A Comprehensive Assessment of Full-face Helmet Utilization in Preventing Head and Neck Injury in Motorcycle Accidents : A Systematic Review

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Abstract:

Introduction: Morbidity and mortality due to motorcycle accidents are still becoming a major problem that cannot be solved. A common cause of deaths in motorcycle road accidents is due to head, facial and neck injuries. One of the simple ways to overcome this problem is using a helmet, but the types of helmet that confers the best protection is not specified. This review aimed to evaluate the best type of helmet in reducing mortality and morbidity rate due to head-facial and cervical trauma. **Material and Methods:** A Systematic review evaluating the most prominent helm in conferring protection was carried out using PRISMA statement guidelines. Studies search were was conducted using search engine ScienceDirect, ProQuest, and PUBMED database with criterion papers published in English between 2009 to 2019 and comparing full face, partial face, and open face helmet effectivity in conferring protection. Appraisal tools of selected studies using Centre for Evidence-Based Medicine (CEBM) appraisal tools. **Result and Discussion** : From the search, 1477 studies were identified and finally obtained 8 studies that fulfill the criterion. Studies are organized according to comparison of a full-face helmet with partial face helmet and full-face helmet with partial face helmet. Studies show that a full-face helmet gives significant protection against head-facial and cervical injury. However, because many of the study criteria are not uniformed, the need for further study with better quality is a must. **Conclusion** : Full-face helmets reduce head-facial and neck injuries better than other helmets in motorcycle accidents thus reducing the morbidity and mortality rate.

Keywords: head-facial injuries, helmet, motorcycle accidents

Introduction:

The World Health Organization stated that every minute, three people die worldwide due to road traffic accidents.[1] A Road traffic accident has still become unsolved problems and it is predicated as the most common cause of death in children and young productive adults (age 5-29 years) on a trauma basis thus causing a high burden in many aspects, especially in economic basis.[1] Moreover, the rate of events, and also the morbidity and mortality rates, keep increasing every year and it is known that it is three times higher in low-middle income countries than in high-income countries, especially in Thailand, Malaysia, and Indonesia. [1-2] In Indonesia, the mortality rate due to road traffic accidents from 2010 until 2014 is increasing with motorcycles being the most commonly used vehicle in the accidents (627.116 units or 70% from all of the vehicles used).[2] These data are supported by empirical facts that motorcycles are the most commonly used vehicles in many low-middle income countries.

From 1990 until 2018, the most common cause of deaths due to motorcycle road accidents has not changed.[3] Head and neck injuries were the cause of death of more than 53% motorcycle accidents in the world and recent reports from Cochrane review also stating that craniocerebral, facial, and neck injuries were common too. [3-4] In Indonesia, Indonesian Health Department (DepKes) stated that head-cervical traumas related to motorcycle accidents were the most common cause of death (74%) followed by hip and lower limb traumas (10%).[2] Based on these problems, factors which caused the high rate, morbidity, and mortality rate due to road traffic accidents, especially motorcycle-related, must be evaluated.

Referring to the epidemiological triangle which is modified from Haddon's matrix, three main factors are related to each other in determining the incidence of road accidents, namely agent (the human), host (vehicle factor), and environment (the road.[5] In low-middle income countries, and also supported by data on Indonesia, undisciplined behavior is the leading cause of the incidence, morbidity, and mortality rate increase in road accidents and the commonest undisciplined behavior that is still being neglected in Indonesia is the usage of helmets.[2-5] One of the effective preventive strategies of motorcycle accident severity is to use a helmet while riding a motorcycle due to its protective effect on death

and head injuries based on Cochrane review with OR 0.58 and 0.31, respectively.[4]

Three common types of the helmet that are currently approved by SNI (Standart Nasional Indonesia), namely full-face, open face, and partial face helmet. But the law in many countries, including Indonesia, is not specifying the types of helmet.[6] Whereas a case-control based review conducted by Lam, et al in Taiwan shows that the types of helmet that are used by the motorcyclist does influence the outcome of the motorcycle accidents patients including the rate of head-facial fracture and cervical spine injury compared to non-helmet user (OR = 0.19, 95% CI and OR = 0.35%, 95% CI respectively).[7] Based on these problems, we have an initiative to find which helmet is the best to overcome the high morbidity and mortality rate due to motorcycle accidents with an idea stated on a systematic review. This study aimed to review what is the best helmet type to prevent head and cervical injuries in motorcycle accidents thus could support and determine the best helmet type that may be documented and implemented in the helmet law, especially in low middle-income countries such as Indonesia.

