Summary of the Evidence

The Case for Motorcycle Helmet Wearing in Children

A submission to the Ministry of Transport

Submitted by:

World Health Organization
COUNTRY OFFICE
FOR Viet Nam
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EXECUTIVE SUMMARY

This report has been prepared at the specific request of the Ministry of Transport to provide a summary of the available evidence and information on whether children should be required to wear helmets when they ride as passengers on motorcycles. This report is in response to widespread beliefs that helmets are dangerous for young children due to the additional weight imposed on the developing neck.

Whilst it is important to note that there are no specific criteria to categorically define when children should wear helmets, the anecdotal and available evidence presented in this report can be summarised as follows:

• Rumors and beliefs that helmets increase the risk of neck injury in children appear to have resulted from misunderstanding and/or misreporting by representatives of the media in Viet Nam after interviews with medical professionals.
• Groups in opposition to children wearing helmets have presented no scientific evidence to support of claims that helmets "increase the risk of neck injury".
• There is no evidence to indicate that helmets increase the risk of neck injury when compared to the demonstrated life saving benefits that helmets provide in the event of a crash.
• Helmets are well documented as an effective road safety intervention, consistently demonstrated to be protective of the head in the event of a motorcycle crash in riders and passengers of all ages.
• Preliminary information indicates helmets are also provide protection to the neck
• Quality child helmets weigh around 250 grams, substantially lighter than standards allow for half head helmets (800 grams)
• It is not implausible that a child or adult may experience some form of intolerance (irritation from the strap, overheating etc) to a helmet. However the consequences of these are negligible compared to severity of injuries sustained if the head impacts the road surface in the event of a crash.
• Research indicates that by the time a child is four years of age:
  o The head size is approximately 90% of that of an adult’s
  o The neck size is approximately 75% of that of an adult’s
• It is a common road safety enforcement practice in many countries for the adult to be held responsible, and penalized accordingly for any illegal action conducted by minor children.
• Innovative modeling supported by WHO for this consultation indicates that:
  o neck muscle forces required only to hold the head static under its own weight, are very small in young children. The model calculations show that the peak forces developed by the neck muscles under these loading conditions are not
greater than 3% of the maximum isometric strength of the neck muscles.

- neck muscle forces increase by only a small amount when children wear helmets. The model calculations show that the forces developed by the neck muscles increase by no more than 10% when a helmet is worn, compared to the values predicted by the model when no helmet is worn.

- On the basis of these results, it can be concluded that **helmet wearing poses virtually no risk of injury to the muscles of the neck in young children** under static loading conditions.

- **WHO encourages adults not to transport children on motorcycles unless absolutely necessary.** If this is the case, then both WHO and UNICEF promote the use of standardized, correctly fitted, helmets for children as a harm reduction strategy.
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BACKGROUND AND INTRODUCTION

Road traffic injury - a leading cause of death and disability in Viet Nam

Viet Nam has a high burden of road traffic injuries. In 2007, official statistics reported 12,800 deaths, representing a mortality rate of 15 per 100,000 population or more than 35 deaths per day (1). Other sources of data suggest that official figures may underestimate the actual volume of deaths by more than 30% and injuries by 90% (2,3).

Motorcycle helmet legislation in Viet Nam

As of January 2009, there were more than 27 million registered vehicles in Vietnam of which 95% were motorized two wheelers (4), a figure which increases by almost 7,000 new motorcycles each day. An estimated 60% of all road traffic fatalities are motorcycle riders and passengers (3).

In 2001, helmet wearing became mandatory for all riders and passengers on specific roadways including national highways and other assigned routes (5,6,7). Unfortunately, enforcement, and therefore effectiveness, of this legislation was limited. Following this law, helmet wearing was estimated at approximately 30% but fluctuated greatly by time of day and type of road (8). Since laws were first introduced, many stakeholders have collaborated to raise awareness and lobby for a change in the helmet law to cover all riders and passengers on all roads.

On the 29th June 2007 the Vietnamese Government released Resolution 32, a universal decree mandating all riders and passengers of motorcycles to wear a helmet on all roads from 15 December 2007 (9).

Helmet wearing in children

Although the new helmet law did not specifically exempt helmet wearing in children, the law was not fully consistent with existing legislation. Under the articles of Vietnam's Ordinance for Administrative Sanctions, children under 14 cannot be given a sanction, which includes all penalties for not wearing of helmet (10). Children between 14-<16 years old can be given a warning. Financial penalties apply to children 16-<18 years, but at half the rates for adults.
Due to these limitations enforcement of helmet wearing in children does not occur. Importantly, current legislation (11) makes no provisions to allow a road traffic infringement penalty to be applied to the adult responsible for the child as it does in other countries such as Australia (12).

