Disparity of motorcycle helmet use in Nepal - weak law enforcement or riders' reluctance?

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ABSTRACT

Like many low- and middle-income countries, Nepal is experiencing a massive motorization, predominantly from increased use of motorcycles which is driving a surge in road-related injuries and fatalities. Motorcycles and their riders have been identified as a focal point for road traffic injury prevention measures. While helmet use is mandatory for both motorcycle drivers and passengers, fines for helmet non-use are only levied on drivers, not on passengers, and it is unclear how this unequal enforcement translates to helmet use rates in Nepal. Hence, a video-based observation on motorcyclists' helmet use was conducted alongside a questionnaire survey on fatalism, perceived police enforcement, risk-taking personality, and perceived usefulness of helmets. For the observation and questionnaire survey, seven rural and urban sites were selected from all seven provinces of Nepal, representing varied populations, road environments, and elevations. The observation of the helmet use behavior of 2,548 motorcycle riders revealed an alarming picture of helmet use in Nepal. While more than 98% of observed motorcycle *drivers* in Nepal used a motorcycle helmet, less than 1% of observed *passengers* did so. Interviews of 220 riders show that the absence of a fine for helmet non-use by passengers is accompanied by an unawareness of the traffic law, where only 11.8% of respondents knew about the mandatory helmet use law for passengers. Unhelmeted riders had a significantly higher attribution of road related crashes to fate, compared with riders that used a helmet. Results of this study can serve as an evidence base for revisions of Nepal's Vehicle and Transportation Management Act in regard to traffic rule enforcement and fines. They further show the global importance of comprehensive regulation on safety related behaviors of road users. The feasibility of more comprehensive enforcement is discussed against the background of helmet availability for passengers.

1. INTRODUCTION

Each year, more than 1.3 million people die due to road traffic related crashes, and 20 to 50 million people are seriously injured globally (WHO, 2018). These road related fatalities and injuries disproportionately affect people in low- and middle-income countries (LMIC), where a rapid motorization combined with a lack of infrastructure improvement has driven a constant increase in the number of road users injured and killed in traffic (World Bank, 2017). Motorcycle riders form a large share of these fatalities and injuries, especially in countries where motorbikes and motorcycles are the main form of transportation (WHO, 2017). Adequate motorcycle helmet use has been singled out as the most critical factor in preventing head injuries in case of a crash (Kim, Wiznia, Averbukh, Dai, & Leslie, 2015; Liu, Ivers, Norton, Boufous, Blows, & Lo, 2008). Despite implementing mandatory motorcycle helmet use laws, a number of LMIC are still suffering from low helmet use rates (Bachani et al., 2012; Peltzer, & Pengpid, 2014; Siebert, Albers, Aung Naing, Perego, & Santikarn, 2019). However, helmet use data is only available for 38.1% of LMIC, prohibiting the constant evaluation of helmet law adherence and preventing evidence-based policy and regulatory changes (WHO, 2018).

One example of a country with a large share of motorcycle traffic and a lack of data on motorcycle helmet use is Nepal, where 71.5% of motorized traffic consists of motorcycles (Department of Transport Management Nepal, 2019), and helmet use is mandatory for drivers and passengers. While adherence to the helmet laws is rated as relatively high by road safety experts in the country, no data on motorcycle helmet use is available (WHO, 2018). Hence, the aim of this study is to generate a comprehensive picture on the adherence to mandatory helmet laws in Nepal and collect subjective data on riders' motorcycle safety related attitudes and perceptions in a combined observational and questionnaire survey.

2. BACKGROUND

2.1. Selected factors related to helmet use

A main factor that is regularly found to have a critical influence on motorcycle helmet use is the existence and enforcement of mandatory helmet laws. Studies have repeatedly shown an increase in helmet use and a decrease in injured and killed motorcycle riders when mandatory helmet laws are passed (Chiu, Kuo, Hung, & Chen, 2000; Ichikawa, Chadbunchachai, & Marui, 2003; Olson et al., 2016). Conversely, a decrease in helmet use and an increase in injured and killed motorcycle riders have been found when helmet laws are repealed (Buckley et al., 2016; Houston & Richardson Jr, 2007; Ulmer & Preusser, 2003). Once laws are

enacted, their enforcement has a main influence on helmet use by motorcyclists (Jiwattanakulpaisarn et al., 2013; Passmore, Nguyen, Nguyen, & Olivé, 2010). A study by Kulanthayan, Radin Umar, Ahmad Hariza and Mohd Nasir (2001) found that riders who expect police enforcement were 2.16 times more likely to comply with helmet regulations. The level of expected police enforcement has been hypothesized to contribute to helmet use differences within countries, e.g., between rural and urban areas (Hung, Stevenson, & Ivers, 2006; Li, Li, Cai, Zhang, & Lo, 2008).

