Submission No 11

RELIGIOUS EXEMPTIONS FOR THE WEARING OF HELMETS

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1. INTRODUCTION

1. My expertise is in the fields of biomechanics and ergonomics/human factors with specific interest in 'accident' investigation and safety. My highest university qualification is a Doctor of Philosophy (PhD). My doctoral research in the 1990s was on the topic of head injury biomechanics and bicycle helmet performance. I am the self-employed director of McIntosh Consultancy and Research and Adjunct Associate Professor at MUARC, Monash University.
2. I have undertaken extensive research on helmets, head injury biomechanics, two-wheeler (bicycle and motorcycle) crashes, helmets and safety over three decades. I have been active for over 25 years in drafting, developing, assessing, applying and reviewing helmet standards. I chaired the working group responsible for the most recent version of AS/NZ 2063 (bicycle helmets) and chaired CS-076, the committee responsible for AS/NZS 1698 (motorcycle helmets). Most recently, I chaired the committee responsible for AS/NZS 1801 (occupational protective helmets) and am the working group convenor for ISO 3873 (industrial protective helmets). I have provided technical advice on helmets to Transport for NSW and other organisations, including the consumer rating programs for bicycle and motorcycle helmets. I provided advice to the International Olympic Committee medical and scientific department regarding helmets for skateboarding which was implemented in the Tokyo Summer Games (2020/2021) by the IOC and Worldskate.
3. I wish to make a submission on the following terms of reference:
    - a) Road safety and crash research relevant to different road users, including bicycle riders, motorcycle riders and electric scooter riders.
    - d) Helmet technology and alternative helmet design.
4. This submission and the responses reflect my personal views.

2. RESPONSES

2.1. Road safety and crash research relevant to different road users, including bicycle riders, motorcycle riders and electric scooter riders.

5. Helmets are intended to protect against the following injuries:

1. Superficial head injuries;
2. Intracranial injury, e.g., penetrating wounds, contusion, haemorrhage and diffuse axonal injury;
3. Fractures of the skull including approximately the upper face and parts of the mid face when an open face motorcycle or bicycle helmet is worn;
4. Fractures of the entire face when a full-face motorcycle helmet is worn, i.e. including the lower face (mandible (jaw)), mid face and upper face; and
5. Nerve and blood vessel injuries arising from momentary deformation and displacement of the cranial bones.

6. ***Research shows that helmets for bicycle riders and motorcycle riders are highly effective in preventing head and brain injury***.

7. Below are some examples of the evidence.

Bicycle helmets –

8. A recent systematic review and meta-analysis of bicycle injuries and helmet use observed:[1]

1. "*…For cyclists involved in a crash or fall, helmet use was associated with odds reductions for head (OR = 0.49, 95% confidence interval (CI): 0.42–0.57), serious head (OR = 0.31, 95% CI: 0.25–0.37), face (OR = 0.67, 95% CI: 0.56–0.81) and fatal head injury (OR = 0.35, 95% CI: 0.14–0.88). No clear evidence of an association between helmet use and neck injury was found (OR = 0.96, 95% CI: 0.74–1.25). There was no evidence of time trends or publication bias. Conclusions: Bicycle helmet use was associated with reduced odds of head injury, serious head injury, facial injury and fatal head injury. The reduction was greater for serious or fatal head injury. Neck injury was rare and not associated with helmet use. These results support the use of strategies to increase the uptake of bicycle helmets as part of a comprehensive cycling safety plan*."

[1] Olivier J & Creighton P, Bicycle injuries and helmet use: a systematic review and meta-analysis, International Journal of Epidemiology, 2017; 46: 278-292

9. Olivier et al (2013) also presented clear evidence of the benefits of the mandatory bicycle helmet legislation in NSW.[2]

10. We observed a high level of effectiveness of bicycle helmets was observed in bicycle users seen in a level one trauma centre in Sydney.[3] There was a significantly lower likelihood of a pedal cyclist experiencing a head injury (OR = 0.21), concussion (OR = 0.46), or intracranial injury including concussion (OR = 0.33) associated with wearing a helmet.[4] There were no cases of diffuse axonal injury, a severe form of brain injury, amongst the bicycle users and few skull fractures. We also conducted an in-depth study of 104 bicycle riders who reported being in a crash and hitting their head whilst wearing a helmet, there were no skull fracture cases, no brain injury in 57% of cases, mild concussion in 42% of cases and two cases of intracranial haemorrhage or contusion. In other words, even in the most focussed study of bicycle helmet performance, helmets were highly effective in preventing head injury, including brain injury.