Barriers to children wearing helmets are not only legislative. Shortly after the introduction of the helmet law it was reported in the media that a local medical practitioner questioned whether children should be wearing helmets and that they were of the view that helmets might increase the risk of injuries to the neck (13). Though these statements were not supported by any presented evidence and were indeed contrary to wide ranging research on the effectiveness of helmets (14, 15); however, they were believed by many parents and child helmet wearing was very negatively impacted. Further investigation of these claims with the medical professional to whom they are attributed has indicated that in most cases representatives of the media either misquoted or misunderstood the position of the medical personnel, and it was this misreporting that circulated nationwide and lead to such a detrimental impact on helmet wearing by children.

**Background**
As part of the technical cooperation on road safety, WHO is working with the Government to strengthen helmet wearing in Viet Nam. One pillar of this programme is towards legislative reform and creating a legislative environment on which to build road safety. Road safety for children is also an important priority for other stakeholders in this process, UNICEF, the Asia Injury Prevention Foundation and the Embassies of Australia, Denmark and the United States.

WHO is specifically working with the Viet Nam Road Administration (VRA) and the Ministry of Transport to develop a mechanism that will allow for adults to be penalized when children they are transporting do not wear helmets. This mechanism will form an important component of the Decree covering infringements, which is a sub law document of the new road safety law passed by the National Assembly in November 2008 (16) and takes effect from 1 July 2009.

With motorcycles representing 95% of all vehicles, it is likely that in no other country are a greater proportion of children transported each day by motorcycle. Survey’s by the AIP Foundation in large urban centres, estimate that more than 75% of children are transported to school and back by motorcycle each day. Motorcycle safety of children and generally helmet use attracts enormous
stakeholder and public interest. The debate on the belief that the weight of helmets increases the risk of neck injuries is a case in point.

**Road traffic injuries in children**

National data are insufficient to be able to adequately determine patterns of child road traffic injury. Data reported by the Police often do not describe injury outcomes, the road user involved or the age of victims. This makes planning, implementing and evaluating road safety interventions difficult.

**Faces behind the numbers**

Le Xuan Han would have celebrated her ninth birthday in October 2008, had she not been tragically killed in a motorcycle crash in March 2008.

Like so many other children in Viet Nam, Han was a passenger on the family motorcycle with her dad, mum and six-year old sister Nhu. The parents were wearing their helmets but the children were dressed for a party and didn't want the helmets to mess their hair and the trip was short, so the parents decided not to make them wear their helmets. A split second decision, with tragic consequences.

When their motorcycle was hit by a drunk driver early on that sunny Sunday morning, the whole family was thrown from their bike. Little Han struck her unprotected head on the road. The family was rushed to Cho Ray hospital with severe injuries. Suffering massive brain injuries, Han never regained consciousness and died the next day.

Han’s mother struggles with her loss every day since that tragic Sunday. She cannot express the magnitude of her grief and guilt, but she is determined that other parents and other families not to go through what they did, becoming a road safety Ambassador with the Asia Injury Prevention Foundation counselling and advocating to other parents to make sure their children wear a helmet.

One family has been devastated, but how many thousand of other families still travel this way every day?

**Viet Nam Multi Site Injury Survey**

The 2001 Viet Nam Multi Centre Injury Survey (VMIS) provided further insights into the burden of road traffic injury in children. This household survey of 128,000 individuals (including 53,000 children) indicated that approximately 4,100 children were killed on Viet Nam's roads, making it the second leading cause of death. The morbidity rate for road traffic injuries was estimated at more than 900/100,000 population. Overall, motorcycles were responsible for 57% of all road traffic injuries in children. It is therefore not surprising that more than 32% of all injuries were to the face, head, brain or spinal cord (17).
Hospital data

Compilation of data from central and provincial hospitals commenced with the promulgation of MoH Decision 1356 (18). The completeness of the data is currently limited and WHO is working with MOH to strengthen data collection in 100 hospitals nationwide. This includes supporting training of personnel and the development of software.