Apart from the existence and enforcement of mandatory motorcycle helmet laws, a number of subjective variables have been found to relate to helmet use, such as the perception of control over situations (Locus of Control: Brijs, Brijs, Sann, Trinh, Wets, & Ruiter, 2014; Champahom, Jomnonkwao, Satiennam, Suesat, & Ratanavaraha, 2020) health belief (Özkan, Lajunen, Doğruyol, Yıldırım, & Çoymak, 2012; Sukor, Tarigan, & Fujii, 2017), social norms and attitudes (Bachani et al., 2012; Bachani et al., 2013). For this study, interviews were planned to be collected using a convenience sample approached in the road environment, so the survey questionnaire had to be relatively short, ruling out the use of long existing questionnaires. Hence, only four subjective variables, collected through a small number of items were assessed: risk-personality (Trimpop, 1994; Wilde, 1982), fatalism (Dixey, 1999; Kayani, King, & Fleiter, 2012; Maghsoudi, Boostani, & Rafeiee, 2018), perceived police enforcement (Kulanthayan et al., (2001), and perceived usefulness of helmets (Ranney, Mello, Baird, Chai, & Clark, 2010; Zamani-Alavijeh, Bazargan, Shafiei, & Bazargan-Hejazi, 2011).

2.2. Nepal

Located between China and India, approximately 29.6 million people live in Nepal. With a median age of 24.5 years, Nepal has a comparably young age structure in comparison to western industrialized countries. There are seven provincial states in Nepal. The population is unevenly distributed, with high levels of urbanization around the capital city Kathmandu and other economic centers such as Biratnagar and Pokhara.

According to the WHO Global Status Report on Road Safety (2018), the number of registered road related fatalities has more than doubled between 2006 and 2016, increasing from approximately 1000 to 2000 registered fatalities. The most recent numbers, registered through the Nepalese Police Force, list 2541 road related fatalities in 2017/18 (Nepal Police, 2018). However, taking potential underreporting into account, the WHO estimates that the true number of road related fatalities could be substantially higher, ranging from 3880 to 5546 traffic related deaths (WHO, 2018). Generally, an overall trend of rapidly rising road related

fatalities can be observed in Nepal (Joshi, Pant, Banstola, Bhatta, & Mytton, 2017), with road traffic related injuries and fatalities representing one of the main causes for hospitalization in Nepal (Joshi, & Shrestha, 2009; Shrestha et al., 2013).

As the motorized vehicle fleet in Nepal consists overwhelmingly of 2-wheelers, which amount to 71.5% of all 3.5 million registered vehicles (Department of Transport Management Nepal, 2019), a special focus needs to be given to the road safety of motorcycle riders. The Global Burden of Disease Study has shown a high share of transport related injuries (Pant et al., 2020) with motorcycle riders severely affected by road related crashes, sustaining severe injuries (Huang et al., 2016; Mytton, Bhatta, Thorne, & Pant, 2019). Hence, the non-use of motorcycle helmets has been identified as a major contributing factor to the severity of riders' injuries (Huang et al., 2016; Mishra, Sinha, Sukhla, & Sinha, 2010; Sathian, Pant, Van Teijlingen, Banerjee, & Roy, 2018; Thapa, 2013). Apart from injuries sustained, crashes involving motorcycles have also been linked to high economic costs to the health system of Nepal (Sapkota, Bista, & Adhikari, 2016).

The regulations regarding helmet use in Nepal are governed by the Motor Vehicles and Transport Management Act 2049 (1993), which states that "While driving a motorcycle or similar other two wheeled motor vehicle, the driver and the pillion rider shall use helmets." (Chapter 7, §130, (2), Vehicle and Transportation Management Act, 1993). However, the provisions in the Nepalese law concerning fines for non-use of a motorcycle helmet only impose a fine for drivers of motorcycles, but not for passengers ("[…] fine of Twenty Five Rupees (US $0.21) to Fifty Rupees (US $0.42)[…] Driving a motor vehicle without fastening the seat-belt or without using the helmet", Chapter 10, §164 (n), Vehicle and Transportation Management Act, 1993). However, in practice, the police fines the helmet rule violators from 500 Rupees (US $ 4.29) to 1,500 Rupees (US $ 12.88) according to a notice on the its website https://traffic.nepalpolice.gov.np/index.php/notice/violation-and-fine. Despite this, the level of enforcement of the law is rated as high (8 out of a maximum of 10) by road safety experts in Nepal (WHO, 2018). It is unclear however what the actual level helmet use of motorcycle drivers and passengers in Nepal is. There are only indications of passenger helmet use, e.g., the Nepalese Road Safety Action Plan (Ministry of Physical Planning & Transport Management, 2013) recognizing a generally low adherence to the mandatory helmet use law by motorcycle passengers, researchers arguing for increased enforcement of motorcycle passenger helmet use (Huang et al., 2016), and proposed new legislation to increase passengers helmet use ("Pillion riders will have to wear helmet", 2019).

2.3. Research questions

While two-wheelers are the predominant mode of transportation and an analysis of hospital data confirms that motorcycle users are a major risk group for crashes with comparably higher rates of head injuries, little is known about helmet use in Nepal. As inconsistencies concerning the national application of law and its enforcement have been found (Ministry of Physical Planning & Transport Management, 2013), this study explores current behavioral patterns regarding helmet use in Nepal. Main questions of interest are the identification of the current rate of motorcycle helmet use of drivers and passengers, their knowledge about the law regarding helmet use, as well as riders' attitudes towards the usefulness of helmets, risk, fatalism and their perception of police enforcement. The following research questions are addressed in this study:

1. What are the helmet use rates of drivers and passengers of motorcycles at different sites around Nepal?
2. How do riders' attitudes relate to their motorcycle helmet use?