Material and Methods:

A systematic review of large observational studies comparing the protective effect of full-face, open face, and partial face helmet against head-facial and cervical traumas in motorcycle road accidents was carried out using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement rules. We searched works of literature published in Pubmed, ScienceDirect, and ProQuest databases with keywords “motorcycle accident (s), helmet, head injury (s), cervical injury (s) and only papers published in English from 2009 until 2019 which are included. The eligible studies were 1) those which are comparing the full-face helmet with other types of helmet (open face, and partial face) on motorcyclists who had traffic accidents 2) the outcomes of studies involved head-facial and cervical injuries (including spinal cord injuries). We appraised eight Selected studies by using the Centre for Evidence-Based Medicine (CEBM) appraisal tools. The literature selections were summarized in **Figure 1**.

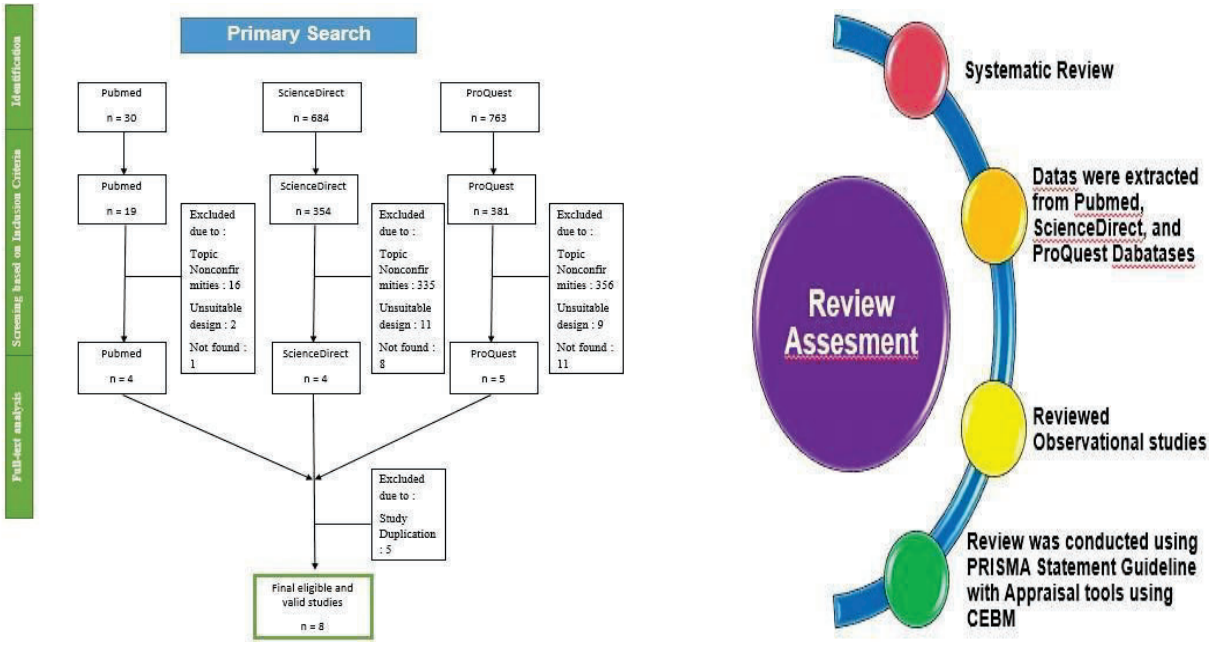

Figure 1. Diagram flow of study search and selection criteria.