Select data from key hospitals are available: in 2008, Viet Duc reported 7.4% of emergency presentations for road traffic injuries occurred in children under 15. A similar proportion of head injuries also occurred in this age group (7.6%) (Figure 1). Data on whether helmets were worn is difficult to collect at hospitals and they are often dependent on self or next of kin reports which may often represent a socially desirable response, especially since helmet wearing is required by law.

Hospital data does not capture injuries that are prevented because children were wearing helmets. Ideally such data could be collected at the crash scene by Police as part of their investigation of the incident or by community household surveys.

Despite limited data on head injuries in children, it is noteworthy that there is also no data on cases of children presenting with neck injuries that are attributed to simply wearing of helmets, demonstrating the myth of this reasoning.

![Figure 1](image)

**Figure 1** Road traffic head injuries by age of person admitted to Viet Duc Hospital in 2008
**Observed helmet wearing in adults and children**

Roadside observations in 2008, by AIP Foundation have shown substantial variations in helmet wearing between adults and children. Average use in adults was highest in HCMC (99%), followed by Da Nang (99%), Can Tho (98%) and Ha Noi (90%).

![Figure. 2. Observed motorcycle helmet wearing in four cities in Viet Nam, 2008](image)

Wearing in children aged less than eight years, and eight to fourteen averaged at 15% and 38% respectively in Hanoi, 28% and 52% respectively in HCMC, 53% each in Can Tho. In Da Nang, observations of children were only estimated for under 15 years of age (30%) (Figure 2).

**Surveys on helmet wearing in children**

**AIP Foundation survey**

This 2008 survey included a sample of more than 4000 people from four major cities in Viet Nam.

Respondents were asked if they believed helmets were safe for children. Affirmative responses increased with child age, ranging from 21-40% for infants (<6 months), 35-51% for toddlers (6 months to <2 years), and 77-85% for children (2-14 years).

When asked whether "children should wear helmets", respondents answered in a similar manner to the previous question with affirmative responses ranging from 13-23% for infants, 19-29% for toddlers, and 53-67% for children (Table 1).
Table 1 Surveyed attitudes to helmet wearing in children

Those who responded in the negative for whether children should wear helmets were asked to clarify the main reason for their objection. The majority expressed the belief that wearing helmets by children in all age groups increased their risk of neck injury (Figure 3). The proportion holding this belief was highest for infants (67%) and decreased with age.

Figure 3 Reasons cited for children not to wear helmets

This survey found that there is strong public support for new enforcement approaches, such as adults being fined when
transporting children who don’t wear helmets (average agreement 76%) (Figure 4).

![Figure 4 Proportional agreements to enforcement of child helmet wearing through adults](image)

In this study, observed helmet use in children was at odds with attitudes and opinions of parents and adults expressed during interviews. When surveyed, an average 82% of parents agreed that helmets were safe for children (2-14 years) and 61% agreed that children (2-14 years) should wear helmets when travelling on a motorcycle. However, when compared with wearing rates, the observations did not correspond with the reported responses. Roadside observations estimated helmet use in only 38% of children. A limitation of self reported feedback is the potential for socially desirable responses that are not an indication of true behaviour.

**OBJECTIVES**

This report was constructed with the following objectives:

- Summarise evidence on child road traffic injuries in Viet Nam
- Review the scientific evidence for any association between cervical spine injuries and helmet use in children
- Study the national standards for helmets in Viet Nam in comparison with international standards
- Identify areas where further information and research is required
- Make recommendations to the Government of Viet Nam in the following areas – appropriate minimum age for motorcycle helmet use, motorcycle helmet standards in Viet Nam and other appropriate recommendations.
EFFECTIVENESS OF HELMETS
Helmets are used for protection from head injury in a wide variety of activities. These include passengers on motorcycles and other two-wheeled motorized vehicles and bicycles. These activities involve individuals across the age spectrum, from young children through to older adults. Many studies have been conducted in various countries documenting the protective effect of helmets against head injuries. **Programmes and legislation to increase helmet use have resulted in a reduction in morbidity and mortality from head injuries.**

Effectiveness of helmets in preventing head injuries to children
The greatest body of evidence on helmet effectiveness comes from large case-control studies examining the effect of helmets on preventing the risk of head injuries in bicycling. A Cochrane review summarized the results of 5 case-control studies, all of which included children of all ages. **Helmets were found to substantially decrease the risk of head injury in all studies, by as much as 85%** (19). Moreover, these studies have all shown that helmets protect against injury in crashes that involve collision with motor vehicles as well as those that do not involve motor vehicles.

