

Brief Report

Helmet protection paradox for powered two-wheeler users: Concerns in data misinterpretation and need for improved data systems

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ABSTRACT

The protective efficacy of helmets may be misconstrued due to shortcomings in crash data collection systems. This paper aims to decipher the reasons behind the “helmet protection paradox,” using Bengaluru, India, as a case study. Official reports indicated that three-fourths of fatal two-wheeler crashes in Bengaluru city involved riders who were wearing helmets, leading to a paradoxical interpretation of the protective efficacy of helmets. Understanding helmet use patterns in the source population and crash data systems is key to resolving this paradox. Our findings suggest that the paradox arises from a combination of a high prevalence of non-standard helmet use in Bengaluru and shortcomings in recording the “type of helmet use” in data systems. It is recommended that existing crash and fatality data systems capture information regarding the “type of helmet use” to prevent erroneous interpretations of the protective efficacy of helmets.

Keywords: Helmet, Helmet protection, Helmet protection paradox, Road traffic injury, Traumatic brain injury

INTRODUCTION

India witnessed approximately 160,000 deaths due to road traffic crashes in 2022, equivalent to 1264 crashes and 462 deaths every day. Nearly 46% of these fatalities occurred among Powered two-wheeler (PTW) users, mostly due to head injuries. PTWs accounted for 74% of total registered vehicles in the year 2023 and their numbers increased by 139% during the decade 2011–2020.^[1] It is proven that the correct use of helmets significantly reduces the risk of head injuries by 69% and fatalities by 42%.^[2] Hence, most policies recommend mandatory helmet legislation and effective enforcement of standard helmet use. Incidences of traumatic brain injuries, deaths and disabilities, higher hospital admission rates, longer hospital stays, increased intensive care unit admissions, and economic costs are higher among non-helmet and incorrect helmet users.^[3] Despite this, helmet use remains low in India.^[4-6]

In India, 50,029 (30%) of PTW user fatalities were reportedly not wearing helmets, with 71.3% of these recorded among riders. In Karnataka state alone, 2067 PTW riders and 856

passengers lost their lives in road traffic crashes due to lack of correct helmet use.

Road traffic fatality data are routinely collected by police in India. During accident reporting, police collect binary categorical information regarding helmet use among crash victims (wearing helmets or not) at the time of the crash. Bengaluru city, in India, recorded a higher proportion of helmet use among fatal PTW crashes, raising concerns about the protective efficacy of helmets. This paper aims to understand the reasons for this “helmet protection paradox” using Bengaluru city as an example.

METHODOLOGY

Data regarding crashes and fatalities among PTW users, described by helmet use (wearing/not wearing) in Bengaluru city, were sourced from a report on “Road Traffic Accidents in Bengaluru City-Year 2021, 2022” published by Bengaluru traffic police (BTP).^[7] Roadside observational studies on helmet use and its types among a representative sample of 98021 PTW users in Bengaluru were conducted in

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Received: 04 July 2024 **Accepted:** 23 December 2024 **Epub ahead of print:** 03 February 2025 **Published:** XXXXX DOI: 10.25259/JNRP_266_2024

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the year 2021 by the National Institute of Mental Health and Neurosciences and the John Hopkins International Injury Research Unit. The findings were released as “Status Summary Report of Road Safety Risk Factors” in Bengaluru.^[8] The observational provided information on the prevalence of helmet use and type of helmet use. Helmet use (%) among PTW fatalities as reported by BTP was inferred against the backdrop of helmet use patterns observed in a population-based study in Bengaluru city and existing accident/crash data systems.

Helmet use is defined in this report as a PTW user wearing any helmet. Types of helmet use refer to full-face helmets, open-face helmets, and cap-helmet/half helmets. Correct helmet use is defined as either a full-face or open-face helmet along with a belt strapped to the chin of the user. The converse of correct helmet use (wearing cap-helmet/unstrapped helmet use irrespective of the type of helmet) is incorrect or non-standard helmet use.

RESULTS

Fatalities among PTW users in Bengaluru city

The number of road traffic injury (RTI) fatalities in Bengaluru city was recorded at 772 for the year 2022 as against 651 in 2021. PTW riders and pillions contributed to more than half of total fatalities (55.8%) [Table 1].

Helmet use among PTW fatalities in Bengaluru city

As noted in Table 1, 72% (the year 2021) of the PTW users' fatalities were reportedly wearing a helmet, conversely, 28% did not wear a helmet. Official data sources indicate that helmet-wearing rates were higher among those who died, leading interpretation that helmets are not protective, and deaths occurred more frequently among helmet users as against non-users.

Prevalence of helmet use in Bengaluru city

A population-based observational study of 15 randomly selected locations in Bengaluru city involving five observation sessions per day (90 min each session) and 3 days per location, which provided helmet use behavior among PTW users in Bengaluru city. The study indicated that the prevalence of helmet use among PTW users is 88% but the prevalence of correct use of helmets is only 34%. Notably, about 26% of PTW riders and 47% of PTW pillions were wearing cap helmets (non-standard helmets). Almost 37% of the riders had not strapped their helmet at the time of observation [Table 2].

