not prevent crashes. Helmets and laws requiring all riders to wear them must be coupled with other effective or promising countermeasures, such as motorcycle antilock braking systems (Basch et al., 2015; Rizzi et al., 2015; Teoh, 2022), crash avoidance technology on other vehicles that detects motorcyclists (Insurance Institute for Highway Safety, 2024b; Kidd et al., 2023; Teoh, 2023a), increasing use of protected left turn signals (Hauer, 2003; Teoh, 2023a) as well as measures to more broadly address high speeds and speeding (Farmer, 2017; Hu & Cicchino, 2023, 2024; Hu & McCartt, 2016; Reagan & Cicchino, 2024) and alcohol use (Insurance Institute for Highway Safety, 2024a). While there is a great deal of opportunity to implement or invent countermeasures, a straightforward rule of the road that can prevent 10% of motorcyclist fatalities is a necessary and foundational component of a Safe System for motorcycling. Unlike many other countermeasures, all-rider helmet laws involve relatively little monetary cost to implement, and the benefits begin immediately.

The intent of the current study was to come up with a simple and straightforward estimate of the human cost of not having all-rider helmet laws. As such, the study has several limitations that should be noted. The first is that the analysis assumed that helmeted and unhelmeted riders' fatality rates per VMT differed only by their helmet use. It is possible that helmet nonuse is associated with other behaviors that increase crash or fatality risk. If helmet nonuse is associated with other behaviors that increase fatality risk per VMT, this study's methods would overestimate the population-level helmet use rate and underestimate the human cost of interest. The estimated helmet use rates in Table 1 are reasonably similar to those in NHTSA's observational surveys (e.g., National Highway Traffic Safety Administration, 2023), and the differences may be due to the sampling method such as observing motorcyclists' helmet use only

during the daytime, even though about a quarter of motorcyclist fatalities occur at night (Insurance Institute for Highway Safety, 2024a).

Another limitation is that the analyses did not distinguish between helmets that meet federal standards and novelty helmets, as this was not coded for all years of FARS, and it may not be coded by all states' police crash reports in the first place. The helmet effectiveness study used in this analysis (Deutermann, 2004) did not exclude novelty helmets as this was not coded in FARS at that time, so it is possible that novelty helmets weakened the effectiveness estimate. The study did suggest that helmet effectiveness had improved since the early 1980s due to improvements in helmet designs, which were not accounted for in the current study. Substituting the earlier years' effectiveness estimate, 29% (Deutermann, 2004), reduced the overall human cost figure to about 20,000. On the other hand, other effectiveness estimates are higher than the 37% figure used. The proportion of observed helmets used that are novelty helmets is similar in all-rider helmet law states and states that do not have these laws (National Highway Traffic Safety Administration, 2023), so it is unlikely that novelty helmets biased the current study's estimated relative helmet use by helmet law type.

Lastly, the analysis begins in 1976, when federal efforts to incentivize states to have all-rider helmet laws ended, but all-rider helmet laws could have saved lives since their advent in 1966. FARS data collection began in 1975 and fatal crash data before then were less reliable. So, while the current study might underestimate the total number of lives that could have been saved in this manner, 1976 was chosen as a reasonable starting point.

More than 6,000 motorcyclists die in crashes each year in crashes on our nation's roads (Insurance Institute for Highway Safety, 2024a). The current study shows that having an all-rider helmet law in every state could reduce this figure by 10% and that over 22,000 people have already lost their lives because of the underutilization of this straightforward traffic rule.

5. Practical Applications

States should reduce the number of rider fatalities in crashes by enacting laws requiring helmet use for all motorcyclists traveling on public roads. The various concerns making this straightforward rule of the road unpopular among some riders must be weighed against the human cost of not having such laws. Coupling all-rider helmet laws with other effective countermeasures increases safety for motorcyclists on our nation's roads.