11. Laboratory tests on bicycle helmets demonstrate their effectiveness:

    1. Cripton et al (2014) undertook paired drop tests from 0.5 to 3.0 m onto a flat anvil (Figure 1).[5] Each test was conducted with and without a bicycle helmet and the peak linear headform acceleration and HIC were reported. A Hybrid III headform was used in the tests, which is more human-like than a rigid headform used AS/NZS 2063. The tests showed substantial reductions in headform acceleration, and the likelihood of head injury, commencing from a drop height of 0.5 m and maintained up to a drop height of 3.0 m. Based on HIC, Cripton et al. calculated that the likelihood of a severe brain injury was 2% at 1.0 m and 31% at 2.0 m with a helmet, and almost 100% from a drop height of 1.0 m to 3.0 m without a helmet. In 2.5 and 3.0 m

[2] Olivier J, Walter SR & Grzebieta R. Long term bicycle related head injury trends for New South Wales, Australia following mandatory helmet legislation, AAP 2013; 50: 1128–1134

[3] I have used the term "we" to describe various research teams that I led at UNSW.

[4] McIntosh AS, Curtis K, Rankin T, et al Associations between helmet use and brain injuries amongst injured pedal- and motor-cyclists: A case series analysis of trauma centre presentations, Australian College of Road Safety Journal, 2013, 24: 11-20

[5] Cripton PA, Dresslera DM, Stuart CA et al. Bicycle helmets are highly effective at preventing head injury during head impact: Head-form accelerations and injury criteria for helmeted and unhelmeted impacts. Accident Analysis and Prevention 2014; 70: 1–7

impacts with a helmet, the predicted likelihood of a severe brain injury was 73% and 97%, respectively.

2. We found similar reductions in the head's angular and linear kinematics and injury likelihood when we conducted paired (helmet and no helmet) oblique impact tests.[6] In a simulated low-severity crash, for example, the helmet reduced the likelihood of head injury (skull and brain) to a level in which either no injury would be expected or the wearer might be concussed. In contrast, for the unhelmeted rider, skull fractures and brain injury would be expected. Angular head accelerations were also substantially greater without a helmet.

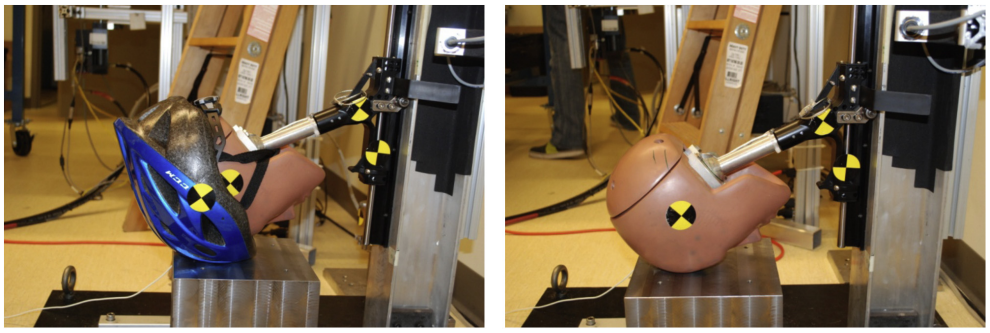

Fig. 1. Photograph showing helmeted Hybrid III headform (left) and unhelmeted Hybrid III headform (right) in contact with the steel anvil. The Hybrid III headform was attached to the ball arm which was mounted to a linear bearing on the monorail drop-tower.

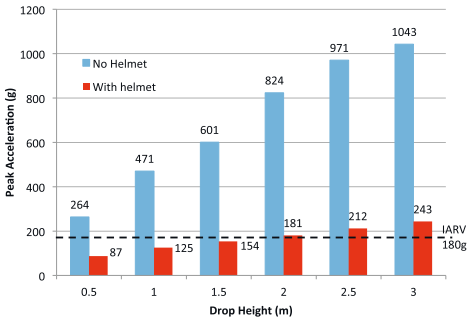

Fig. 3. Peak accelerations for both helmeted and unhelmeted drops. Numbers over bars indicate peak acceleration. For 2 m drop height, results stated are the mean value calculated from three drops. Horizontal dashed line indicates the IARVof 180 g (5% chance of skull fracture) for a midsize male.

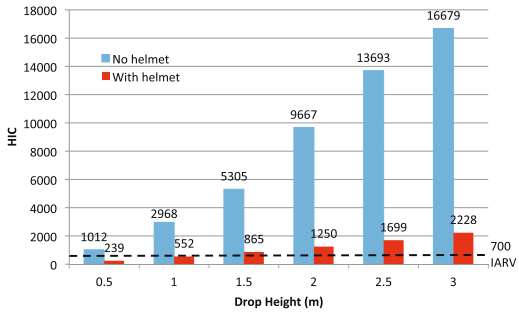

Fig. 4. Head Injury Criterion (HIC) calculated using HIC_{15} convention for both helmeted and unhelmeted drops. Numeric values over bars indicate HIC values and long dashed line indicates IARV based on HIC.

