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**International  
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# Evidence Synthesis on Interventions Targeting Motorcyclist Safety



## Key Findings

- The following interventions effectively reduced motorcyclist crashes, fatalities, or injuries.
- Anti-lock braking systems (ABS) alone and in combination with combined braking systems (CBS) reduced hospital-reported motorcyclist crashes.<sup>1</sup>
- Protective clothing for motorcyclists, such as motorcycle jackets with body armor, reduced the risk of injury.<sup>2</sup>
- Divergence markings (separate directional markings) and lane-based motorcycle waiting zones at intersections reduced the rates of right-turn collisions, sideswipe collisions, and rear-end collisions.<sup>3</sup>
- Road traffic legislation assigning certain restrictions on motorcycle riders, including restrictions on night riding, carrying passengers, and driving on certain roads and highways reduced motorcyclist fatalities.<sup>4</sup>



## Recommendations

The recommendations for enhancing motorcyclist safety include:

- Adapting a safe systems approach to road injury prevention among motorcyclists<sup>5</sup>
- Including a combination of measures geared toward motorcyclist safety in national road safety plans<sup>3,6</sup>
- Implementing ABS on all motorcycles<sup>1,7-9</sup>
- Introducing divergence markings (separate directional markings) and lane-based motorcycle waiting zones to guide motorcycles into appropriate locations at intersections<sup>3</sup>
- Introducing road shoulders alongside rural roads in cases where complete lane separation is not possible<sup>10-14</sup>
- Establishing roadside barriers in front of hazards<sup>5,15</sup>
- Scaling up and incorporating safe riding and hazard perception training into national motorcycle licensing systems<sup>16,17</sup>
- Advocating for laws that address multiple risk factors for motorcyclists (instead of isolated helmet laws), such as lowering blood alcohol concentration limits, mandatory pre-licensing education, limits on the number of passengers, longer duration of permit holding, and enhanced enforcement of such laws<sup>18-20</sup>
- Conducting further research into autonomous crash avoidance systems and their ability to detect motorcyclists<sup>21</sup>



## The problem

Motorcycles, mopeds, scooters, and electric bikes (e-bikes) contributed to about 30% of all crash fatalities reported to the World Health Organization (WHO) in 2016.<sup>22</sup> Ongoing urbanization in low-and middle-income countries (LMICs) has led to a rapid increase in the use of powered two-wheelers like motorcycles. In countries that have seen a rise in the number of powered two- and three-wheelers, over 70% of the national vehicle fleet consists of motorcycles.<sup>23</sup> Below are some examples of the increasing burden of motorcyclist fatalities and non-fatal injuries seen in LMICs in recent years.

- Motorcyclists represented over 70% of all road fatalities in Cambodia in 2015.<sup>24</sup>
- Crash data from 2017 shows that more than 70% of crashes occurred among motorcyclists in Sri Lanka.<sup>25</sup>
- In Kampala, motorcyclists represented 48% and 46% of road deaths in 2019 and 2020, respectively. In both years, motorcyclists accounted for a higher proportion of serious injuries at 58%, compared to pedestrians, bicyclists, and car occupants.<sup>26</sup>



## What has already been proven to work

- Correct helmet use has been found to reduce the risk of fatal injuries by 42%.<sup>24</sup>
- Helmet laws and/or enforcement of such laws resulted in a reduction in fatalities and injuries among motorcycle riders.<sup>27-32</sup>
- Speeding increases the probability of motorcyclist fatalities by 212%. Thus, compliance with safe speeds is likely to have a protective effect on motorcyclists.<sup>33</sup>
- Implementation of laws around low blood alcohol concentrations led to a decrease in injuries in young drivers ranging from 11% to 33%.<sup>34</sup>



## What this review adds

The existing literature on motorcyclist safety interventions presents an array of evidence of the benefits of helmet use, safe speed adherence, and compliance with zero alcohol laws among motorcyclists. This review excluded interventions focusing on helmet use, safe speed adherence, and avoidance of driving under the influence. However, studies discussing these interventions delivered in combination with other motorcycle-specific interventions were included.

This review presents global evidence of the effectiveness of other interventions targeting motorcyclist\* safety, including motorcycle-specific lanes, anti-lock braking systems (ABS), restrictions on learner and provisional riders, and training for new riders, among others.<sup>35-41</sup> Additionally, outcomes such as road traffic fatalities, non-fatal injuries, crashes, and improvements in safety behavior and/or practices were considered.