The study shows that though helmet use is high, the prevalence of correct helmet use is low and the use of non-standard helmets is common. Hence, most PTW users are not

Table 1: Fatalities among PTW users in Bengaluru city for the year 2021 and 2022.

	2021	2022
Total reported crashes	3211	3823
Total reported RTI fatalities	651	772
Total reported PTW users' fatalities	404	431
PTW rider fatalities (%)	328 (81.1)	341 (79.1)
PTW pillion fatalities (%)	76 (18.8)	90 (20.8)
Fatalities-recorded as wearing a helmet (Rider and pillion) (%)	291 (72)	319 (74)
Fatalities-recorded as not wearing helmet (%)	113 (28)	112 (26)

PTW: Powered two-wheeler, RTI: Road traffic injury

Table 2: Helmet use in Bengaluru (year 2022) (n=121,098).

	n (%)
Overall (any type of helmet)	106908 (88)
Correct helmet use	41456 (34.2)
Riders	37726 (38.4)
Pillion	369 (16.6)
Full face helmet use	
Riders	43448 (44.3)
Pillion	2947 (13.3)
Non-full face helmet use	
Riders	20930 (21.3)
Pillion	2715 (12.3)
Cap helmet use	
Riders	26219 (26.7)
Pillion	10561 (47.2)
Helmet strapped	
Riders	53581 (56)
Pillion	11217 (50.9)
Helmet unstrapped	
Riders	35826 (36.5)
Pillion	4847 (22)

Correct helmet use: Full or open face helmet with tightly strapped on to chin, Cap helmet: Non-standard helmet use

adequately protected against head injuries and fatalities due to the high prevalence of non-standard and incorrect helmet use.

DISCUSSION

Helmet legislation was introduced in Karnataka state and Bengaluru city as early as year 2006. Over time, increases in penalty levels, scaled-up enforcement, automated enforcement, advocacy campaigns, and periodical monitoring have increased helmet usage in the city. These efforts have resulted in higher helmet use rates in Bengaluru. Visible, uniform and random enforcement of helmet law by police along with strict penalties is essential for the success of helmet legislation but police often, do not uniformly penalize PTWs using incorrect or non-standard helmets. In such a

scenario, more PTWs use non-standard helmets for the sake of cost and convenience.^[9] Furthermore, a routine accident reporting system does not collect information about “*type of helmet use*” among riders (victims) but collects information only on “*helmet use*” as a binary category (wearing or not).

Mechanism of helmet protection paradox with the example from Bengaluru city

The helmet protection paradox is an erroneous interpretation of the reduced protective efficacy of helmets from existing RTI data systems, and it arises due to a combination of the below situations [Figure 1].

1. A routine fatal accident reporting system does not collect information about different types of helmet use among victims (full face, open face, cap helmet, standard or non-standard use, and correct or incorrect use)
2. High overall helmet use rates are observed in the population
3. Low correct helmet use or high non-standard helmet use.

The helmet protection paradox is an epidemiological adverse effect of injury reporting systems that do not capture details of “*type of helmet use*” among fatal and non-fatal PTW road crashes. It is more likely to be observed in situations where helmet use is

very high in a population but is mostly due to increased wearing of non-standard helmets or due to incorrect helmet use. In a city where helmet use is very high (88% in Bengaluru), riders involved in a crash, would most likely be wearing some sort of a helmet. Hence, there is a higher probability of police recording “helmet use” among crash victims. However, the probability of fatalities is very much inflated due to the high prevalence of incorrect and non-standard helmet use, which offers less protection against traumatic brain injuries. This results in an erroneous inference that “helmets are less protective.”

The mechanism for this paradox and example for Bengaluru city is described in Figure 1. It shows that the prevalence of overall helmet use (88%) is high but correct helmet use is low (34%), and this combination inflates the probability of fatal crashes reporting helmet use (74% of fatal crashes reported helmet use), due to use of poor quality, non-standard helmets, or inappropriate/incorrect use of helmets. This observation needs more verification through systematic studies with data from police and hospitals to bring in required changes along with an examination of other confounding factors. Continuation of the present state of affairs without improving the data systems might also result in changing the opinion of policymakers to make undesired repeal of the law over time.