Results:

From 1477 published papers from Pubmed, ScienceDirect, and ProQuest databases, we include 1154 studies because the other studies are not published in English and published below 2009. Of those, we finally include eight eligible and valid studies because of the other studies discussing other topics besides the comparison of full-face, open face, and partial face helmet in preventing head-facial and cervical injuries, unsuitable study design, studies not found, and study duplication. The final eligible and valid studies (n=8) then were reviewed here and the results were summarized in **Table 1.**

Full-face Helmet Versus Partial Face Helmet

This systematic review is comparing the effectiveness of the full-face helmet and many types of helmet, one of them is a partial type helmet.[7,8,11,13] There were four studies from Malaysia, Taiwan, and the United States comparing the full-face helmet against partial-type helmet. The output evaluated were head and neck injuries (**Table 1)**. Overall, wearing a full-face helmet compared to a partial helmet could reduce the incidences of cervical and head injuries by 17% compared to four prior studies that evaluated here (95% CI p-value <0.001). And also, all of the participants that are included

Table 1. Summary of Studies Comparing Between Full-face Helmet, Partial Face, and Open Helmet on Head-facial and Cervical Outcomes in Motorcyclists Who Had Road Accidents.

Study	Lam et al[7]	Ramli et al [8]	Cini et al[9]	Brewer et al [10]	Erhardt et al [11]	Albuquerque et al[12]	Yu et al[13]	Sung et al[14]
Country	Taiwan	Malaysia	Brazil	United States	United States	Brazil	Taiwan	Korea
Year	2015	2014	2014	2013	2015	2014	2011	2016
Study Design	Observational Case-control	Observational Case-control	Observational Case-control	Observational Cohort Retrospective study	Observational Cohort Retrospective	Observational Retrospective cohort	Observational Matched case-control	Observational Cohort Retrospective study
Inclusion	Patients intracranial hemorrhage, skull-face fracture, and brain concussion Motorcycle crash Over 17 years of age Data from 2000 until 2009 in	All motorcyclists (Pillion or single rider) All age groups (<16 – 25) All types and severity of injuries Were involved in a motorcycle	Patients injured in the face in a motorcycle accident	All helmeted adults patients older than 18 years old Crashes on an all-terrain vehicle	Riders who are using either full-face, half, and open-face helmet Aged > 15 years old Any type of collision except that is located on	Motorcycle accident victims had to be referred to the outpatient clinic at the hospital	Age ≥15 y Lived in Taichung Visited the emergency room at China Medical University Hospital due to	All drivers and passengers over 15 years old who were riding a motorcycle Wearing a helmet with known types

	Taiwan Head injury registry	crash within the catchment Data from 2010 until 2011 in South Klang Malaysia			open-desert		motorcycle injuries	
Exclusion	Any cases with missing data on helmet use, types of helmet used, or cervical spine injury	Motorcyclists who did not sustain any injury, or discharged themselves from hospital care without a definitive diagnosis, Involved in a road crash outside South Klang	Those with injuries to any other part of the body or whose injuries resulted in the death	Not wearing any helmet at the time of the crash Unidentified types of the helm	Unhelmeted Riders Riders who fall on the open-desert environment	Incomplete hospital records or refusion to participate	Riders who were not operating a motorcycle—i.e. those who were riding a minibike, a bicycle or a tricycle or wore a safety helmet for construction or were involved in a crash outside the	Incomplete Medical Record

		Valley, Malaysia					city of Taichung	
Number of Participants	5,225 participants	755 participants	1,628 participants	151	6460	253	458 participants	509
Primary Outcome	Cervical spine injuries	Facial injuries	Facial injuries	Skull-facial fractures, traumatic brain injury, cervical spine fractures	Neck and head injury	Facial Injury Severity Scale, traumatic brain injury, facial fractures	Head Injury	Head Injury
Full-face helmet with head injury, n	28 (2.1%)	2 (14%)	12 (16%)	16 (19%)	542 (12,7%)	24 (52%)	50 (40%)	52 (20%)
Full-face helmet without head injury, n	1,259 (97.9%)	12 (86%)	63 (84%)	68 (81%)	3698 (87.3%)	22 (48%)	73 (60%)	209 (80%)
Partial helmet with head injury, n	104 (3%)	304 (51%)	-	-	256 (24.7%)	-	274 (57%)	44 (40%)
Partial helmet	3,385 (97%)	293 (49%)	-	-	780 (75.3%)	-	208 (43%)	66 (60%)

without head injury, n								
Open Helmet with head or cervical injury, n	-	-	9 (26%)	49 (73%)	125 (21%)	39 (76%)	-	63 (45%)
Open Helmet without head or cervical injury, n	-	-	25 (74%)	18 (27%)	468 (89%)	12 (34%)	-	72 (55%)

were all of the studies taken as a cohort-based study with the five latest year publications that were included.[9,10,11,12,14] The setting of the studies also varies from countries with many sets of the event thus the validity of helm use in preventing motorcycle accidents has better external validity. The weakness of the studies was conducted with few subjects and some studies that included in the cohort are only patients who have been admitted to the hospital that cooperate with the researcher. The summary can be evaluated in **Table 3.**

Table 2. Summary of comparison of Full-face Helmet Versus Partial Face Helmet on Head-facial and Cervical Trauma on Motorcyclists Who Had Accidents based on This Review.

