Head Impact Conditions in Real-World Fatal Motorcycle Crashes

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I. INTRODUCTION

Each year, half of the fatal traffic accidents world-wide involve vulnerable road-users, with motorcyclists making up 23% of those fatalities [1]. The most comprehensive European investigation into powered two-wheeler (PTW) accidents [2] revealed that PTW fatalities accounted for 11% of total road deaths globally, including either the driver or the passenger. Further, it was found that at the instant of the precipitating event, 19.4% of those PTWs were travelling at speeds of 50 km/h or lower [2]. PTWs are increasingly considered a viable mobility solution, especially in regions of intense traffic congestion. Recent statistics show a slight increase in the number of registered PTWs [3], as well as increases in the most popular PTW engine capacity registered, while at the same time, the regulations for both PTWs and cars are changing. In light of these trends we should expect to see differences in the accident profiles and types of injury. The aim of this study was to analyse more recent data to improve knowledge and understanding of current patterns in fatal accidents. Specifically herein we investigate injury type distribution of body region and helmet impact patterns.

II. METHODS

InSAFE [4] is an ongoing in-depth crash study being conducted by the University of Florence in the metropolitan area of Florence (Italy). The methodology has been described previously [4]. This paper focuses on the fatal crashes drawn from the InSAFE database that occurred between 2010 and 2014 (five year span). The following inclusion criteria were applied for selecting cases: 1) powered two-wheeler (PTW) vehicles; 2) driver and/or pillion passenger cases; 3) vehicle-to-vehicle collisions (V-V); 4) single PTW collisions (S-V); 5) death within 30 days of injury occurrence. Twenty-seven fatal accidents, with 28 fatally injured motorcyclists, were studied and a preliminary analysis on the helmets and the head impacts and injuries was carried out.

III. INITIAL FINDINGS

The collisions with obstacles, parked vehicles or another vulnerable road user (type 7) were the most frequent collision types, followed by the head-on crashes (type 2) and angled head-on-side impacts (type 4) (Fig.1). With all collision types pooled, the mean travelling speed was 59.1 km/h (SD 13.1), and the mean collision speed was 47.3 km/h (SD 17.7). In the S-V subset, the mean collision speed was 56.7 km/h (SD 15.5), while the ΔV was 33.7 km/h (SD 19.7). In the V-V subset, the head-on crashes showed higher mean collision speed (44.0 km/h, SD 18.4) and higher mean ΔV (75.5 km/h, SD 35.5) compared to side impacts (29.9 km/h, SD 12.3; 28.1 km/h, SD 10.1). In 80% of cases, travelling speed was above 50 km/h, and in 50%, collision speed was above 50 km/h (Fig. 2).

Each motorcyclist was wearing a helmet at the time of the crash, but in one case the helmet was a non-approved model. Eight (28%) of the motorcyclists wore full-face helmets, 18 (65%) wore an open-face helmets and in two cases (7%) helmet type was unknown. The helmet retention systems were categorized as *Quick-release* (Q-r, 46.5%, 13/28), *Slide-bar* (S-b, 21%, 6/28) and *Double D-ring* (D-D, 14%, 4/28). In eight cases the helmet was lost after the first impact: in six of these cases the helmet retention systems had not been closed (1 *D-D*; 1 *Q-r*; 2 *S-b*; 2 unknown) and in the other two cases the straps were too loose (2 *Q-r*). Table I shows the damage frequency distribution by helmet region. Cars (47%, 9/19 cases) and surroundings (42%, 8/19 cases) were the main cause of fatal head injuries. Head impacts above the waistline of the car (7/9 cases), and head impacts against poles and curbs (5/8 cases) were the most frequent subtypes.

The head was the most frequent body region fatally injured (68%) and in 10 people it was the only site. The main categories of head injuries were subdural hematoma, brain swelling, diffuse axonal injury, intracranial

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hematoma and fractures of the skull, facial and cervical bones. In V-V crashes, 12 out of 17 people suffered fatal head injuries and in three of these cases the helmet had been lost. In S-V crashes, 7 out of 11 people suffered fatal head injuries with helmet loss in two cases.