A second Cochrane review (20) recently summarized the effectiveness of helmets in preventing head injuries to motorcyclists. This included the results of 61 studies, which were remarkably consistent. **The risk of death was reduced by 42% with helmets. The risk of head injury was decreased by 69%.**

Studies have shown that efforts to increase helmet use whether by public education campaigns alone, or in conjunction with regulations requiring helmet use, have resulted in a decrease in the death rate and serious injury rate from head injuries. This was related to the large increase in helmet use that results from these programmes. This has been seen with bicycle helmets (21, 22) as well as with motorcycle helmets (23).

In 1980, Bowman and Schneider (24) conducted a risk/benefit analysis to analyze a large number of crash conditions with and without helmets to truly determine whether there was an overall benefit or represents an overall risk. This research involved 65 different crash simulations using the DOT NHTSA MVMA (Motor Vehicle Manufacturers Association) model to quantify head
accelerations and neck forces for helmeted and un-helmeted motorcycle riders.

The test model was an adult male wearing a 1.8 kg Bell Motorcycle helmet, a helmet that meets the FMVSS 218 standard (one of the helmet standards in the USA) and is very similar to the TCVN standard. It can be concluded that the results would be at least no different if a Vietnamese standard helmet were used during the simulation testing.

The key results indicated by this research are that overall head accelerations are reduced by 33 to 66% when a helmet is worn compared to when it is not worn. Further, neck forces were either reduced or unchanged when the same scenario was simulated with a helmet compared to no helmet.

It is important to note that the simulations in this study represented relative differences between helmeted and un-helmeted conditions, therefore, whatever the joint/mass conditions (i.e. if a small child were used as the simulation model rather than an adult male), it can be assumed that the difference between conditions would remain the same.

Since the crash conditions were the same (i.e. paired) for each simulation, the outcome or differential between the helmet and no helmet conditions for a child would be no different.

**Effect of helmets on risk of neck injury**

Concerns have been raised by a few vocal individuals in Viet Nam, that helmets might increase the forces on the neck in the event of a crash and thereby increase the risk of neck injury. Others have hypothesized that, through energy absorption, **helmets decrease the risk of neck injury**.

Theoretically, a randomized controlled trial could be used to test the effect of helmets on the risk of neck injury. However, such a study is unethical to do, given that helmets have already been found to be protective against head injury. In addition, given the rarity of a crash event, and the rarity of neck injuries in a crash, such a study would require an enormous sample size.

The most efficient method to examine this question is to use the case-control methodology, in which individuals with neck injury are compared to those without neck injury on helmet use. This is the same study design that has been used to establish the effectiveness of helmets in preventing head injuries.
A number of case control studies have examined the effect of helmet wearing on risk of neck injury. These are summarized below (Table 2).