\*This review focuses only on motorcycles; interventions targeting other powered two-wheelers such as e-bikes, scooters, mopeds, tuk-tuks, etc. were not included.



## Summary of Evidence

### Interventions targeting motorcyclist safety

Below is a summary of interventions that were found to be effective. Majority (58%) of the evidence came from high-income countries.

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<b>Divergence markings and lane-based motorcycle waiting zones to guide motorcycles into appropriate locations at intersections<sup>3</sup></b>	Taiwan	Post-encroachment time (PET), the time between the first road user leaving the encroachment zone and the second road user arriving in it, increased by a range of 3%–20%, and the rates of right-turn collisions, sideswipe collisions, and rear-end collisions decreased by 64%, 77%, and 62%, respectively.
<b>Protective clothing for motorcyclists (jackets, gloves, boots, and pants with and without body armor)<sup>2</sup></b>	Australia	<p>Overall, riders were significantly less likely to be admitted to the hospital if they crashed while wearing a motorcycle jacket (RR = 0.79, 95% CI: 0.69–0.91), motorcycle pants (RR = 0.49, 95% CI: 0.25–0.94), or motorcycle gloves (RR = 0.41, 95% CI: 0.26–0.66). The effect of motorcycle boots on hospitalization was not significant (RR = 1.04, 95% CI: 0.59–1.83).</p> <p>When body armor was fitted, there was a 23% lower risk of injury associated with motorcycle jackets (RR = 0.77, 95% CI: 0.68–0.86), 39% for motorcycle pants for leg injuries only (RR = 0.61, 95% CI: 0.41–0.91), and 45% by motorcycle boots (RR = 0.55, 95% CI: 0.35–0.85).</p>

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<b>ABS on motorcycles<sup>8,9</sup></b>	United States	<p>The fatal crash rate per 10,000 registered vehicle years was 5.70 for ABS motorcycles, compared with 7.40 for the same motorcycles not equipped with ABS. The overall standardized mortality ratio (SMR) is 0.78 with a 95% CI of 0.69 to 0.87). This represents a statistically significant 22% reduction in fatal crash risk associated with ABS.</p> <p>ABS was associated with reduced fatal crash risk across all types of motorcycles, although slightly larger effects were observed for cruiser/standard, touring, and sport-touring motorcycles than for sport/unclad sport and super sport motorcycles.<sup>9</sup></p>
	Spain, Italy, Sweden	<p>The overall reduction in injury crashes among ABS-fitted motorcycles was statistically significant in all countries.</p> <p>The reductions were 24% (95% CI: 12–36) in Italy, 29% (95% CI: 20–38) in Spain, and 34% (95% CI: 16–52) in Sweden.</p> <p>The reductions in fatal and severe crashes with motorcycle ABS were generally greater, compared to all injuries, ranging from 34% (95% CI: 24–44) in Spain to 42% (95% CI: 23–61) in Sweden. The results for severe and fatal rear-end crashes were even more impressive, ranging from 57% (95% CI: 45–69) in Spain to 60% (95% CI: 42–78) in Sweden.<sup>8</sup></p>
<ul style="list-style-type: none"> <li>• <b>ABS on motorcycles alone</b></li> <li>• <b>Combination of ABS and combined braking systems (CBS)<sup>1</sup></b></li> </ul>	Sweden	<p><b>ABS alone:</b></p> <p>Hospital-reported crashes were reduced with ABS by 47% (95% CI: 15–79), and crashes in intersections were reduced by 48% (95% CI: 9–87). The reduction of rear-end crashes was not statistically significant (43%; 95% CI: –3 to 89%).</p> <p>With ABS, the risk for permanent medical impairment of at least 1% and at least 10% were reduced by 15% and 37%, respectively. These were statistically significant at the 95 and 99% levels, respectively.</p> <p><b>ABS + CBS:</b></p> <p>With ABS and CBS, hospital-reported crashes were reduced by 49% (95% CI: 11–87), whereas the results for ABS alone were lower and not statistically significant (40%; 95% CI: –8 to 88).</p> <p>Total reductions in permanent medical impairment of at least 1% was 56% (<math>P &lt; 0.001</math>) with ABS + CBS and 50% with ABS alone (<math>P = 0.003</math>).</p>