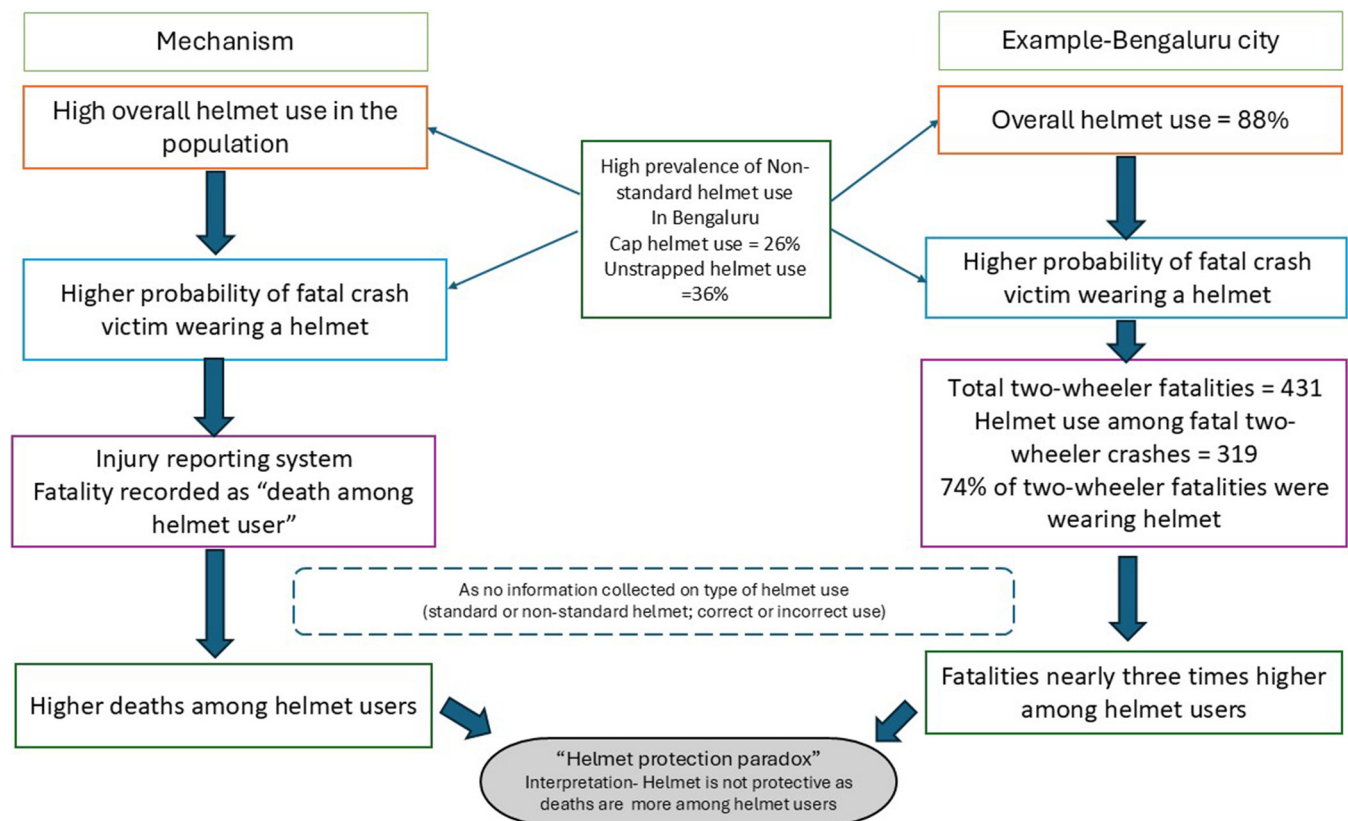


Figure 1: Mechanism of helmet protection paradox.

CONCLUSION

Data from existing information systems reported that a higher proportion of PTW fatalities were wearing a helmet at the time of the crash, raising questions about the effectiveness of helmets. This paradoxical observation is conceptually explained by a high prevalence of non-standard helmet use in the population. As the current accident reporting formats do not capture the type of helmet used at the time of the crash, this has led to erroneous interpretations of the effectiveness of helmets.

Recommendations

Our study recommends to

- Include “type of helmet use” as a variable in crash data collection formats and accident investigation reports. Data regarding the type of helmet used to be collected from both fatal and non-fatal RTIs (including autopsy studies) among PTW riders and pillions.
- Provide helmet-related fatalities information stratified by speeding and drink-driving in the annual reports to understand their confounding effect.
- Conduct regular population-based studies on helmet use to correlate the role of non-standard helmets in PTW fatalities.
- Traffic Police and Transport Department to take cognizance of this potential “helmet paradox” as there is scope for misinformation by media to the society, undermining decadal efforts of protective benefits of helmet use. There is a need to strengthen enforcement of correct helmet use.
- Test this concept of helmet paradox in other cities where there has been an increase in overall helmet use.

Acknowledgment

The authors acknowledge the contribution of Project Coordinators and Field Data Collectors for the timely completion of road safety risk factors data collection.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient’s consent was not required, as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Sukumar GM, Patel N, Priyanthi A, Gururaj G, Kumar A, Anucheth M, *et al.* Helmet protection paradox for powered two-wheeler users: Concerns in data misinterpretation and need for improved data systems. *J Neurosci Rural Pract.* doi: 10.25259/JNRP_266_2024