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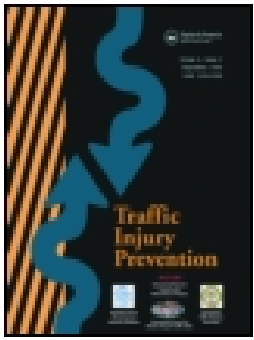
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## Comparing consequences of using two different definitions for body regions for the improvement of personal protective equipment for powered two-wheelers

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### ABSTRACT

**Objective:** Various definitions and uses of the term *body region* can be found in the literature. A definition of body regions using the Abbreviated Injury Scale (AIS) codes not strictly aligned with AIS chapters was developed for use in the European Commission-funded PIONEERS project (Protective Innovations of New Equipment for Enhanced Rider Safety). This work aims to examine the consequences of differently defined body regions on injury priority ranking using the percentage of patients showing at least moderate injury severity (AIS 2+) per regarded body region.

**Methods:** Three different crash investigation data sets of injured riders and/or pillion riders of powered 2-wheelers (PTWs) were used for this analysis. The first contained data for 143 fatalities, the second contained data for 58 severely injured, and the last for contained data for 982 patients from a sample that was close to national representativeness. Frequency of injury was examined using body regions based on the AIS chapters (and first digit of the AIS Unique Identifier) and based on the PIONEERS definition.

**Results:** Though different body region definitions did not result in different top-ranked body regions in terms of injury frequency, different definitions did provide different levels of information that impact priority within AIS chapter-defined regions. For PTW riders, cervical injuries are the highest priority spinal injuries. Thoracic and lumbar spinal injuries seem to occur together with other injuries in the thorax and abdominal region. Severe lower extremity injuries frequently involve the pelvis and the leg.

**Conclusions:** Body regions need to be defined carefully to avoid misinterpretations. Publications that use body regions for their analysis to present injury frequencies should clearly define what they include in each region.

### KEYWORDS

Injury coding; injury analysis; crash analysis; powered-two-wheeler; Abbreviated Injury Scale (AIS)

### Introduction

Riders of powered 2-wheelers (PTWs) are vulnerable road users. With the exception of helmets, there has been little progress in crash protection technologies. To set priorities for technology development for casualty and injury reduction, there is a need to identify the most vulnerable body regions and frequent injuries. However, a review of the literature reveals that previous PTW research has often presented injury data using different body region groupings (Peek-Asa and Kraus 1996; Centre for Transport and Energy Research and Development 2006; European Association of Motorcycle Manufacturers 2009; McIntyre et al. 2011). In most cases, a definition of which body parts and injuries belonged to which body region was missing. Often it was possible to assume that the first digit of the Abbreviated Injury Scale (AIS) codes was used as body regions, categorized by chapters in the AIS code book (e.g. American Association of Automotive Medicine 2008), yet frequently an additional pelvic body region was included, whether or

not the neck included the cervical spine was unclear, and the head and face sometimes formed a joint body region. To develop specific countermeasures for the injuries sustained by PTW riders, these details are very important. For example, the cervical spine should be included in the neck region when exploring the protective potential of neck braces. Further, the understanding of pelvis injury risk in PTW riders needs a broader view of the pelvis, including pelvic bones, pelvic organs, and the related soft tissue (Meredith et al. 2016). An overall external region for skin injuries will not provide information on the need for improved (or wearing of specific types of) protective clothing; for example, jackets versus pants.

In the European Commission-funded PIONEERS project, a working group assigned AIS injury codes to defined body regions relevant to PTW rider protection. The resulting PIONEERS body region definitions and assignment of codes to body regions are presented elsewhere (Schick et al. 2019; Wisch et al. 2019). Though this definition aimed to

overcome limitations arising due to lack of clarity and potentially irrelevant injury groupings for studying injury mechanisms and developing personal protective equipment (PPE) for PTWs in previous work, the real impact of different body region groupings on priority setting has not previously been studied. The objective of this analysis is to examine the consequences of using different body region definitions on AIS 2+ (AIS severities 2 to 6) injury frequencies aggregated to the patient level per body region. This might demonstrate the practicality of the PIONEERS definition for PTW safety research and highlight the need for any future improvements.