Since self-reported as well as observed helmet use data will be collected in the scope of this study, the accuracy of self-reported helmet use in comparison to observed helmet use will be assessed in an exploratory analysis.

3. METHOD

Between August and November 2018, two methods were used to collect data on motorcycle helmet use, a comprehensive observation of helmet use in traffic and a questionnaire survey, with both methods applied at seven sites across Nepal. Observations were conducted for two days at each site, while survey data was usually collected for two days, and a third day was added when less than 30 respondents had answered the questionnaire at a site within the two days. The study was conducted under the ethics guidelines of the German Psychological Society (Deutsche Gesellschaft für Psychologie, 2016). In the following, the observational methodology of the study will be described, after which the questionnaire survey method will be presented.

3.1. Observation

For the observation of helmet use, a video-based approach was chosen. The use of video-cameras has a number of advantages over direct observation (Eby, 2011; Siebert & Lin, 2020), as videos can be paused or slowed down to allow the registration of helmet use in crowded scenes, and videos can be moved forward and backward to find a video frame with

an unoccluded view of individual motorcycles. Video based registration further allows the verification of registration data through multiple observers.

To record road traffic in Nepal, two low-cost cameras were built from a Raspberry Pi Zero W module, a Raspberry Pi Camera module, a 128Gigabyte micro-SD memory card, and a 13,000 mAh power bank. The camera components were enclosed by a waterproof grey container with a strap system to attach the cameras on the roadside. The grey case and straps helped to blend in the cameras into the road environment (Figure 1). The cameras were capable of recording video data for up to 48 hours with a resolution of 1920x1080 pixels and a recording rate of ten frames per second. The camera module used in this study does not have an infrared filter, which improves camera performance in low light environments, but results in a slight red tint on the video data.

Figure 1. Observation camera attached to a concrete utility pole in Kathmandu (marked with a rectangle).

The selection of observation sites for this study was guided by earlier studies, which had shown significant differences in observed helmet use rates in different regions within countries (Bachani et al., 2012; Siebert et al., 2019). Based on these results, rural and urban observation sites in all seven provincial states of Nepal were chosen, encompassing different population groups, road environments, geographical elevations, and overall structures (Table 1). Within the seven regions, the following seven observational sites were chosen: Birendranagar, Janakpur, Kathmandu, Pokhara, Salleri, Tansen, Tikapur (Figure 2). Whenever possible, one camera was installed at a street with high traffic volume, and one camera was installed at a street with lower traffic volume (relative to the city observed).

Cameras were installed before sunset and taken down after sunset two days after (approximately 40 hours), recording two full days of daylight traffic.

Table 1. Details of study sites where observational and survey data were collected (data from the websites of respective municipalities).

Sites	Province	Region	Geography (elevation)	Population (density)
Birendranagar	Karnali	Mid-West	Valley (660m)	115,451 (429/km^2)
Janakpur	Province 2	South-East	Plains (75m)	159,468 (1,700/km^2)
Kathmandu	Bagmati	Centre	Valley (1,400m)	671,846 (29,000/km^2)
Pokhara	Gandaki	West	Valley (1,400m)	402,995 (868/km^2)
Salleri	Province 1	North-East	Mountain (2,400m)	24,323 (43/km^2)
Tansen	Lumbini	West	Hill (1,350m)	57,045 (479/km^2)
Tikapur	Sudurpaschim	South-West	Plain (160m)	76,114 (650/km^2)

Figure 2. Location of the seven sites selected for the observational study and the questionnaire survey in Nepal (© OpenStreetMap contributors).

3.1.1. Observation coding

Before the observational data was analyzed, all video data was split into five-second video clips. Taking the recording duration at each observation site into consideration, a number of video clips from all observation sites were randomly selected. For the 208 hours source material, this resulted in 417 five-second video clips. For each individual motorcycle in a video-clip, helmet use (yes/no) and rider position (driver/passenger) were registered. All classification was conducted using the video annotation tool BeaverDam (Shen, 2016), in

which each motorcycle was annotated with a rectangular frame (Figure 3). To ensure a high level of data quality, video-clips were first registered by one of the authors, after which another author rechecked the data. The random selection of video clips from observation sites could have potentially led to double counting, i.e. the repeated registration of helmet use behavior of riders on the same motorcycle, e.g. on a roundtrip. Since the prevention of double counting would have entailed the registration of additional variables (e.g. license plates), which would have increased observation coding time, and the potential for double counting was generally expected to be low, no measures to prevent double counting were implemented.

Figure 3. Depiction of video material of a medium sized street in Birendranagar without annotations (left) and a large street in Janakpur with annotation boxes (right).

3.2. Questionnaire survey method

A questionnaire was constructed and applied at the same seven locations in Nepal where traffic was observed (Figure 2). The survey was administered in places where motorcyclists were taking breaks or stopped in the general vicinity of camera installation sites. Stores, shops, and parking lots were the most common places for the selection of participants. The questionnaire was constructed in English, after which it was translated to Nepali. The translation was pretested in Kathmandu to ensure understandability of the survey.