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8. Figures and Tables

Figure 1

Number of laws in effect as of July 1 in 50 states and DC requiring helmet use by all motorcyclists, 1975–2024

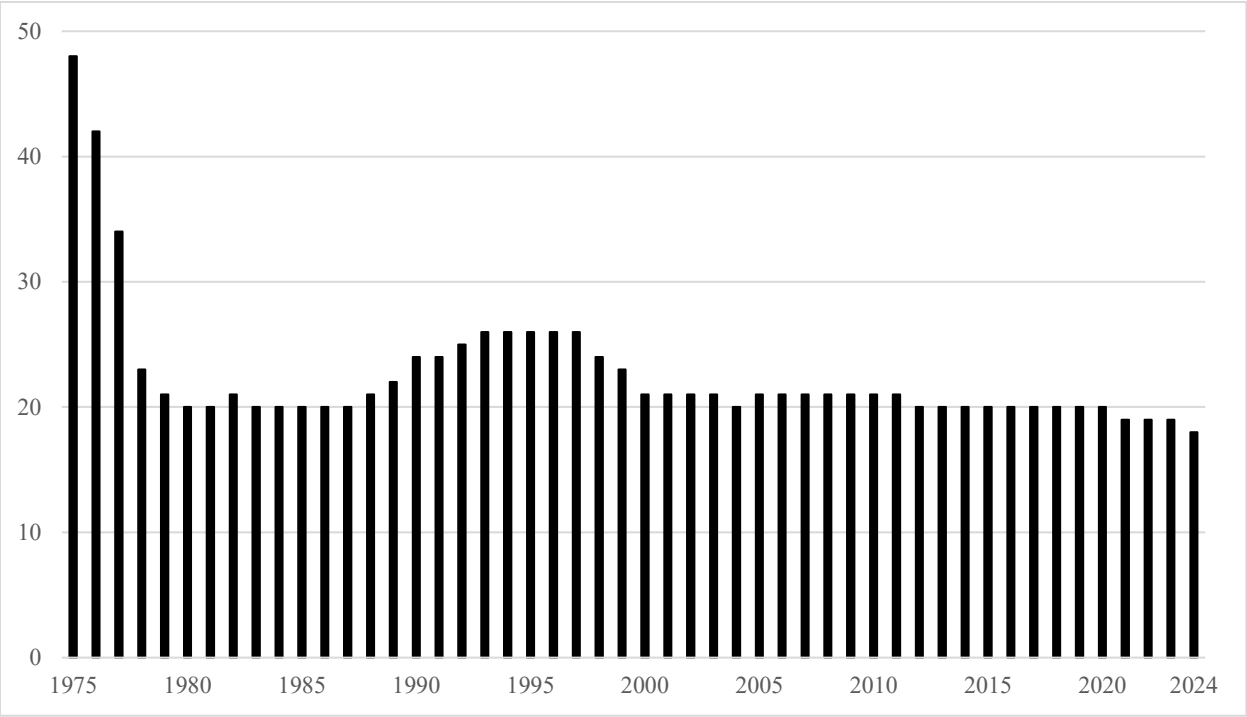

Table 1

Estimated fatalities that would have been prevented if helmet use in states that allowed unhelmeted motorcycling had been as high as in states with all-rider helmet use laws, 1976–2022