<table>
<thead>
<tr>
<th>Study title</th>
<th>Description</th>
<th>Findings</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helmet use and the risk of neck or cervical spine injury among users of motorized two-wheel vehicle</td>
<td>Examined the effect of helmets on neck injury among motorized two-wheel users (motorcycle and moped) in France in 1996-2005.</td>
<td>Of 13323 injured individuals, 35 had serious neck injuries. 0.2% of people with helmets and 0.5% of people without helmets sustained a serious neck injury. Among children 0-14 years, the adjusted relative risk was 0.34 (95% CI 0.18 to 0.64), i.e. helmeted children had a 66% lower risk of neck injury in a crash than unhelmeted riders.</td>
<td>25</td>
</tr>
<tr>
<td>Motorcycle helmets and spinal injuries: dispelling the myth</td>
<td>An analysis of 1,153 injured motorcyclists in four states in the US.</td>
<td>Helmet use was not significantly associated with spinal injuries (odds ratio, 1.12; 95% confidence intervals, 0.79, 1.58).</td>
<td>26</td>
</tr>
<tr>
<td>The effect of helmets on the incidence and severity of head and cervical spine injuries in motorcycle and moped accident victims</td>
<td>A study of 152 motorcyclists and 71 moped riders in Belgium.</td>
<td>0.10% of the helmeted riders and 0.11% of the unhelmeted riders had neck injuries.</td>
<td>27</td>
</tr>
<tr>
<td>Motorcycle helmets and spinal cord injury: helmet usage and type</td>
<td>Study of 100 motorcyclists in Australia.</td>
<td>The study showed that there was no significant difference in the odds of cervical spinal cord injury among un-helmeted and helmeted motorcyclist acute survivors.</td>
<td>28</td>
</tr>
<tr>
<td>Relation between motorcycle helmet use and cervical spinal cord injury</td>
<td>A study of 396 injured motorcyclists in Taiwan.</td>
<td>Helmeted riders were 50% less likely to sustain a cervical spine injury than were unhelmeted riders (odds ratio 0.50, 95% CI 0.26 to 0.98).</td>
<td>29</td>
</tr>
<tr>
<td>Craniofacial trauma in injured motorcyclists: the impact of helmet usage</td>
<td>A study of 331 motorcyclists in the US.</td>
<td>6.5% of helmeted and 4.3% of un-helmeted riders sustained a cervical spine injury, a difference that was not significant.</td>
<td>30</td>
</tr>
<tr>
<td>Helmets for preventing injury in motorcycle riders</td>
<td>Cochrane review summarized the results of 14 studies.</td>
<td>No relationship between helmet wearing and the risk of neck injury among motorcycle riders in crashes (Odds Ratio 0.85, 95% CI 0.66-1.09, test for heterogeneity p=0.69).</td>
<td>20</td>
</tr>
<tr>
<td>Impact of helmets on injuries to riders of all-terrain vehicles.</td>
<td>Among 11,589 people hospitalized with injuries from all terrain vehicle crashes (ATV).</td>
<td>Un-helmeted riders were 3.5 fold more likely to have neck injuries than were helmeted riders.</td>
<td>31</td>
</tr>
<tr>
<td>Epidemiology of bicycle injuries and risk factors for serious injury</td>
<td>Among 3854 injured bicyclists of all ages in a Seattle USA study. 2.4% had neck injuries, only 12 of which were fractures. Children were significantly less likely to have neck injuries than adults.</td>
<td>There was no association of neck injury with helmet use (odds ratio 0.9, 95% CI 0.6 to 1.4). Helmet use was associated with a lower risk of cervical spine fractures (OR 0.4, 95% CI 0.1 to 1.3), although this was not statistically significant. Among children less than 6 years there was only one with a neck injury, and this was un-helmeted.</td>
<td>32</td>
</tr>
</tbody>
</table>
The data presented above clearly show that helmets are effective in decreasing the risk of head and brain injury to individuals of all ages, including children. Helmets work to protect the head at all ages, including children under 5. **The evidence also indicates that helmet wearing does not increase the risk of a neck injury, and may in fact be associated with a decreased risk of neck injury.**

**Our thorough (but ongoing) search has not identified any evidence showing that wearing a helmet will increase the risk of neck injury in a child, or that helmet use will weaken the neck muscles or impair development of the bony spine.** Helmet use in infants as young as a few months to treat deformations of the skull has not shown any short-term or long-term adverse effects on the spine.

Given these data, **there is no lower age limit on which children should wear helmets to afford them protection against head injury when riding on a bicycle or motorcycle.** While carrying young children on motorcycles is far from ideal, it is a fact of life in many low-income countries where motorized two-wheeled vehicles are the typical means of transportation. **In those instances where young children are on these vehicles, helmet use should be required because it is life-saving.**

It is also important to remember that helmets not only save lives, they also decrease the risk of severe, disabling brain injury. Only about one third of children die after arriving in the hospital in coma after a traumatic brain injury. The remainder survives, but does so with life-long disability. Helmets do prevent these injuries and do affect the quality of life of survivors of crashes. They should be used whenever children are placed in a situation where impact to the head can occur and no other means are available to prevent injury.

Preliminary research (as yet unpublished work by MoH & WHO) has also been undertaken on the effectiveness of Viet Nam's mandatory helmet law. By comparing the incidence of road traffic head injuries admitted to a sample of hospitals, three months prior with three months post the introduction of the helmet law, implied a statistically significant **16% reduction in the risk of incurring a head injury.** This is exactly what would be expected given the rate of helmet use.
APPLICABILITY OF HELMETS TO VIETNAMESE CHILDREN