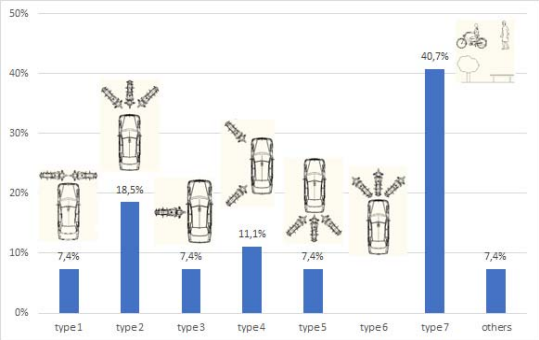

Fig. 1. Fatal motorcycle collision types (N = 27).

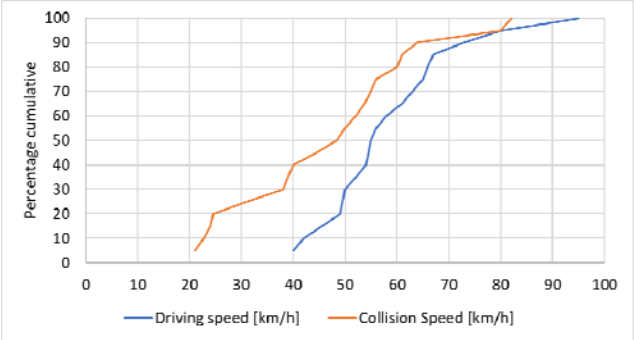

Fig. 2. Motorcycle Travel and Collision speeds [N = 20].

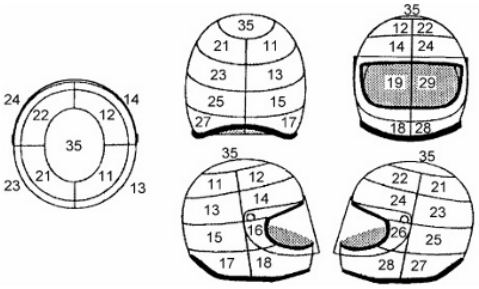

Fig. 3 Helmet sectors

TABLE 1 Helmet damages (only percentages above 10%)

	No damage	Wipe-trace, scratch-mark	Breakage, deformation
Sector 12-14	73,1%	15,4%	11,5%
Sector 15	65,4%	19,2%	15,4%
Sector 16	57,7%	23,1%	19,2%
Sector 17	73,1%	11,5%	15,4%
Sector 18	65,4%	19,2%	15,4%
Sector 19	61,5%	19,2%	19,2%
...	...	...	...
Sector 28	69,2%	15,4%	15,4%
Sector 29	73,1%	15,4%	11,5%

IV. DISCUSSION

Preliminary results show that 80% of fatalities occurred at collision speeds above 50 km/h, meaning that impact energy was higher in these compared to cases of serious *non*-fatal injuries [5-6]. This to bring a change in the injury location compared to those reported cases in the reference [7] where the upper and lower extremities were the body regions most often injured. Serious injuries mainly occurred at collision speeds between 47 and 53 km/h (mean value), and they were mainly located on the head and thorax [5-6].

This study found that fatalities occurred at collision speeds lower than those reported by reference [8] (47.3 km/h vs. 69 km/h). This discrepancy could be due to the facts that our sample included a greater number of light PTWs, whereas [8] dataset consist of more large motorcycles and extra urban accidents. Further studies are needed to get a better understanding about this variance.

No relation was found between helmet loss and type of retention system, although the loose strap condition was only seen in helmets with a Q-r latch. The distribution of helmet damage (abrasion and breakage) was located primarily in the lateral and the frontal regions, while impacts to the back and the top of helmets were less frequent.

V. ACKNOWLEDGEMENT

This work was supported by the Florence Police data in Italy. It is part of the Fatal Road Accident Investigation in Florence (FRAIF) project funded by the Fondazione Cassa di Risparmio di Firenze, Italy.

VI. REFERENCES

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