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Infrastructure Measures to Protect the Unrecognized Vulnerable Road User: Motorcyclists †

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Abstract: Motorcyclists are 28 times more likely to die in traffic crashes than occupants in passenger cars and they constitute 14% of the total traffic fatalities while being less than 3% percent of registered vehicles. Training and education of motorcycle operators has been an area of focus to improve these statistics, but, considering that motorcycle safety has become worse in the last 20 years, more must be done. This paper summarizes the needs and results of existing infrastructure-related improvements for motorcyclist safety, while also identifying areas of research needed to continue to advance motorcyclist safety through engineering-based infrastructure improvements.

Keywords: motorcycle; infrastructure; safety

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1. Introduction

A Vulnerable Road User (VRU) was recently defined in the VRU Safety Assessment section 23 U.S.C. 148(1) of the U.S. Bipartisan Infrastructure Law (BIL) as a "pedestrian, bicyclist, other cyclist . . . ", but motorcyclists were specifically noted as not included as a VRU [1]. Unfortunately, about the same time, the U.S. DOT National Highway Traffic Safety Administration (NHTSA) reported that more motorcyclists were killed in traffic crashes in 2020 than when data first was collected on fatal crashes back in the 1970s. They also reported that motorcyclists constitute 14% of the total traffic fatalities while being less than 3% of all registered vehicles [2], suggesting that they are indeed vulnerable.

This paper provides a brief history of motorcycle safety research and then describes the status of infrastructure design considerations for motorcycles. Next, several infrastructure-related improvements to safety are highlighted. The last section identifies future opportunities that could affect motorcyclist mortality.

2. Motorcycle Safety Historical Focus

With motorcycle fatalities reaching 5000 a year (see Figure 1), the NHTSA sponsored the first major U.S. motorcycle safety study in the 1970s. The "Hurt Study" (named for the lead investigator, Dr. Hurt) looked in depth at over 900 motorcycle crashes and identified the conspicuity of motorcycles, especially at intersections, as an important consideration to motorcyclist safety, but also recognized the potential contribution of infrastructure. The next major crash analysis study was performed in Europe (the MAIDS or Motorcycle Accident In-Depth Study) in the late 1990s. Both studies led to an increased focus on motorcyclist access to rider education safety programs and the use of personal protective equipment (PPE), such as helmets [3].

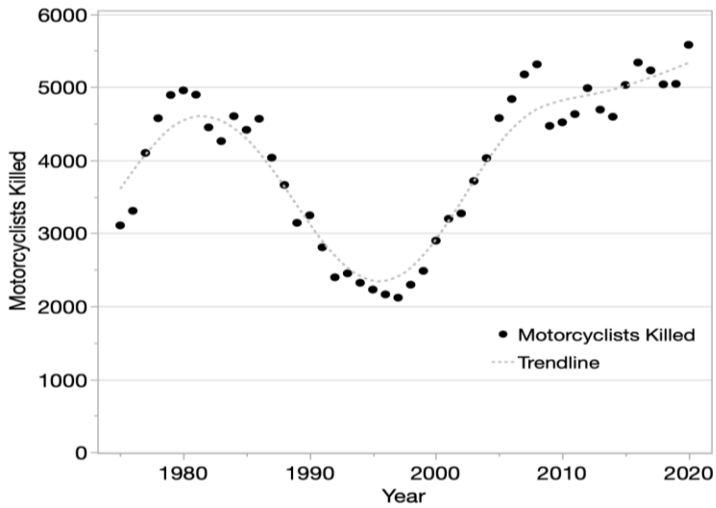

Figure 1. Motorcycle fatalities: 1975 to 2020 (Developed from FARS data [4]).

Since those studies, motorcycle fatalities have oscillated, as shown in Figure 1, and are now again above the "Hurt" study levels of 5000 [4]. It can be seen from the figure that U.S. motorcycle fatalities doubled from a low around 1994 to 2014, but it has also been reported that U.S. passenger car and light truck fatalities decreased by 34% in that same timeframe [5].

3. Motorcycle Safety and Infrastructure Design

Due to the NHTSA recommendations, currently, every state in the U.S. has a State Highway Safety Plan (SHSP) that identifies motorcyclists as a specific safety focus. The SHSPs predominately consider PPE education (i.e., helmets) or operator training efforts, with only limited descriptions of engineering methods or infrastructure changes used to improve motorcyclist safety. The main roadway design manual used by the U.S., the AASHTO Policy on Geometric Design of Highways and Streets (or "Green Book"), is relatively silent on motorcycles. In contrast, Australia's VicRoads, the United Kingdom's Institute of Highway Engineers and Transport for London all have guidance documents on roadway design specifically for motorcycles [6–8]. Even the World Health Organization (WHO) recognizes motorcyclists as VRUs and has guidelines specifically on how to design roads to be safer for motorcycles [9].