Figure 1: Test method and results from paired drop tests.[5] Peak headform acceleration is strongly associated with the risk of head injury (skull fracture and brain injury). Note - Permission for use of images requested.

[6] McIntosh AS, Lai A & Schilter E. Bicycle Helmets: Head Impact Dynamics in Helmeted and Unhelmeted Oblique Impact Tests, Traffic Injury Prevention, 2013; 14: 501-508

Motorcycle helmets –

12. Repeated conclusions from the 1981 landmark 'Hurt report' on motorcycle crashes in California USA were:[7]

    1. "*It is clear that the safety helmets provide significant protection at all levels of head and neck injury severity*."
    2. "*The helmeted riders show significantly lower injury frequency in all types of lesions*."
    3. "*The only significant protective equipment is the qualified safety helmet, and it is capable of a spectacular reduction of head injury frequency and severity... This research shows NO reasons for a motorcycle rider to be without a safety helmet; qualified helmets do not limit vision or hearing in traffic or cause injury*."
    4. The term "qualified" in this context means a helmet compliant with a standard.

13. A helmeted motorcycle rider has a statistically significant lower risk of head injury. Thom and Hurt (1993) observed that helmeted motorcyclists had a significant reduction in base of skull fractures and multiple skull fractures compared with unhelmeted motorcyclists, but these fractures still occurred with helmeted riders.[8] In a study of 2090 motorcycle crashes, Rowland et al. (1996) found that unhelmeted riders were three times more likely to suffer a head injury and four times more likely to suffer a severe head injury than helmeted riders.[9] Gabella et al. (1995) found that unhelmeted motorcyclists were 2.4 times more likely to sustain head injuries than helmeted riders in matched accidents.[10] The National Highway Traffic Safety Administration (NHTSA) estimated that in 2008, helmets saved the lives of 1829 motorcyclists in the USA.[11] Furthermore, NHTSA

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[7] Hurt HH, Ouellet JV & Thom DR, Final Report Motorcycle Accident Cause Factors and Identification of Countermeasures, Report to US Department of Transportation, DOT-HS-5-01160, January 1981

[8] Thom D & Hurt H, Basilar skull fractures in fatal motorcycle accidents, Proceedings of the 37th. Association for the Advancement of Automotive Medicine, San Antonio, 1993.

[9] Rowland J, Rivara F, Salzburg P et al, Motorcycle helmet use and injury outcome and hospitalization costs from crashes in Washington state, *Am J Public Health*, 1996, 86, p. 41-5

[10] Gabella B, Reiner K Hoffman R et al, Relationship of helmet use and head injuries among crash victims, *Accident Analysis and Prevention*, 1995, 27(3), p.363-9.

[11] The National Highway Traffic Administration. Traffic Safety Facts 2008 Data – Motorcycles DOT HS 811 159. Department of Transportation; 2008.

identified that motorcycle helmets are 37% effective in preventing fatal injuries.

14. In a meta-analysis using 61 observational studies, Liu et al (2008) concluded: "*Motorcycle helmets were found to reduce the risk of death and head injury in motorcyclists who crashed. From four higher quality studies helmets were estimated to reduce the risk of death by 42% (OR 0.58, 95% CI 0.50 to 0.68) and from six higher quality studies helmets were estimated to reduce the risk of head injury by 69% (OR 0.31, 95% CI 0.25 to 0.38). Insufficient evidence was found to estimate the effect of motorcycle helmets compared with no helmet on facial or neck injuries. However, studies of poorer quality suggest that helmets have no effect on the risk of neck injuries and are protective for facial injury. There was insufficient evidence to demonstrate whether differences in helmet type confer more or less advantage in injury reduction.*"[12]

15. We also analysed 220 motorcyclists who were seen at a major trauma centre in Sydney over an 18-month period.[4] The results show that a helmeted motorcyclist had a reduction in the likelihood of head injury of approximately 65% and intracranial injury (excluding concussion) of approximately 78% compared to the unhelmeted rider.

16. We assessed AS/NZS 1698 compliant motorcycle helmets using an oblique impact test rig.[13] [14] Tests were conducted on full-face motorcycle helmets. Helmets were dropped onto a moving rigid striker plate. The striker plate's horizontal speed was 0, 25 km/h and 35 km/h and the drop heights were 0.5 m, 1.0 m and 1.5 m. The authors concluded found: "*The study reinforced the importance of wearing a helmet to protect the head. Helmets reduce head impact force, head linear and angular accelerations, and neck loads. Even in a relatively minor impact, 0.5m 25 km/h, a helmet can reduce* HIC_{15} *by over 12-fold and peak linear headform acceleration almost 6-fold compared to no helmet. Up to a 5-fold reduction in head angular accelerations was also observed….In more severe impacts, the helmet continued to provide protection to the head and*