In November 2008, previous national standards for adult and child helmets were merged into a single standard. The new standard (QCVN-2:2008) specifies a maximum weight of 800 grams for commonly worn half head helmets (Section 2.2.2) (33). A market survey found that helmets in the small and medium sizes are substantially lighter than allowable maximum weight (Table 3). Based on the standard growth curves for Vietnamese children (Figure 5), the smallest sizes are appropriate with children less than two year of age.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Size</th>
<th>Head size (cm)</th>
<th>Age relevance of head size</th>
<th>Helmet weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROTEC</td>
<td>XS</td>
<td>48-51</td>
<td>22-60</td>
<td>0.23 kg</td>
</tr>
<tr>
<td>PROTEC</td>
<td>S</td>
<td>50-52</td>
<td>59-&gt;60</td>
<td>0.34 kg</td>
</tr>
<tr>
<td>AMORO</td>
<td>S</td>
<td>50-53</td>
<td>59-&gt;60</td>
<td></td>
</tr>
<tr>
<td>ANDES</td>
<td>S</td>
<td>50-53</td>
<td>59-&gt;60</td>
<td>0.4 kg</td>
</tr>
<tr>
<td>OSAKAR</td>
<td>S</td>
<td>50-53</td>
<td>59-&gt;60</td>
<td></td>
</tr>
<tr>
<td>PROTEC</td>
<td>M</td>
<td>53-55</td>
<td>&gt;60</td>
<td>0.36 kg</td>
</tr>
<tr>
<td>OSAKAR</td>
<td>M</td>
<td>54-56</td>
<td>&gt;60</td>
<td></td>
</tr>
<tr>
<td>ANDERSE</td>
<td>M</td>
<td>54-56</td>
<td>&gt;60</td>
<td>0.55 kg</td>
</tr>
<tr>
<td>EVO</td>
<td>M</td>
<td>56.5-58.5</td>
<td>&gt;60</td>
<td>0.4 kg</td>
</tr>
<tr>
<td>EPIC</td>
<td>M</td>
<td>56.5-59.5</td>
<td>&gt;60</td>
<td>0.45 kg</td>
</tr>
</tbody>
</table>

Table 3  Availability and sizes of helmets in Viet Nam (B=boys, G= girls)

International evidence indicates that the head circumference of a four year old child is nearly 90% (34) that of an adult's head circumference. However, the facial structure of children differs greatly from adults. Child heads are smaller in vertical height than adults'. Hence an adult's helmet, if used on a child, will likely obscure vision and not fit properly.

It is important to note that Viet Nam is one of only three countries (also Malaysia and US Snell CM1 standard) in the world to address the requirements of children in their helmet standards. This consideration should provide parents and adults with an additional degree of confidence that helmets are both appropriate and suitable for Vietnamese children.

Anthropometric and biomechanical factors

Based on bioengineering and anthropometric modeling data, the effect of helmet weight on child neck injury depends on the type of impact the child receives. If the impact is to the body, then as the weight of the helmet increases, so does the risk of neck injury. If
the impact is to the head, then as the weight of the helmet increases, the risk of neck injury decreases.

The neck in children reaches 75% of the adult size by age 4, according to data from the University of Michigan Transport Research Institute. Neck rigidity gradually increases with age. Upper limits of helmet weights for young children are between 0.91 and 1.17 kg, and for older children, < 1.6 kg (34). All helmets manufactured for children in Viet Nam are substantially lower than these weight limits.

Helmets have long been used to re-mold the skull shapes of infants with plagiocephaly, a type of deformed skull (35). These are placed on very young infants and there have been no cases of neck injuries reported as a result of this helmet use. There has also been no evidence that wearing helmets in these cases affects the development of the spine and related muscles in these infants.

Modeling of static loading strength of a child's neck

To contribute to the evidence base on the suitability of helmets for children, as well as to refute myths that the increased helmet weight increases the risk of neck injury in children, WHO supported the completion of innovative modeling by Professor Marcus Pandy from the University of Melbourne (Australia). Prof Pandy's model is based on existing research on the strength of the neck in adults and was scaled down to represent the neck strength of children.

Based on a static scenario (non mobile) and the weights of helmets commonly available for children in Viet Nam, the modeling indicated that neck muscle forces required to hold the head statically under its own weight are very small in young children. The model calculations show that the peak forces developed by the neck muscles under these loading conditions are not greater than 3% of the maximum isometric strength of the neck muscles. When adding the weight of the helmet, neck muscle forces increased by only a small amount. The model calculations show that neck muscle forces are increased by only a small amount. For example, the forces developed by the trapezius muscles for a two-year-old child not wearing a helmet were 3.5 N and 1.9 N, respectively, with the neck held in the neutral position (see Figures 4 and 5). However, when the mass of a helmet was added to the model, these muscle forces increased to 4.5 N and 2.5 N, respectively indicating that the forces developed by the neck muscles increase by no more than 10% when a helmet is worn,
On the basis of these results, it can be concluded that helmet wearing poses virtually no risk of injury to the muscles of the neck in young children under static loading conditions.