	Outcomes		
	Yes	No	Total
Full-face helmet	626	5042	5668
Partial helmet	938	4666	5,604
Total	1564	9708	5,996

Table 3. Summary of comparison of Full-face Helmet Versus Open Face Helmet on Head-facial and Cervical Trauma on Motorcyclists Who Had Accidents based on This Review.

	Outcomes		
	Yes	No	Total
Full-face helmet	759	4060	4819
Open face helmet	285	595	880
Total	1044	4655	5,996

Discussion

Road traffic accidents until now still become unsolved problems, and most of the incidents are caused by motorcycle accidents, especially in low-middle income countries worldwide.[1-2] Many actions can be done to overcome the burden of these problems and based on the current review, using a helmet is one of the best ways to reduce the morbidity and mortality rate of motorcycle accidents.[4] Here, we reviewed the best helm that can be used to reduce the burden of motorcycle accidents.

This review of large observational studies found that the overall full-face helmet is the most prominent to prevent head and cervical injuries in motorcycle accidents.[7-14] The Full-face helmet

could ameliorate the outcomes of the victim compared to other helmet types of helmet either in preventing fracture or brain-spinal cord injuries. But, it does not mean that the full-face helmet did not have disadvantages. Lam, et al stated that a full-face helmet is heavier thus causing discomfort.[7] The Full-face helmet also reduces the eye view of the rider compared to the other helmet. The main finding of this systematic review is that a full-face helmet was better than either partial or open face helmet in preventing head-facial and cervical injuries of motorcycle riders in an accident. The risks of head-facial and cervical injuries (including neurological deficit) were lower by 17% when compared with a partial-helmet and 24.26% when compared with an open face helmet.[7-14]

The reason why a full-face helmet could confer better protection, especially in head injuries, is that three causative factors determining the prognosis of motorcycle-related accidents are helmet wearing, helmet fixation status and visor damage.[8] It is highlighted that helmet fixation is a stronger predictor in determining the head injury than helmet types. Usage of the full-face helmet could prevent dislodgement due to its effect in fixating the head of the user. The problems arising from these cases are that the removal of the full-face helmet may be harder and causes discomfort due to more heat and moisture in tropical countries, such as Indonesia.[8] Moreover, it needs support from the government in promoting and cutting the cost of the full-face helmet, especially in low-middle income countries to prevent more burden caused by disability or death due to motorcycle accidents.

There were some limitations to this review. First, the outcome criterion was not uniformed in the comparison between all helmets due to different specific types of head-facial and neck injuries. Second, the eligible participants vary among studies based on inclusion and exclusion criteria and there was still no study conducted in Indonesia, which is one of the main aims in this review implementation.

Our findings are in agreement and consistent with previous literature comparing the protective effect between full-face, partial, and open face helmets conducted by Liu, et al in 2008 published on Cochrane review.[4] This systematic review suggests that using a full-face helmet offers the best solutions to overcome high morbidity and mortality rate due to head-facial and cervical trauma due to its protective

advantages.[4] By implementing the law of using full-face helmet, namely in Indonesia, we are one step closer to achieve sustainable development goals for road safety (SDGs), namely good health and well-being by halving the number of global deaths and injuries from road traffic crashes and sustainable cities and communities by providing access to safe, affordable, accessible, and sustainable and safe transport system for all.[1]

Conclusion:

In General, this review concludes that a full-face helmet reduces head-facial and neck injuries better than other helmets in motorcycle accidents thus reducing the morbidity and mortality rate. Policymakers may need to specify the full-face helmet as the recommended helmet especially in low-middle income countries

Declarations

Ethics approval and consent to participate

Not applicable.

Availability of data and material

Not applicable.

Conflict of interests

The authors report no relationships that could be construed as a conflict of interest.

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Authors' contributions

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