## Methods

Three PTW data sets containing accidents involving PTW riders (including pillion riders) with at least minor injury and with at maximum one further involved traffic accident participant were used for this study. One data set stems from the Ludwig-Maximilians-Universitaet (LMU) in Munich, Germany, and is named “LMU.” It contains accident-related and impact-related data for 143 fatally injured PTW riders with autopsies collected in southern Bavaria (2004–2015). Injuries were coded from the autopsy records using AIS 2015 by medical students and a certified supervisor with 22 years’ AIS coding experience. The second data set stems from the University of Florence and is named “InSAFE” (In-depth Study of road Accident in Florence). It contains accident-related and impact-related data from technical reconstruction for 58 hospitalized PTW riders with Injury Severity Score > 15 collected from the metropolitan area of Florence, Italy (2010–2018). Injuries were coded from the medical record, including both full-body computed tomography scans and X-ray imaging using the AIS 2005 update 2008 by a physician and a technician with 9 years’ experience. The third data set, named “GIDAS,” is taken from the German In-depth Accident Study. This is a mostly nationally representative in-depth database collecting road traffic accidents with at least one injured person from 2 areas in Germany. The data set contains accident-related and impact-related data on 982 PTW patients (2005–2018). GIDAS uses medical records including computed tomography scans and X-ray and AIS 2005 update 2008 (American Association of Automotive Medicine 2008). GIDAS personnel supervised by physicians at participating medical schools performed the coding. All 3 data sets were descriptively analyzed using the AIS chapter body region definition and the PIONEERS body region definition. The AIS chapter definition leads to 9 different body regions: Head, face, neck, thorax, abdomen, spine, upper extremities, lower extremities, and external. The PIONEERS definition leads to 7 different body regions named head and face, neck and cervical spine (CS), thorax and thoracic spine (TS), abdomen and lumbar spine (LS), upper extremities, pelvis, and lower extremities.

To examine the effect of different body region definitions on priority setting for PTW injury countermeasures, the percentage of riders with at least one AIS 2+ injury in the

regarded body region was calculated for every single body region. Variations in priority body regions resulting from the 2 different body region definitions were examined qualitatively by comparing the ordered ranking by these percentages across body region definitions and across the different data sets.

## Results

Table 1 shows the absolute and relative frequencies of patients showing AIS 2+ injury in each regarded body region and variations in the ordered rank of body region depending on the definition used for the 3 analyzed data sets. There is no apparent difference in the top 2 ranked body regions by the different body region schema for LMU and InSAFE (thorax and TS followed by head and face; thorax followed by head). For the fatalities, the abdomen (abdomen and LS and abdomen) also remained in the top 3 in both. For InSAFE the AIS chapter definition places spine at rank 3, whereas by the PIONEERS definition it is the upper extremities. In contrast, the top 3 ranked body regions in GIDAS are lower extremities, upper extremities, and thorax and thorax and LS.

In the serious/fatal injury data sets LMU and InSAFE, the thorax consistently is the most commonly injured region when the spine is and is not included and, in fact, the inclusion of spinal regions in the thoracic and abdominal regions within the PIONEERS definition has little overall effect. It appears that thoracic and lumbar spine injuries, respectively, do not frequently occur in patients without thorax and abdominal AIS 2+ injuries, respectively. The PIONEERS body region neck includes most of the patients who show spinal injury according to AIS chapters.

Further, from Table 1 it appears that patients suffering from facial injuries as seen from the AIS chapters do not contribute notably to head and face body region using the PIONEERS definition. Similarly, in the fatal data sample it appears that half of the patients with lower extremities injuries depicted from the AIS chapter body region definition suffer from pelvic AIS 2+ injuries.

## Discussion

The primary finding from this analysis is that there is little difference between the PIONEERS body region definition and the AIS chapter-based body region definition on identification of the most frequently injured body regions among PTW riders and the nature of the sample studied has a much greater effect. For decisions on priorities, especially for the prevention of fatalities, AIS 2+ frequencies should be neglected but injuries of AIS 4 or higher should be regarded. Because we used 3 different data sets, AIS 2+ was chosen for demonstration reasons. To what extent AIS version and coding habits influence actual results was not a focus. However, for the purposes of developing measures to protect PTW riders, this comparison provided greater insight into the distribution of injuries within AIS chapter-based body regions. This is most evident in the lower extremities where the PIONEERS body region definition

**Table 1.** Shares of patients with AIS 2+ injuries by body region for each data set and ranking by frequency for both body region definitions.