3.2.1. Construction

The structure of the survey consisted of four broad sections, beginning with *demographic variables* such as “level of education”, “age”, and “gender” followed by *motorcycle related variables* such as “driver’s license ownership”, “motorcycle ownership”, “frequency of motorcycle use”, “crash history”, and “knowledge about helmet laws”. Subsequently, a block of questions regarding *police enforcement* was presented, including questions about “likelihood to be caught or fined without a helmet” or the “level of police enforcement”. Questions related to *the psychological constructs* of risk perception and personality (Trimpop, 1994; Wilde, 1982) as well as attitudes towards fatalism (Özkan, Lajunen, Doğruyol,

Yıldırım, & Çoymak, 2012), and perceived usefulness of helmets were presented in the last section. The majority of items in the questionnaire was answered on five-point Likert-scales, with the two poles representing approval/disapproval. For example, on the statement "I like to take risks in my daily life" the poles were "fully disagree" and "fully agree". The answer options in between the poles were not articulated and only represented by numbers. All items on *fatalism*, *police enforcement*, *risk-personality*, and *usefulness of helmets* are presented in Table 3 in the results section of this paper. The three items used to assess fatalism were adapted from existing questionnaires ("Accidents are unavoidable": Jones & Wuebker (1985); "How long I live is predetermined": Shen, Condit, & Wright (2009); "What is the main reason for traffic accidents?": Adapted from Özkan & Lajunen (2005)), while other items were generated by the authors or present generic items e.g. on the frequency of enforcement.

3.2.2. Application

The questionnaire survey was carried out in Birendranagar, Janakpur, Kathmandu, Pokhara, Salleri, Tansen, Tikapur (Figure 2). On site, participants were approached in places where motorcycle users were taking breaks or stopping by. Hence, participants were not always in direct proximity of their motorcycle when approached. Stores, shops, and parking lots were the most common places for the selection of participants. Participants were free to decline participation in the survey, hence the sample can be classified as a convenience sample.

Before the start of the questionnaire, participants were presented with information on the topic of the questionnaire, and informed that participation in the study was voluntary and could withdraw at any point without any consequences. As the questionnaire had a number of filter questions, i.e., questions where the answer determines follow-up questions, the questionnaire was presented on an android tablet (Samsung Galaxy Tab) and an android phone (LG G6), using the software *Limesurvey*. Since previous studies had revealed a tendency of participants to answer untruthfully about their helmet use during self-reported surveys (Bachani et al., 2013), participants that reported to wear a helmet on the day of the survey were asked to take a picture of their helmet with the camera of the phone/tablet. In some cases, this required respondents to walk up to their motorcycle with the interviewer.

3.3. Analysis

Observational and survey data was analyzed using SPSS 25 (IBM Corp, 2015). For observational data on helmet use, the non-parametric Chi-square test was used to assess potential differences between driver and passenger helmet use, with φ calculated for evaluating effect size (Cohen, 1988). When expected values for individual cells were lower

than 5, Fisher's exact test was used. For survey data, the non-parametric Mann-Whitney U test was used to compare individual items between riders who used a helmet on the day of the survey and those that did not. For these comparisons, the effect size *r* was calculated (Rosenthal, 1991).

4. RESULTS

In the following sections, the results of the observations as well as the questionnaire survey are presented. A general data overview of participants and their demographics is described in section 4.1, followed by data on observed and reported helmet use in section 4.2, and a more detailed analysis of the relation between helmet use and subjective data in section 4.3.

4.1. Data overview

In the video-based observation of rider behaviors, the position and helmet use of 2,548 riders was registered. Of all riders, 1,885 (74.0%) were drivers and 663 (26.0%) were passengers, with passengers representing between 22.6% (in Birendranagar) and 32.8% (in Tikapur) of observed riders at individual observation sites. The distribution of the observational sample at the seven observation sites is presented in Table 2.

Table 2. Sample of the observational and questionnaire survey at the seven observation sites. The number of drivers observed is equal to the number of motorcycles observed.

	Birendranagar	Janakpur	Kathmandu	Pokhara	Salleri	Tansen	Tikapur	**Overall**
Drivers observed	209	302	804	208	64	253	45	**1885**
Passengers observed	61	103	252	93	31	101	22	**663**
Percentage of passengers in observation	22.6	25.4	23.9	30.9	32.6	28.5	32.8	**26.0**
Drivers interviewed	23	22	23	24	13	37	41	**183**
Passengers interviewed	8	5	7	5	3	5	3	**36**
Percentage of passengers in survey	25.8	18.5	23.3	17.2	18.8	11.9	6.7	**16.4**

In the questionnaire survey, also administered in the seven provincial states of Nepal (Figure 2), $n = 220$ motorcycle riders completed the questionnaire. Not all riders that were approached took part in the survey, but the survey response rate was not registered. The number of respondents at the seven research sites varied between a minimum of $n = 16$ in Salleri and a

maximum of *n* = 45 in Tikapur (Table 2). Of the *n* = 220 respondents, 84% (*n* = 184) participants were male, and 16% (*n* = 35) female, with one missing response. The mean age of the sample was 26.57 years (*SD* = 7.03), ranging from a minimum of 14 to a maximum of 52 years. Hence, the sample mean is comparable to the overall age structure of Nepal (mean age of 24.5 years, Sapkota et al., 2016, Thapa, 2013). The majority of the sample (73.2%) reported to have finished "higher education"; i.e., university, while approximately one fourth (23.2%) of participants indicate to have finished secondary education and only a fraction (below 4%) had only primary or no education.