4. Specific Infrastructure Interests for Motorcyclists

The U.S. Motorcycle Advisory Council (MAC), which was authorized in the Fixing America's Surface Transportation (FAST) Act, identified 11 areas of infrastructure of concern to motorcyclists. As described in a recent Federal Highway Administration (FHWA) technical report, which was developed in response to the MAC recommendations, some noteworthy actions related to these areas of motorcycle safety in the U.S. have been identified [10]. These areas are described in more detail in the following sections.

4.1. Pavement Markings

The Minnesota and Florida Departments of Transportation (DOTs) are both addressing the friction of pavement markings in critical areas for motorcyclists. Minnesota has used high-friction markings on roundabouts and has research underway that is considering how to measure and address the effects of differential roadway friction. Florida has used high-friction pavement shields on interstate routes, starting with the interstates near Daytona Beach, the site of Annual Bike Week [10]. They are now expanding these requirements to the entire state.

Virginia Tech has also been testing continuous friction measurement equipment (CFME), which can identify pavement friction issues, including pavement marking friction, better than current U.S. equipment [3,11].

4.2. Work Zones

The Montana DOT has a motorcycle advisory sign policy that provides information for motorcycles in work zones that may be especially difficult for motorcycles to traverse (e.g., rough road or gravel-type conditions). This policy has been in place since 2013, and is aided by the Montana DOT's 511 website. Since it is not always possible to avoid all work zones, the National Work Zone Safety Information Clearinghouse also has a one-hour online training program for work-zone managers that offers guidance on how to ensure that their work zones address the specific concerns of two-wheeled vehicles (motorcyclists and bicyclists) [10].

4.3. Intersections

The proper detection of motorcycles for intersection approaches is critical to prevent trapping a motorcyclist in a dilemma zone, where they must choose between crashing due to braking too hard or crashing due to someone else in the intersection not seeing them enter on the end of a yellow. Only 10 states' DOTs specifically recognize the special requirements of detecting motorcycles at signalized intersections in their specifications (80% of states do not mention motorcycles at all) [3]. However, the Ohio DOT developed its own loop detector designed to specifically detect motorcycles. They also specify and test pole-mounted detectors to make sure they identify motorcycles accurately [10].

4.4. Roadside Barriers

Guardrails and other roadside barriers are designed to reduce the severity of crashes for motor vehicles. Although motorcyclists constitute about 14% of all traffic fatalities, they account for 40% of all vehicle–guardrail-related fatalities in the U.S. [12]. European Standard EN-1317-8, a full-scale vehicle–barrier crash testing standard for motorcycle-barrier impacts, has been in use for over a decade in Europe [13], but the U.S. does not have any similar standards. The Texas DOT has sponsored recent research using finite-element modeling and full-crash testing to develop barrier retrofits to improve motorcycle safety [14]. The North Carolina DOT, Utah DOT, and Caltrans have all tested motorcycle safety barriers on the roadway. Also called Motorcycle Protection Systems (MPS), they can be retrofitted on existing guardrails by placing a barrier rail below the main guardrail. This lower barrier prevents the motorcyclist from hitting the supporting poles of a guardrail, which is the kind of impact that is especially hazardous for motorcyclists. The Utah DOT documented a safety improvement with a MPS section that had a motorcycle injury every year in the five years before the installation, and none in the subsequent three-year period [13]. A recent U.S. cooperative research study recommended that MPS be further evaluated, and guidance be developed for their testing and use in the U.S. [12].

5. Crucial Infrastructure Opportunities of ITS (Intelligent Transportation Systems)

ITS is at the center of the future in transportation, tied in with automated and connected vehicles. The roadway, including traffic-safety appurtenances, and the vehicles themselves are all a part of the future of ITS. Even now, cars use different levels of automation or advanced driver-assistance systems (ADAS) to improve safety, such as blind-spot warnings in mirrors and the now-ubiquitous cruise control and anti-lock brakes. Automation is also available in motorcycles, and at least 14 different ARAS (advanced rider assistance systems) have been identified, the most common being anti-lock braking (ABS), but also including advanced curve warnings to identify if a rider is approaching a horizontal curve too fast [15]. The connected vehicles of the future also could improve the conspicuity of motorcycles and prevent hundreds of fatal motorcycle crashes per year [16].

6. Conclusions

Motorcyclists are vulnerable users of the roadway, as shown by their disproportionate number of fatal crashes as compared to other road users. Efforts to address these sometimes-forgotten VRUs can be found in the U.S., but more needs to be done. As part of the MAC effort, research problem statements have been developed related to measuring and specifying pavement marking friction and gathering information on how to modify other existing roadway guidance documents to reflect the particular needs of motorcyclists. One promising note: the AASHTO Guide for Pavement Friction recently added some language on the consideration of motorcycles as related to pavement friction [17]. Next, the "Green Book" and the Roadside Design Guide also need to recognize the vulnerable motorcyclist.

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