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<b>Signage and vocal prompts on safe behavior among motorcycle riders (safe behavior includes getting off and walking motorcycles on a sidewalk)<sup>42</sup></b>	Japan	<p>Overall, 85% of motorcycle riders exhibited safe behavior.</p> <p>Separately, 87% of the male riders and 94% of the female riders engaged in safe behavior.</p> <p>Overall, the mean percentage of safe behavior increased from 22% during the baseline to 88% during the intervention.</p>
<b>Road traffic law that:</b> <ul style="list-style-type: none"> <li>• penalizes motorcyclists for carrying more than one passenger at a time,</li> <li>• bans the use of both commercial and personal motorcycles from certain highways, bridges, and roads across Lagos State,</li> <li>• requires commercial motorcycles to only operate between the hours of 6:00 a.m. and 8:00 p.m. every day<sup>4</sup></li> </ul>	Nigeria	<p>A 76% reduction in motorcyclist fatalities was observed during the overall study period.</p> <p>Between the pre-intervention (January to August 2012) and immediate post-intervention periods (September 2012 to April 2013), the number of motorcyclist fatalities dropped by 53% (<math>p = 0.002</math>). From the immediate post-intervention to the sustained post-intervention periods (May to December 2013), fatalities declined by 45% (<math>p = 0.186</math>, not statistically significant). Despite a minor uptick in fatalities in the middle of 2015, the reduction was persistent throughout the study period.</p> <p>Mean motorcyclist fatality rates in the pre-intervention and sustained post-intervention periods were significantly different as well (<math>p &lt; 0.0001</math>).</p>
<b>Periodic changes in road traffic law (with changes in government) in the following order:</b> <ul style="list-style-type: none"> <li>• Prohibition of the use of motorcycles on major roads and bridges between 2014-2016</li> <li>• Incorporation of several motorbike (heavy capacity) hailing services in 2017, that were allowed on the roads and bridges, that were previously prohibited by the 2012 traffic law</li> <li>• Complete ban on motorcycles on roads in the main business districts of Lagos, except those used for courier and logistic services in 2019<sup>43</sup></li> </ul>	Nigeria	<p>There was a downward trend in the frequency of motorcycle accident mortality from 2010 to 2019.</p> <p>Government policies on motorcycle transportation have likely played a role in this trend, namely, the ban on motorcycles from major roads and bridges in 2014-2016 and the introduction of motorbike hailing services in 2017-2019. There was a 17% reduction in fatalities from motorcycle accidents in the era of the motorbike hailing services (January 2017 to December 2019).</p>

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<p><b>State-specific motorcycle licensing law that:</b></p> <ul style="list-style-type: none"> <li>• requires a skill test before learner's permit is provided</li> <li>• introduces restrictions* on the duration of the learner's permit</li> <li>• introduces restrictions on carrying passengers</li> <li>• introduces restrictions on night riding<sup>19</sup></li> </ul>	United States	<p>The presence of a skill test requirement for obtaining a permit (RR = 0.76, 95% CI: 0.69–0.84), longer permit duration (95-190 days [RR = 0.86, 95% CI: 0.79–0.95] and &gt;190 days [RR = 0.87, 95% CI: 0.81–0.93]), and three or more learner's permit restrictions (RR = 0.78, 95% CI: 0.73–0.84) were all independently associated with lower motorcyclist fatality rates.</p>
<p><b>Criminalization of several traffic offenses including driving without a license<sup>20</sup></b></p>	Spain	<p>The overall number of male drivers involved in injury collisions dropped (RR = 0.93, 95% CI: 0.89–0.97) after the reform of the penal code, but no change was observed among women (RR = 0.99, 95% CI: 0.95–1.03).</p> <p>In total, 13,891 men (P &lt; 0.01) were prevented from being injured.</p> <p>Larger reductions were observed among young male drivers and among male motorcycle or moped riders than among the drivers of other vehicles.</p>
<p><b>Probationary driving license scheme (PDLS) that introduces restrictions for novice motorcyclists such as:</b></p> <ul style="list-style-type: none"> <li>• the requirement to display a 'P' decal (commonly called a 'plate') at the front and rear of their motorcycles</li> <li>• bans carrying any passenger</li> <li>• bans exceeding 70 km/h, even on roads with speed limits above 70 km/h</li> <li>• bans driving on the offside lane of expressways with three or more traffic lanes<sup>44</sup></li> </ul>	Hong Kong, China	<ul style="list-style-type: none"> <li>• The overall crash rate, and serious and fatal injury crash rates, involving novice motorcyclists showed a downward trend after the introduction of the PDLS.</li> <li>• Between the pre-intervention and post-intervention periods: <ul style="list-style-type: none"> <li>• The average monthly crash rate per 1,000 novice motorcyclists dropped by 16%.</li> <li>• The average monthly crash rates with serious and fatal injuries reduced by 23% and 8%, respectively.</li> </ul> </li> </ul>
<p><b>Video-based classroom and simulation training to improve hazard perception and tackle unawareness while driving<sup>45</sup></b></p>	Thailand	<p>Unawareness riding behavior was mitigated by &gt;60% from baseline (p&lt;0.05) in the group exposed to training.</p> <p>Perceived behavioral control into unawareness riding behavioral score was statistically significantly mitigated by 61-72% from baseline scores, one week after training.</p>