Total trapezius muscle force for a 2 year-old and 4 year-old child with and without a helmet

Figure 5: Forces calculated for the strap muscles (trapezius) for a two-year-old child (2 yr) and a four-year-old child (4 yr) with and without a helmet. The force predicted for the trapezius muscle is very small whether a helmet is worn or not. The forces in the other muscles included in the model are either of similar magnitude or smaller than that calculated for trapezius (see Figure 5).
Figure 6 Standard growth curves for average head circumference by age for Vietnamese children
Vòng đầu theo tuổi – Bé trai
Vòng đầu theo tuổi – Bé gái

THÁNG TUỔI
The Snell Memorial Foundation (a motorcycle helmet standards organization in the USA) held a conference in 2003 at the Philadelphia Children's Hospital to discuss the development of a motorcycle helmet standard for children. Exposure to motorcycles and other motor sports (e.g. karting) in the USA and other high income countries is predominantly as a recreational pursuit. At that time no helmet standard existed for young children. An important component of the proceedings was to review the evidence on the effectiveness of helmets for children as well as the anatomical, biomechanical and anthropometric variances between adults and children all of which needed to be addressed in a child helmet standard (34).

Consensus outcomes of the conference were that child helmets must address the following criteria:

1. Reduced weight compared to adult helmets
2. Reduced size (to lower risk of neck injury and not restrict vision) and improve the ease of use. It was felt that the 300 g acceleration limit used for testing of adults' helmets should be maintained for testing of children’s helmets.

The evidence presented was that by four years of age children's necks are 75% the size of an adult. Head size is approximately 90% of an adult. However coupled with the light weight of the helmet, there is no evidence to suggest that children from this age cannot wear helmets.

In 2007, Snell released the CM 2007 standard (Child Motorsport) (36). In 2008, the first helmet meeting this standard was certified. Produced by Bell, this full face helmet was designed for children from 6 years of age and weighs approximately 1-1.2 kg (depending on the size). This information should be compared to standards that apply to helmets for children in Viet Nam. From the information in Table 3 it will be noted that Vietnamese standard helmets are substantially lighter than overseas helmets specifically designed for children. This finding further demonstrates that Vietnamese helmets in children’s sizes are not excessively weighty, nor likely to increase the risk of neck injury when worn.

**Comparisons with bicycle helmets**

As shown in Table 3, motorcycle helmets of the sizes applicable for young children weigh less than 250g. These weights make them comparable in weight to helmets designed and used in Australia (37) and USA for example for use in bicycle riding (Table 4).
## Table 4  Weights and sizes of common bicycle helmets (information from manufacturer's websites)

<table>
<thead>
<tr>
<th>Brand</th>
<th>Standard</th>
<th>Weight</th>
<th>Circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adura Dragster</td>
<td>AS2063</td>
<td>228g</td>
<td>50-57cm</td>
</tr>
<tr>
<td>Adura J6 Pixie</td>
<td>AS2063</td>
<td>215g</td>
<td>47-55cm</td>
</tr>
<tr>
<td>Adura Jitterbug</td>
<td>AS2063</td>
<td>232g</td>
<td>49-51cm</td>
</tr>
<tr>
<td>Bell Lill Bell Shell</td>
<td>CPSC</td>
<td>260g</td>
<td>50-54cm</td>
</tr>
<tr>
<td>Bell Amigo</td>
<td>CPSC</td>
<td>252g</td>
<td>50-55cm</td>
</tr>
</tbody>
</table>

Based on the Consumer Product Safety Commission (CPSC) standard (38) in the USA and the development of strength in a child’s neck, the American Academy of Paediatrics, a leading national medical body, has promulgated a position paper that children under the age of one should not be passengers on bicycles as they may not have sufficient neck muscle strength to control head movement in the event of a sudden stop. **Children above one year of age have on average the sufficient strength to control neck movement even with the additional weight of the helmet** (39).

### Legislative and enforcement challenges

Resolution 32 mandating helmet wearing for all motorcycle riders and passengers was at variance with existing legislation including the Ordinance for Administrative Sanctions where children under the age of 16 cannot be issued a financial penalty when not wearing a helmet. **Importantly, there is currently no mechanism where adults are held responsible when children under their care do not wear helmets.**

In countries like Australia, the driver is held responsible for any breaches of road safety law by children under 16 and is liable for any infringements (12). Such responsibility increases vigilance of the vehicle operator to adhere to road safety legal requirements. Such issues are not specific to helmets in Australia, but also include children not wearing seatbelts or child restraints, in which instance the driver can be financially penalised.