	Fatalities in all-rider helmet law states		Fatalities in states that allowed unhelmeted riding		Estimated population-level helmet use rate		
	Helmeted	Unhelmeted	Helmeted	Unhelmeted	In states with all-rider helmet laws	In states where unhelmeted riding allowed	Estimated fatalities attributable to allowing unhelmeted motorcycling
1976	1,229	1,093	115	869	64.1%	17.4%	182
1977	1,408	976	255	1,460	69.6%	21.7%	330
1978	1,126	665	462	2,321	72.9%	24.0%	552
1979	1,030	656	573	2,633	71.4%	25.7%	599
1980	1,100	674	561	2,803	72.1%	24.1%	657
1981	1,051	613	572	2,660	73.1%	25.4%	629
1982	1,085	522	518	2,324	76.7%	26.1%	589
1983	953	622	502	2,183	70.9%	26.7%	486
1984	1,060	645	527	2,370	72.3%	26.1%	548
1985	1,035	647	526	2,354	71.7%	26.2%	538
1986	1,064	554	562	2,386	75.3%	27.2%	583
1987	923	515	524	2,072	74.0%	28.6%	487
1988	895	440	502	1,824	76.4%	30.4%	446
1989	851	366	372	1,546	78.7%	27.6%	403
1990	1,051	425	321	1,446	79.7%	26.1%	388
1991	904	348	301	1,252	80.5%	27.6%	338
1992	1,142	388	135	730	82.4%	22.7%	209
1993	1,190	392	126	737	82.8%	21.3%	213
1994	1,114	342	147	714	83.8%	24.6%	207
1995	1,078	330	140	678	83.8%	24.7%	197
1996	1,050	297	141	673	84.9%	25.0%	199
1997	1,037	280	142	657	85.5%	25.5%	196
1998	989	269	214	822	85.4%	29.2%	241
1999	1,050	281	297	855	85.6%	35.5%	246
2000	1,122	279	406	1,088	86.5%	37.2%	316
2001	1,194	268	452	1,281	87.6%	35.9%	382
2002	1,238	242	461	1,326	89.0%	35.6%	407
2003	1,359	250	601	1,500	89.6%	38.9%	461
2004	1,447	240	789	1,550	90.5%	44.7%	475
2005	1,682	284	908	1,701	90.4%	45.9%	518
2006	1,868	266	912	1,764	91.8%	45.1%	555
2007	1,970	276	1,040	1,888	91.9%	46.6%	592
2008	1,996	268	1,102	1,941	92.2%	47.4%	612
2009	1,636	235	874	1,722	91.7%	44.6%	542
2010	1,732	202	852	1,731	93.2%	43.9%	562
2011	1,792	184	910	1,744	93.9%	45.3%	574
2012	1,756	206	1,080	1,944	93.1%	46.9%	626
2013	1,632	175	1,070	1,814	93.7%	48.4%	589
2014	1,717	182	1,042	1,653	93.7%	50.0%	535
2015	1,751	186	1,223	1,866	93.7%	51.0%	602
2016	1,923	223	1,197	1,994	93.2%	48.8%	640
2017	1,872	236	1,283	1,838	92.6%	52.6%	575
2018	1,846	230	1,197	1,765	92.7%	51.8%	554
2019	1,840	247	1,199	1,758	92.2%	52.0%	545
2020	1,958	268	1,385	2,008	92.1%	52.3%	619
2021	2,057	301	1,564	2,215	91.6%	52.8%	673
2022	2,109	299	1,689	2,125	91.8%	55.8%	640
Total	64,912	17,887	31,771	78,585			22,058

Table 2

Estimated motorcyclist fatalities attributable to allowing unhelmeted motorcycling by state, 1976–2022

	Estimated fatalities attributable to allowing unhelmeted motorcycling	Most recent year with a fatality when unhelmeted motorcycling was allowed
AK	38	2022
AL	0	Before 1976
AR	322	2022
AZ	965	2022
CA	2,536	1991
CO	672	2022
CT	513	2022
DC	0	Before 1976
DE	73	2022
FL	1,786	2022
GA	0	Before 1976
HI	211	2022
IA	571	2022
ID	187	2022
IL	1,738	2022
IN	1,151	2022
KS	395	2022
KY	407	2022
LA	197	2004
MA	0	Before 1976
MD	93	1992
ME	197	2022
MI	267	2022
MN	584	2022
MO	57	2022
MS	0	Before 1976
MT	185	2022
NC	0	Before 1976
ND	96	2022
NE*	71	1988
NH	188	2022
NJ	0	Before 1976
NM	404	2022
NV	0	Before 1976
NY	0	Before 1976
OH	1,651	2022
OK	644	2022
OR	93	1988
PA	595	2022
RI	96	2022
SC	1,000	2022
SD	185	2022
TN	0	Before 1976
TX	2,490	2022
UT	267	2022
VA	0	Before 1976
VT	0	Before 1976
WA	153	1990
WI	841	2022
WV	0	Before 1976
WY	114	2022

* Nebraska weakened its all-rider helmet law, effective January 1, 2024.