An evaluation of mandatory bicycle helmet legislation

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Bicycles are an important form of exercise, transportation, and recreation in New Zealand. However, bicycle injuries are a leading contributor to unintentional injury. From 2016 to 2019, cyclist injuries accounted for an average of 9.4 deaths per year and 7.2% of all serious injuries. In an effort to reduce cyclist head injury, New Zealand cycle helmet legislation became effective in 1994, requiring all cyclists to use standard approved helmets for all on-road cycling. Subsequently, helmet use increased to above 90% for all ages. However, this legislation has generated significant controversy. Detractors criticise it as an ineffective intervention, citing unintended consequences including reduced cyclist participation, increased risk of crash, and therefore net population harm. Population health interventions like mandatory legislation must demonstrate evidence of net individual and population benefit in order to be justified. By consideration of criteria assessing benefits and harms, a recommendation can be made regarding the use of mandatory helmet legislation in New Zealand for the mitigation of unintentional child and adult injury.

Are bicycle helmets effective in reducing head injury risk in event of crash?

Literature investigating the efficacy of bicycle helmet use to prevent injury in the event of a crash consists primarily of case-control studies, with randomised controlled trial precluded given ethical considerations. Three relevant systematic reviews with meta-analysis have been performed. All find helmet use to be associated with a significant odds reduction of head, brain, facial, and fatal injury. However, Attewell et al. additionally found evidence of a nonsignificant odds increase of neck injury associated with helmet use. Elvik updated Attewell et al. to adjust for publication bias, and ultimately found concordant results regarding neck injuries. The most recent review of these three relevant systematic reviews, by Olivier et al. in 2017, identified limitations of Elvik’s re-analysis. Their meta-analysis of 40 studies yielded an odds reduction of 51% for head, 69% for serious head, 33% for facial, and 65% for fatal head injuries. The odds ratio for neck injury was near null effect (OR=0.96) and no strong evidence of publication or time trend bias was identified.

Biomechanical evidence supports the conclusions of these meta-analyses, with McNally et al. by computer simulation finding no evidence of any association between helmet use and neck injury. Although Curnow has posited that helmet use might exacerbate diffuse axonal injury, McIntosh et al. have published biomechanical evidence reporting no association of helmet use with angular acceleration, contradicting this hypothesis.

Is mandatory helmet legislation effective in increasing helmet use?

Given that evidence supports the efficacy of helmets in the event of crash to reduce head injury risk, evidence that mandatory helmet legislation increases helmet use will provide indirect support of population benefit.

Karkhaneh et al. undertook a pertinent systematic review, finding twelve observational before-and-after and non-equivalent control group studies, with one specific to NZ. All reported increased helmet use; baseline rates of 4%–59% increased to 37%–91% following legislation and the pooled odds ratio for helmet use was 4.60. The authors note the plausible confounding effects of the variable promotional activities used to support legislation. However, they refer to evidence that benefit of legislation is conferred even in the absence of rigorous enforcement, and that fear of enforcement contributes relatively little to reasons for helmet use, ultimately concluding that legislation effective in increasing helmet use.
Is mandatory helmet legislation effective in reducing head injury risk?

Evidence that mandatory helmet legislation reduces head injury risk will provide direct support of population benefit. Macpherson et al\(^2\) performed a relevant systematic review in 2008 collecting four non-randomised controlled before-and-after studies, all examining legislation applying only to children. Three demonstrated significant benefit of legislation for children in Canada and California. Authors expressed concern regarding paucity of evidence, failure of included studies to measure helmet use, and potential inadequacy of controls. However, they conclude mandatory legislation effective in reducing mortality and head injury risk.

Excluded from review on basis of design were the only two extant publications addressing legislation efficacy in New Zealand. Povey et al\(^2\) reported a 20% reduction in cyclist head injuries in motor vehicle crashes for all children and 24% and 34% reductions in non-motor vehicle crashes for primary and secondary school children respectively, using limb injury rates to control for background confounders of injury risk. Robinson\(^2\) contended that results were an artefact of baseline trends. However, Wang et al\(^2\) in later re-analysis confirmed the validity of the original results. The second publication centred in New Zealand by Scuffham et al\(^5\) found when controlling using non-head injury rates that legislation averted 139 head injuries over a three-year period.