Over 80% (*n* = 177 riders) of the respondents reported to have a driver's license, with 91.3% of drivers and 25% of passengers reported to have one. Only 46.3% (*n* = 82) of license owners reported to have taken driving classes to acquire the license. Those riders that indicated to have a license acquired it an average of 5.6 years (*SD* = 4.8) before the survey. Motorcycle ownership in the overall sample was high, with 71.4% (*n* = 157) reporting to own a motorcycle. Higher motorcycle ownership was reported by drivers (79.2%) than passengers (30.6%). Asked about the frequency of motorcycle use, 79.5% (*n* = 175) of riders reported to use it every day, with 14.6% (*n* = 32) reporting at least once a week, and only 5% (*n* = 11) reported less frequent use of a motorcycle.

Asked about their crash history, 28.2% (*n* = 62) respondents reported to have been involved in a road related crash within the last year of the survey. When asked for whom it was mandatory to use a helmet according to the law in Nepal, 95.9% (*n* = 211) of respondents named the driver, while only 11.8% (*n* = 26) also indicated mandatory helmet use of passengers, and only 6.8% (*n* = 15) also named child-passengers. This does not correspond to the law, which lists mandatory helmet use for drivers as well as passengers (see section 2.2).

When interviewed, 83.6% of riders (*n* = 183) arrived at the survey site as drivers, and 16.4% (*n* = 36) arrived as passengers. This is a slightly lower share of passengers compared to the data found in the observational part of the study (Table 2). Of 183 drivers, 88% were male (*n* = 161), while of 36 passengers, 65.7% (*n* = 23) were male.

4.2. Helmet use and rider position

The analysis of observational data reveals an overall average of 72.3% helmet use among the observed Nepalese motorcycle users. The highest average rate of helmet use (drivers and passengers combined) was observed in Birendranagar (77.4%) and the lowest in Salleri (63.2%). A large discrepancy between drivers and passengers was observed (Figure 4). While the average helmet use of all observed *drivers* was 98.7%, average *passenger* helmet use was

0.8%, i.e., of 663 observed passengers only 5 used a helmet. Hence, average helmet use at observation sites, as well as small variations in average helmet use between sites, can almost exclusively be attributed to the share of observed passengers at a given observation site. A Chi-square test reveals a significant disparity between the helmet use of observed drivers and passengers (χ^2 = 2401.8, *df* = 1, *p*<.001; φ=.97 indicating a large effect size (Cohen, 1988).

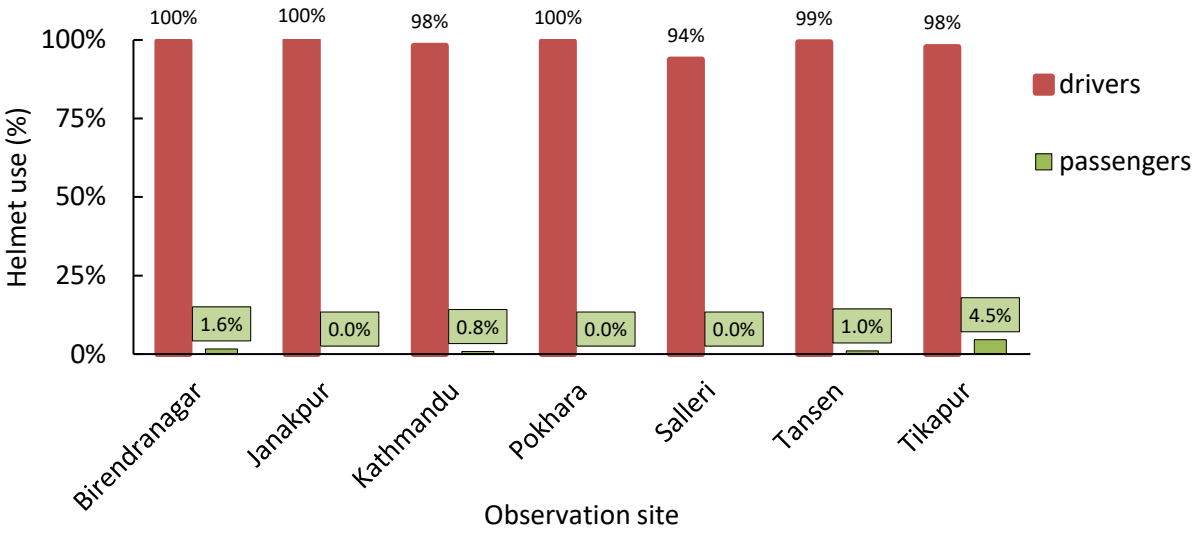

Figure 4. Observed driver and passenger helmet use at the seven observation sites. Helmet use of passengers is highlighted in textboxes.

The questionnaire data shows a similar distribution of helmet use. The average helmet use for all respondents in the questionnaire survey was 86.4%, i.e., 190 of 220 respondents reported using a helmet on the day of the survey. Analyzing helmet use separately for drivers and passengers, it was found that the use of a helmet was 98.4% among drivers (180 out of 183) and 25% among passengers (9 out of 36), with one respondent not answering the question. Fisher's exact test revealed that drivers' and passengers' self-reported helmet use differs significantly (*p*<.01; φ=.79 indicating a large effect size (Cohen, 1988). Self-reported helmet use data for the seven observation sites is presented in Figure 5.