	PIONEERS (rank)	AIS 2+ (%)	AIS chapter (rank)	AIS 2+ (%)
LMU fatalities <i>n</i> = 143 <sup>a</sup> (100%)	Head and face (2)	80	Head (2)	78
	Neck and CS (6)	49	Face (8)	16
	Thorax and TS (1)	96	Neck (7)	29
	Abdomen and LS (3)	73	Thorax (1)	95
	Upper extremities (4)	61	Abdomen (3)	73
	Pelvis (7)	38	Spine (6)	57
	Lower extremities (5)	51	Upper extremities (5)	60
			Lower extremities (4)	61
			External (9)	2
InSAFE patients <i>n</i> = 58 (100%)	Head and face (2)	57	Head (2)	57
	Neck and CS (6)	19	Face (7)	24
	Thorax and TS (1)	88	Neck (8)	2
	Abdomen and LS (4)	40	Thorax (1)	84
	Upper extremities (3)	41	Abdomen (6)	33
	Pelvis (7)	14	Spine (3)	43
	Lower extremities (5)	31	Upper extremities (4)	41
			Lower extremities (5)	40
			External (9)	0
GIDAS patients <i>n</i> = 982 (100%)	Head and face (4)	14	Head (4)	13
	Neck and CS (7)	5	Face (7)	4
	Thorax and TS (3)	19	Neck (8)	2
	Abdomen and LS (5)	8	Thorax (3)	16
	Upper extremities (2)	35	Abdomen (6)	5
	Pelvis (6)	7	Spine (5)	11
	Lower extremities (1)	37	Upper extremities (2)	35
			Lower extremities (1)	41
			External (9)	0

<sup>a</sup>*n* = 142 (100%) for PIONEERS definition, due to one explosion type injury (AIS 6).

demonstrates that many of the severe injuries occur not only to the femur or leg but also to the pelvis. This distinction is highly important to developers of PPE.

Though it is clear from this comparative analysis that neck injuries as seen by the PIONEERS definition seem to mainly consist of cervical spine injuries, one area where the PIONEERS definition may be improved is to further delineate spinal injuries from injury to other structures by body region. For example, the neck brace is a PPE that addresses cervical spinal injury, but it does not address injury to other structures of the neck. Furthermore, being able to discriminate between spinal injury and other injury in the thoracic and abdominal regions may be important, because it is likely that different mechanisms lead to injury of these different structures and therefore different countermeasures may be needed. However, to prevent injuries within one body region, it is always necessary to look at the specific injury, its severity, and its individual injury mechanism. Though the PIONEERS definition appears useful for providing a good overview of protective needs by body region for PTW riders, ultimately more detailed body region information like that defined for the Crash Injury Research database (Schneider et al. 2011) may be more favorable. In the interim, this analysis highlights the need to encourage researchers to carefully choose the appropriate sample for analysis and always include a definition of body regions used in their publications.

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## References

- American Association of Automotive Medicine. 2008. Abbreviated injury scale 2005, update 2008. Thomas A. Gennarelli, Elaine Wodzin, editors. Barrington, IL: American Association of Automotive Medicine.
- Centre for Transport and Energy Research and Development. 2006. Advanced protection systems: Final report for the work on "Motorcyclist Accidents" (SP4). APROSYS EU project.
- European Association of Motorcycle Manufacturers. 2009. MAIDS project: In-depth investigations of accidents involving powered two wheelers: Final Report 2.0. ACEM, Brussels.
- McIntyre A, Nieuwesteeg M, Cockfield S. 2011. Motorcyclist injuries and protective clothing: research with TAC clients. Australasian Road Safety Research, Policing and Education Conference, Perth, Australia: ARSRPE Conference Proceeding.
- Meredith L, Baldock M, Fitzharris M, Duflou J, Dal Nevo R, Griffiths M, Brown J. 2016. Motorcycle fuel tanks and pelvic fractures: a motorcycle fuel tank syndrome. *Traffic Inj Prev.* 17(6):644–649.
- Peek-Asa C, Kraus JF. 1996. Injuries sustained by motorcycle riders in the approaching turn crash configuration. *Accid Anal Prev.* 28(5):561–569.
- Schick S, Piantini S, Wisch M, Brown J. 2019. Defining body regions by AIS © for categorizing injuries of powered-two-wheelers. International IRCOBI Conference on the Biomechanics of Impact, IRCOBI 2019, IRC-19-11.
- Schneider LW, Rupp JD, Scarboro M, Pintar F, Arbogast KB, Rudd RW, Sochor MR, Stitzel J, Sherwood C, MacWilliams JB, et al. 2011. BioTab—a new method for analyzing and documenting injury causation in motor-vehicle crashes. *Traffic Inj Prev.* 12(3):256–265.
- Wisch M, Piantini S, Schick S, Whyte T, Brown J, Canu A, Perrin C, Serre T, Perera N, Martínez E, et al. 2019. Powered two-wheelers – Road traffic accident scenarios and common injuries, Deliverable 1.1, EU-Project PIONEERS (Protective Innovations of New Equipment for Enhanced Rider Safety), Horizon2020, Grant Agreement Number: 769054, to be published in 2019.