[12] Liu BC, Ivers R, Norton R, Boufous S, Blows S, Lo SK. Helmets for preventing injury in motorcycle riders. Cochrane Database of Systematic Reviews 2008, Issue 1. Art. No.: CD004333. DOI: 10.1002/14651858.CD004333.pub3

[13] Pang TY, Thai KT, McIntosh AS, et al, Head and neck responses in oblique motorcycle helmet impacts: A novel laboratory test method International Journal of Crashworthiness, 2011; 16: 297-307

[14] McIntosh AS & Lai A, Motorcycle Helmets: Head and Neck Dynamics in Helmeted and Unhelmeted Oblique Impacts, Traffic Injury Prevention, 2013; 14: 835-844.

neck where it could be assumed from the unhelmeted test results that the unprotected head and neck would be exposed to catastrophic injury risks." [14]

17. We also undertook an in-depth study of motorcycle crashes as per the bicycle helmet study referred to above. Sixty-eight (68) motorcyclists who had been wearing a helmet at the time of a crash and struck on the head/helmet, regardless of injury outcome, were recruited and the crashes, helmet performance and injury outcomes analysed. In 97% of cases, an AS/NZS 1698 compliant helmet was worn. It was observed that 74% of motorcyclists did not have any head injury, despite the selection criteria of being struck on the head during a crash. Twenty five percent (25%) of motorcyclists had a cranial or intracranial injury (excluding superficial injury) and these were largely concussion (23.5%). Almost half of the motorcycle cases were single vehicle crashes and caused by loss of control. This in-depth study demonstrated that an AS/NZS 1698 compliant helmet is very successful in mitigating the risk, including severity, of head injuries.

2.2. Helmet technology and alternative helmet design.

18. Helmet laws in Australia limit the range of helmets available based on the conformity to one or more standards. The helmet laws are largely aligned with standards and regulations that apply to very large populations around the world. Current standards are listed below.

    1. Motorcycle helmets –
        i. UNECE 22. International regulation
        ii. AS/NZS 1698. Australia and New Zealand.
    2. Bicycle helmets -
        i. AS/NZS 2063:2020 and 2008.
        ii. EN 1078:2012+A1:2012. Europe
        iii. US CPSC 16 C.F.R. Part 1203. USA
        iv. ASTM F1447-18. USA
        v. SNELL standard B-95. USA

19. Helmets performance and conformity to standards is assessed on:

    1. Impact performance – impact tests are conducted on the helmet to assess the ability of the helmet to attenuate energy and reduces the forces acting on the head and the head's responses, e.g. acceleration. There are strong correlations between impact force and injury and head acceleration and injury.
    2. Stability – stability is assessed by a 'roll off' test. The helmet should remain on the head.

3. Helmet retention – the strength of the retention system is assessed by applying a load to the retention system and measuring elongation.

20. There are purportedly 25 million or more Sikhs around the world, with the majority residing in India. The opportunity exists for the Sikh community to develop helmet technologies and for those to be accepted within Australian rules and regulations.

21. There are two multisport helmets that have been developed for Sikh children that can be sold and worn in Australia:

1. Bold Helmets produce a multisport helmet for Sikh children, which can be worn riding a bicycle or scooter. Bold Helmets claim compliance with EN 1078:2012+A1:2012 and US CPSC 16 C.F.R. Part 1203.
2. The Brave Helmet (available on ebay) is also designed for Sikh children and intended as multisport (bicycle, skate and skateboard). The company claims "*Meets or exceeds all safety standards for bicycle helmets*." Labelling on the helmet indicates compliance with US CPSC 16 C.F.R. Part 1203. Therefore, they can be sold and worn in Australia

22. I have not identified a UNECE 22 or AS/NZS 1698 compliant motorcycle helmet. The Sikh community has attempted to address the issue of head protection via 'protective' turbans, e.g. https://toughturban.com.

23. The Indian defence force have addressed the issue by developing ballistic helmets for Sikh troops.

1. https://www.iadb.in/2023/03/18/tactical-helmets-for-sikhs-can-kanpur-mkus-veer-brave-this-controversy/

24. Helmet technologies for Sikh motorcyclists would need to address the fundamental performance requirements of: impact performance, stability and retention. The external dimensions of a hypothetical motorcycle helmet that could be worn by an adult Sikh may not optimally protect the brain and cervical spine, because an impact to an elevated central section has the potential to generate a rotational force (moment) and contribute to specific mechanisms of brain and cervical spine injury. Those injury mechanism could be addressed using helmet technologies that are present in many helmets today, e.g. MIPS™ and Omni-Directional Suspension™. However, wearing a helmet offers a much lower injury risk than not wearing a helmet. In short, there is a well-understood pathway for designing a helmet and assessing its performance. The ideal pathway would be focussed on complying with UNECE 22, which now includes oblique impact tests which assess rotational forces applied to the head.