Additional pertinent literature has since been published internationally. Importantly, Walter et al\(^7\) found when controlling using limb injury rate that legislation in New South Wales contributed a 29% reduction in cyclist head injury. Injury rates showed continued divergence with time, eviscerating maintenance of benefit.\(^8\) Olivier et al\(^9\) demonstrate a 46% reduction in cycling fatalities post-legislation, and an absence of evidence suggesting confounding by the introduction of other road safety measures. Further international evidence supports legislation efficacy among children in Australia,\(^9\) Canada,\(^3,1\) and the USA.\(^3,3,3\) Conflicting evidence comes from publications indicating mixed results for children in Sweden\(^7\) and an absence of benefit for children and adults in Canada.\(^3\)

Clarke\(^\) used retrospective injury data to conclude that legislation in New Zealand has increased cyclist injury risk by 20% from the period 1988–1991 to 2003–2007. Olivier et al\(^9\) contend that Clarke ignores data from the period most directly following introduction of legislation and fails to separate head injuries, for which helmets are a targeted intervention, from other injury types. Additionally, Clarke’s methodology fails to address background confounders and baseline trends and therefore does not evidence a causal association between cyclist injury and the introduction of helmet legislation. The subsequent re-analysis by Olivier et al of injury data from the same period supports a decline in cyclist injury following legislation.\(^9\)

Does mandatory helmet legislation reduce cycling participation?

Literature investigating the association between cycling participation and rates of collision have largely concluded an inverse or non-linear relationship, including most recently Jacobsen,\(^4\) whose results seemed to evidence a “safety in numbers” effect. Bhatia et al\(^4\) identify as limitations confounding and inability to establish the temporal direction of effect; however, the inference remains plausible. Consequently, if helmet legislation reduces cycling participation, the corollary may be an increased risk of crash. Further, reduced participation implies reduced physical activity, itself a population hazard. Both effects engender population harm.

Publications investigating the effect of legislation on cycling participation draw mixed conclusions. Robinson\(^4\) used New South Wales and Victorian data to conclude legislation in Australia to have reduced cyclist participation; however, Olivier et al\(^9\) note the omission of relevant data which, when included, support the contrary position. Rissel et al\(^4\) reported that a repeal of helmet legislation would produce an increase in cyclist participation in Sydney; however, Olivier et al\(^9\) criticised their statistical analysis, performing a re-analysis with opposing findings.

Canadian literature evidences no significantly reduced ridership following legislation among
children. Australian literature concurs for cyclists of all ages. American evidence is contradictory, reporting separately a significantly reduced ridership among children, and limited evidence of reduced ridership among high school students.

**Does helmet use increase the risk of a crash?**

Adams et al argue that risk compensation might temper helmet efficacy, whereby helmet use yields riskier cyclist behaviour and therefore increased risk of a crash, yielding population harm.

A recent systematic review by Esmaeilkia et al identified 23 pertinent studies, with 18 opposing the hypothesis of risk compensation, and only two providing supportive data. One supportive study by Walker reported significantly reduced motorist overtaking distance associated with helmet use, but Olivier et al performed a multivariate re-analysis, categorising overtaking distance according to the typically recommended safe distance of 1m, finding no association of helmet use with unsafe passing.

Review authors considered most included studies inadequate, as they did not directly measure cyclist risk compensation, and instead analysed indirect proxies, such as perceived risk, or general risk-taking in non-cycling contexts. No randomised trials were identified, though a single random crossover design study was performed which did not support risk compensation. Overall, the current systematic review has found little to no support that bicycle helmet use is associated with engaging in risky behaviour, though there certainly exists a paucity of high-quality evidence.

**Does mandatory helmet legislation provide total population health benefit?**

A single publication has attempted to model the total population health impact that mandatory helmet legislation might have in a jurisdiction in which it is enacted. Here, De Jong concludes a large negative health impact of legislation in jurisdictions where cycling is already “safe” as defined by model parameters, and a small positive impact in jurisdictions where cycling is considered “unsafe.” However, De Jong’s model assumes that helmet legislation necessarily yields reduced cyclist participation and increased riskiness of behaviour. As demonstrated, these assumptions remain unsupported by the available evidence. When excluding this assumption, Olivier et al find De Jong’s model to yield the opposite verdict.

**Conclusion**

Strong evidence supports that helmet use reduces head injury risk in the event of a crash, and that mandatory helmet legislation increases helmet use and reduces head injury risk for child and adult populations to whom legislation applies. These conclusions provide evidence of the population health benefit of legislation. Conversely, no evidence exists to support that helmet legislation reduces cycling participation, and no strong evidence supports that helmet use increases the risk of a crash, providing no evidence of population health harm. Accordingly, the balance of evidence supports that mandatory helmet legislation is an efficacious population health intervention, and should remain in effect in New Zealand for the mitigation of child and adult unintentional injury.
COMPETING INTERESTS

Nil.

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