It is important that revised legislation be consistent with the position that all riders and passengers must wear helmets, including children. At the same time, its implementation must be consistent with the reality of the situation in Viet Nam where large proportions of survey participants believe that adults can already be penalised but even so, do not put helmets on children.
CONCLUSION

The new helmet legislation has resulted in a substantial increase in helmet wearing in Vietnam, primarily among adults, but initially including children. After the circulation of un-supported information that helmet wearing endangered the development of the child’s neck, wearing rates decreased substantially. The widespread circulation and acceptance by many parents of this position highlighted the fact that many stakeholders were not adequately prepared to timely and appropriately respond to negate the impact of these rumours as they rapidly spread nationwide.

Helmet wearing has effectively reduced the number of patients with head injuries admitted to hospitals in Viet Nam. The Government’s decision to require all riders and passengers of motorcycles to wear helmets is leading to positive road safety benefits. However, the issues surrounding helmet wearing by children must be addressed to maximise the road safety potential of this legislation. To sustain and increase the early gains of the new helmet law, the Government of Viet Nam should expand helmet enforcement, revise the law to specifically address the requirements of adults and children and undertake national public education and advocacy.

The findings outlined in this report indicate that the belief of many parents is not justified nor based on any documented scientific or medical findings. Parents should have confidence in the suitability of helmets meeting national standards and understand that the life saving benefits of wearing a helmet greatly outweighs chances of a minor neck injury from the weigh of the helmet.

Despite some ongoing challenges remaining in the implementation of the mandatory helmet law, it has been a successful milestone in the history of road safety in Viet Nam. There are many lessons to be learnt from the experiences to date, especially for regional low and middle income countries where motorcycles represent the typical mode of transport for both adults and children.

RECOMMENDATIONS

Minimum age for helmet wearing

As the Ministry of Transport will be aware, there is currently no specific medical criteria with which to define an appropriate minimum age from which children should be required to wear helmets.

In the absence of a specifically verifiable recommendation, the best approach is one based on harm minimization. There are inherent
risks of injury associated with any motorized two wheeled transport and these risks are significantly greater when riding without a helmet. From that perspective it is preferable that alternative methods of transport should be sought for young children. In Viet Nam however, where 95% of vehicles are motorcycles and alternative options are limited. The next best approach therefore is to require all children to wear helmets when passengers on motorcycles. WHO’s global position in this area is that:

- Parents are encouraged not to transport children on motorcycles, BUT
- Where this is necessary due to limited transport alternatives, WHO promotes the use of standardized correctly fitted helmets for all children.
- If parents/adults cannot put a helmet on children for whatever reason, then the recommendation for alternative means of transport should be further stressed.

It is important to note that a harm minimisation approach recognises that the life saving benefits of wearing a correctly fitted helmet greatly outweigh the potential risk of minor neck injury from the weight of the helmet.

Follow up
The International Working Group recommends that based on the evidence presented in this report that the Minister of Transport consider the following options:

1. Convene a consultation on child helmet wearing where this and other issues arising from the public consultation can be presented and discussed in a open forum;
2. Consider hosting a regional conference on motorcycle safety for children which would facilitate discussion on this and other issues relating to child road safety. Viet Nam can be a global leader in this effort;
3. Support and disseminate results from innovative modelling and simulation research on child helmet wearing to combat myths and beliefs of large proportions of the population;
4. Use the occasion of Viet Nam Children’s Day on 1 June 2009 to further advocate for road safety in children and request consideration of adopting this as a special theme;
5. In association with the Committee for Culture and Ideology and the Ministry of Communications, organise media training workshops to ensure that information disseminated by the media on road safety issues is accurate;
6. Should compulsory helmet wearing by children be included in the final amended road safety law to takes effect on 1 July 2009,
- Implement an advance public education campaign to increase public knowledge of the new requirements;
- Liaise with the Ministry of Public Security to develop guidelines for traffic police on appropriate procedures and mechanisms to enforce this requirement
- Consider an amnesty for the first two months post introduction of the legislation where adults receive a warning that future financial penalties will apply when children in their care are not wearing helmets.

The international reference group would be pleased to consider support to the Vietnamese Government in the implementation of these recommendations.
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