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<b>Safe riding behaviors and first responder training and distribution of helmets<sup>16</sup></b>	Uganda	<p>At enrollment, compared to regular drivers, SafeBoda drivers (exposed to the intervention) were more likely to report safe riding behaviors (e.g., they were more likely to report having a driver's license [66% vs. 35%, <math>p &lt; 0.001</math>] and wearing a reflective jacket [100% vs 49%, <math>p &lt; 0.001</math>]).</p> <p>The mean road traffic knowledge score was 87.7 for SafeBoda vs. 84.8 for regular drivers, with a statistically significant mean difference of 2.9 points (95% CI: 0.50–5.30, <math>p = 0.020</math>). However, evidence of a statistically significant mediation effect of road traffic knowledge on risk of road traffic crash was not found.</p> <p>SafeBoda drivers were less likely to report being involved in a road traffic crash (RTC) in the six months prior to their enrollment in the study (RR = 0.68, 95% CI: 0.48–0.97, <math>p = 0.03</math>). SafeBoda drivers were 39% less likely to be involved in a RTCs than regular drivers after adjusting for age, possession of a driver's license, and education (RR = 0.61, 95% CI: 0.39–0.97, <math>p = 0.04</math>). The total effect of the SafeBoda program on the risk of RTC (irrespective of pathway) was a reduction of 41.6 crashes per 1,000 drivers compared to regular drivers (95% CI: –0.081 to –0.010, <math>p = 0.03</math>).</p>
<b>State laws on helmet, speed limit, alcohol, and mandatory rider education program<sup>46</sup></b>	United States	<p>Mandatory rider education programs reduced non-fatal injuries by approximately 10% (<math>p &lt; 0.01</math>).</p>

TYPE OF INTERVENTION	COUNTRY	EFFECTIVENESS
<p><b>The Road Safety Plan of Malaysia included:</b></p> <ul style="list-style-type: none"> <li>• <b>community-based campaigns about proper riding gear, such as reflective strips and reflective vest, light-colored clothing, high visibility painted motorcycles, visibility enhancement sticker, at-risk individuals such as young, male riders</b></li> <li>• <b>advocacy about crash and injury prevention</b></li> <li>• <b>monitoring selected road stretch locations, and identifying hazardous locations</b></li> <li>• <b>establishing motorcycle-specific lanes</b></li> <li>• <b>installing temporary warning signage, road studs, and linkers at locations considered hazardous</b></li> <li>• <b>repairing potholes</b></li> <li>• <b>distribution of helmets<sup>15</sup></b></li> </ul>	<p>Malaysia</p>	<p>The use of light-colored clothing increased significantly (<math>p &lt; 0.05</math>) following a media intervention.</p> <p>RTCs decreased by 64% after community-based programs.</p> <p>Creation of separate motorcycle lanes reduced fatality by 600%.</p>
<p><b>Multiple interventions delivered individually following a safe systems approach (installation of a roadside barrier in front of a hazard [safe roadways]; helmet use [safe vehicles and protective devices]; safe speed adherence; not drinking while driving [safe people])<sup>5</sup></b></p>	<p>United States and Australia</p>	<p>The killed or hospitalized (KH) rate reduced from 81% to 63% in the United States data and from 81% to 53% in the Australian data when the effects of the four interventions were calculated concurrently (safe systems approach), compared with the converse.</p> <p>The killed or severely injured rate reduced from 67% to 40% in the United States data and from 69% to 23% in the Australian data with the safe system approach.</p> <p>The rates of KH, considering interventions individually, generally decreased when a barrier was present, when the motorcyclist was helmeted, when speed was not involved or when alcohol was not involved (except for helmet use in Australia).</p>

\* For learner's permit restrictions, states were categorized into two groups: one to two restrictions (including those states that do not require a learner's permit) and more than two restrictions. Restrictions on the duration of a learner's permit ranged from 1 to 95 days (including those states that do not require a learner's permit), 95 to 190 days, and > 190 days.



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