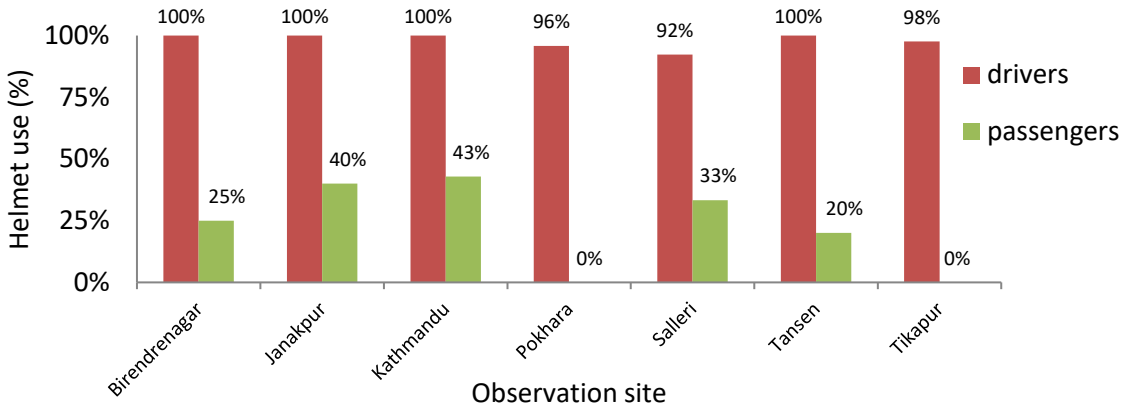

Figure 5. Self-reported helmet use by drivers and passengers at the seven observation sites.

Self-reported helmet use by passengers can be subject to a bias towards reporting higher helmet use (Bachani et al., 2013). Participants were asked to use the phone or tablet camera to take a picture of their helmet, if they had answered to use a helmet on the day of the survey (Figure 6).

Figure 6. Photos of helmets taken with the tablet/phone during the questionnaire survey.

Due to technical problems with the survey software, n = 13 respondents were not asked to take a photo of their helmet, despite answering that they were wearing one. Hence, these respondents are excluded from the following analysis. Counting only those participants who indicated wearing a helmet and also took a picture of said helmet, the overall helmet use in the questionnaire survey dropped from 86.4% (190 of 220 respondents) to 81.6% (169 of 207

respondents). Self-reported helmet use including the camera-based validation is presented in Figure 7. It can be observed that self-reported *driver* helmet use decreased only slightly from 98.4% to 96.5%, while self-reported *passenger* helmet use decreased to a greater extent from 25% to 8.6%. It is important to keep in mind that some of the respondents might have declined to take a photo of their helmet they were using, while others might have taken a photo of a helmet of someone else.

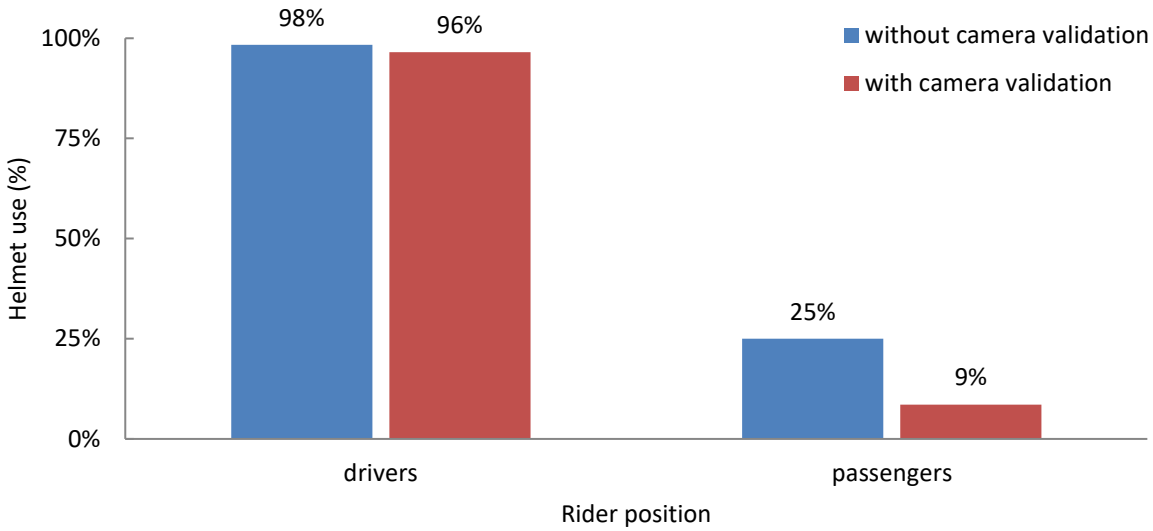

Figure 7. Average self-reported helmet use of drivers (n = 171) and passengers (n =35) with and without camera validation.

Asked if they own a motorcycle helmet, 49.5% (n = 107) reported owning one helmet, 40.3% (n = 87) reported owning more than one helmet and 10.2% (n = 22) did not own a helmet. Forty-four percent of drivers reported owning more than one helmet which they could potentially lend to their passengers, and 51.5% of passengers reported owning one or more helmets which they could potentially use but chose not to.

4.3. Relation of subjective variables and motorcycle helmet use

In addition to the direct questions on their helmet use, respondents were asked about perceived police enforcement, their risk-personality, fatalistic beliefs, and the perceived usefulness of motorcycle helmets for injury prevention. These questionnaire items, as well as mean scores for all riders, helmet users and helmet non-users are presented in Table 3, alongside the test statistics for the Mann-Whitney U test for the comparison of helmet users and non-users.

Table 3. Questionnaire items (including anchors) and mean values for *fatalism, police enforcement, risk-personality, and usefulness of helmets* for all riders, helmet users, and

helmet non-users. In addition, Mann-Whitney U test statistics for the comparison of helmet users and non-users (incl. p-value and effect size r) are listed.

	Overall mean	Helmet users	Helmet non-users	*U* (*p*)	*r-value*
Fatalism					
Accidents are unavoidable. [disagree – agree]	2.69	2.68	2.73	2805 (.88)	.01
How long I live is predetermined. [disagree – agree]	2.22	2.22	2.25	2526 (.94)	-.01
What is the main reason for traffic accidents? [human behavior - fate]	1.76	1.64	2.55	3527 (.002*)	.21
Police enforcement					
How often does the police check if people wear a helmet in your area? [not often – very often]	4.12	4.18	3.69	2173 (.06)	-.13
How likely is it that the police will catch you if you don't wear a helmet? [not likely – very likely]	4.14	4.18	3.86	2242.5 (.10)	-.11
Have you been stopped by the police in the past? [never – often]	2.59	2.66	2.17	2283.5 (.15)	-.10
How likely is it that you have to pay the full fine if police catches you without a helmet? [not likely – very likely]	3.85	3.88	3.63	2199.5 (.29)	-.07
How likely is it that people bribe the police to avoid a fine for not wearing a helmet? [very likely – not likely]	2.87	2.85	2.96	2656.5 (.63)	.03
Risk-personality					
I consider myself a daring person. [disagree – agree]	3.99	3.96	4.17	3023 (.46)	.05
I like to take risks in my daily life. [disagree – agree]	2.15	2.07	2.66	3236 (.036*)	.14
I like to ride fast on a motorcycle. [disagree – agree]	2.40	2.34	2.79	3191 (.11)	.11
Usefulness of helmets					
Do you think a helmet is useful to protect you from injury? [not useful – very useful]	4.31	4.31	4.30	2507.5 (.92)	.01

*$p<.05$

Ratings on *fatalistic beliefs* were relatively low, with respondents disagreeing with the inevitability of crashes, predetermination of life, and fate playing a large role in road related

crashes. The largest descriptive difference in ratings can be observed for the item "What is the main reason for traffic accidents?". A Mann-Whitney U test reveals a significant difference (p=.002) for this item, indicating that non-helmet riders' assessment of crash reasons was significantly different from helmet users towards *fate* as a reason for accidents. The effect size of r=.21 indicates a small effect (Cohen, 1988).

For questions on *perceived police enforcement*, it was observed that riders generally report a high level of perceived *police enforcement*, with high ratings for frequency of checks and high likeliness of being caught for transgression of traffic rules. However, the frequency of actual police checking was rated as low overall. Ratings for frequency of checking and likelihood of being punished for transgressions were slightly higher for helmet users than for helmet non-users. There were no significant differences between helmet users and non-users in their responses to questions on police enforcement.

For items on *risk personality*, ratings for the item "I consider myself a daring person" was descriptively higher than for items on *risk-taking in daily life* and a *propensity to ride a motorcycle fast*. A Mann-Whitney U test revealed a significant difference between helmet users and non-users for the item "I like to take risks in my daily life." (p=.036), indicating significantly higher agreement to this statement of non-helmet users in comparison to helmet users. The effect size of r=.14 indicates a small effect (Cohen, 1988). The perceived *usefulness of motorcycle helmets* for injury prevention was rated as high by respondents, with little difference between helmet users and non-users.

Considering the observational and questionnaire results on helmet use and rider position, it appeared that subjective variables do not differ by large margins between helmet users and non-users, while there was a strong relation between rider position (driver vs. passenger) and motorcycle helmet use.

5. DISCUSSION

This study was conducted to generate an evidence base for the adherence to mandatory helmet laws in all seven provincial states of Nepal. The helmet use behavior of 2,548 motorcycle riders was analyzed in a video-based observation and an additional 220 riders were interviewed about their helmet use and their attitudes towards motorcycle helmets.

With regard to the helmet use of motorcycle riders in Nepal, the observation as well as the questionnaire survey showed an almost exclusive use of helmets by drivers. While overall *driver* helmet use was 98.7% in observations and 96.5% in the questionnaire survey, *passenger* helmet use was only 0.8% in observations and 8.6% in the questionnaire survey.

Although a tendency for higher helmet use by drivers had been expected, since similar trends had been found in other countries before (Siebert et al., 2019; Xuequn, Ke, Ivers, Du, & Senserrick, 2011), the extreme disparity between the helmet use of drivers and passengers is alarming. A potentially related variable for this *disparity of helmet use* was found as inadequacy of law enforcement regarding the helmet use by passengers, and caused by the lack of regulation on fines for passengers' non-use of helmets. The results of this study contrast the information provided in the WHO's Global Status Report on Road Safety which states that helmet use is mandatory for motorcycle drivers and passengers and that enforcement of this law is high in Nepal. The data points presented in the latest Global Status Report (WHO, 2018) can inadvertently conceal the true challenge for motorcyclists' safety in Nepal, i.e., a lack of enforcement of the passenger helmet law.

The impact of the lack of fine-backed enforcement and/or awareness raising among motorcycle riders is evident from the data collected in the questionnaire survey in this study. Only 11.8% of respondents believed that helmet use is mandatory for passengers, while a large majority (95.9%) indicate that drivers need to use helmets, clearly showing the consequence of the one-sided traffic-fine regulation on the knowledge of road users. Our analysis of riders' subjective background concerning risk-personality, fatalistic beliefs, attitudes towards the usefulness of helmets, as well as perceived police enforcement also supports this hypothesis. There is little difference between helmet users and helmet non-users in subjective beliefs and attitudes investigated in this study. And while two items on the survey on fatalism and risk personality (Table 3) were answered significantly different by helmet users and non-users, the related effect sizes were small, especially in comparison to the effect found for the relation of helmet use and rider position (Section 4.2). These findings differ from earlier research on the relation between subjective variables and motorcycle helmet use, which had found stronger relations between helmet use and subjective variables (Brijs et al., 2014; Ranney et al., 2010; Sukor, Tarigan, & Fujii, 2017). It has to be assumed that it is mainly the position of riders on the motorcycle which is associated with the differences in helmet use in Nepal. Results from the questionnaire survey further revealed that the non-use of helmets by passengers cannot be attributed to the unavailability of helmets, as more than half of all passengers interviewed report to own one or more helmets, and a large number of drivers own more than one helmet which they could lend their passengers.

Despite these alarming results, the outlook for the effectiveness of changes in helmet use regulation is positive. Although passenger helmet use is extremely low, drivers' helmet use is very high among the observed population, not only compared to other low-income countries,

but also in relation to middle- and high-income countries (WHO, 2018). This high adherence to the penalized mandatory helmet use law for drivers shows the potential of more comprehensive regulation which include fines for helmet non-use for passengers. High levels of perceived police enforcement (Table 3) of the existing fine-backed law, together with an existing availability of helmets to passengers, indicates that a new regulation could be efficiently enforced. Hence, our results can be used as an evidence base for the potential of legislative improvements in the traffic laws concerning mandatory helmet use.

While this study presents a comprehensive picture of motorcycle helmet use in Nepal, there are a number of limitations on the study design and execution. In this study, traffic was only observed during the day, although studies have shown a decrease in helmet use during the evening hours and at night (Li et al., 2008; Nakahara, Chadbunchachai, Ichikawa, Tipsuntornsak, & Wakai, 2005). Furthermore, although multiple study sites were chosen throughout Nepal, hard to reach rural areas were not included in this study. Since decreased police enforcement in rural areas as well as during the evening and at night have been associated with decreases in helmet use (Hung, Stevenson, & Ivers, 2006; Li et al., 2008). Future studies should aim for a more comprehensive sample, in diversity of population density, as well as the time of the day. Similarly, differences in weather conditions or different days of the week (which were not strictly controlled in this study), might have influenced traffic conditions and flow, which potentially relate to helmet use. Despite the selection of study sites in all provinces of Nepal (Table 1), the data collection cannot be considered as representative for all of Nepal. A similar limitation of sampling is present in the administration of the questionnaire survey of this study. Respondents were classified as a convenience sample, i.e. only riders which were open to take part in the survey were interviewed. This might have led to a biased sample as respondents were not chosen randomly, and riders might have been willing to take part in the survey if they generally behave more safely on the motorcycle, potentially leading to biased answers, e.g. on questions of police fines received in the past. Future studies should register the response rate, by counting the number of approached riders, and relating their number to actual participants in the survey. In addition, the share of passengers among the interviewed motorcycle riders was lower than the share of passengers observed in traffic. Future studies should aim for a comparable driver/ passenger ratio. This study used a questionnaire, compiled by the authors as a means for relatively short answering time. The application of a new questionnaire instead of using an existing instrument might have limited the validity of the results of this study.

While surveys will always need to balance number of questions and response duration for the survey, future studies should aim to use existing validated scales, e.g. in shortened versions.

6. CONCLUSION

Mandatory motorcycle helmet laws, backed by applicable fines, build the foundation of head injury prevention for motorcyclists. The lopsided regulation on motorcycle helmet use in Nepal prevents a comprehensive enforcement of riders' helmet use. Our results show a strong need for a change towards helmet use regulation which levies fines on passengers that do not use helmets. The barriers to law adherence after a change of regulation are comparatively low, as a large share of passengers have access to helmets. The high population density around commercial centers of the country can be leveraged for an efficient enforcement of the new regulation with comparatively little resources. Apart from direct implications for transport policy in Nepal, the results of this study can serve as an argument for comprehensive regulation and enforcement for countries that plan to implement or adapt motorcycle helmet use regulation.

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