Cost–benefit analysis

Using regression analyses, it has been suggested in the USA that improving the static stability by one-tenth could reduce the number of fatal rollover accidents by around 9 per 100,000 registered vehicles (Robertson 1989). However, the costs of such improvements to static stability are not known. The benefit–cost ratio cannot therefore be calculated.

4.10 Bicycle helmets

Problem and objective

Cyclists run a higher risk of being injured in traffic than any other group of road users (Bjørnskau 2000). Based on the national household travel survey 1997–98, the following estimates for the risk of injury, stated in terms of the number of injured people per million person kilometres of travel in Norway, have been developed on the basis of official accident statistics and the injury register at the National Institute for Public Health (SIFF; Table 4.10.1).

The risk of injury to cyclists is about seven times higher than for car drivers, according to official accident statistics. If hospital records are used as a basis, the risk to cyclists is about 50 times as high as for car drivers. This huge difference is due primarily to the fact that single-vehicle accidents, i.e. accidents where no other vehicles or road users are involved other than the cyclist, are hardly reported at all in official accident statistics. Records at a Norwegian hospital (Schrøder Hansen, Hansen, Walløe and Fjeldsgård 1995) showed that around 44% of injured cyclists, who went to hospital for treatment, had head or facial injuries. A bicycle gives no protection in the event of an accident and the probability of sustaining head injuries if one falls off a bicycle is high. By using bicycle helmets, cyclists can protect themselves from head injuries in the event

Table 4.10.1: Injured drivers/cyclists per million person kilometres in Norway (different sources)

	Injured drivers/cyclists per million person kilometres	
Form of transport	Official accident statistics	SIFF's register (hospital records)
Bicycle	1.24	14.98
Moped/motorcycle	1.30	2.13
Car (driver)	0.18	0.30

of an accident. The objective of bicycle helmets is to prevent and reduce the severity of injuries amongst cyclists who are involved in accidents.

Description of the measure

The most common type of bicycle helmets is helmets with a hard shell, i.e. a helmet which consists of an inner, porous layer covered by a hard shell. Soft helmets without a hard shell, i.e. helmets which consist of a porous, protective layer, are less common. Mandatory wearing of bicycle helmets is intended to ensure that a high proportion of cyclist wear helmets.

Effect on accidents

Individual effect of wearing a bicycle helmet. A number of studies have evaluated the effects of bicycle helmets on the probability of sustaining head injuries in bicycle accidents. The results presented here come from the following studies:

Dorsch, Woodward and Somers (1987) (Australia)
Wasserman et al. (1988) (USA)
Thompson, Rivara and Thompson (1989) (USA)
Thompson, Thompson, Rivara and Wolf (1990) (USA)
Wasserman and Buccini (1990) (USA)
Spaite et al. (1991) (USA)
McDermott, Lane, Brazenor and Debney (1993) (Australia)
Thomas et al. (1994) (Australia)
Maimaris, Summer, Browning and Palmer (1994) (Great Britain)
Schrøder Hansen, Hansen, Walløe and Fjeldsgård (1995) (Norway)
Thompson, Rivara and Thompson (1996) (USA)
Thompson, Nunn, Rivara and Thompson (1996) (USA)
Finvers, Strother and Mohtadi (1996) (Canada)
Jacobson, Blizzard and Dwyer (1998) (Australia)
Shafi et al. (1998) (USA)
Linn, Smith and Sheps (1998) (Canada)
Schrøder Hansen, Engesæter and Viste (2003) (Norway)

On the basis of these studies, best estimates of the effect of bicycle helmets on the probability of being injured in a bicycle accident are given in Table 4.10.2. The results refer to effects on both adults and children.

Table 4.10.2: Effects on injuries of wearing bicycle helmets

	Percentage change in the number of injuries		
Injury severity	Types of injuries affected	Best estimate	95% confidence interval
Bicycle helmet (hard)			
Unspecified	Head injuries	−64	(−73; −51)
Unspecified	Facial injuries	−34	(−52; −9)
Unspecified	Neck injuries	+36	(0; +86)
Unspecified	Other than head injuries	+5	(−14; +28)
Soft bicycle helmet			
Unspecified	Head injuries	−41	(−63: −5)
Unspecified	Facial injuries	+14	(−29; +45)

Hard bicycle helmets were found to reduce the probability of head injuries and, to a lesser degree, of facial injuries. However, these results seem to be affected by publication bias and methodological weaknesses, and they are likely to be affected by time trends that are not controlled for in most studies (Robinson 2001). The results are therefore highly uncertain and the effects are likely to be overestimated.

Bicycle helmets do not prevent injuries on other parts of the body. Neck injuries have been found to increase by 36%. Soft bicycle helmets have a much smaller protective effect, and the effect on facial injuries is not statistically significant. Effects of bicycle helmets are also likely to be different among children and among adults.

Potential effects of mandatory wearing of bicycle helmets. The effect on the number of injuries amongst cyclists of mandatory wearing of bicycle helmets is determined by three different partial effects, or mechanisms, which can pull in different directions. The three partial effects are the helmet effect, the behavioural effect and the exposure effect. The effect of mandatory wearing of bicycle helmets on the number of cyclists injured can be modelled as the product of the three partial effects.

The helmet effect is the protective effect of bicycle helmets, i.e. less severe injuries in the case of accidents. The size of this effect depends mainly on two factors: (1) What type of cyclists are using a helmet and (2) to what degree the use of bicycle helmet increases.

The behavioural effect is the effect of wearing a helmet on the cyclist's risk of being involved in accidents. A cyclist who uses a helmet is more protected against injury than a cyclist who does not use a helmet. It has been suggested that this can lead to cyclists with helmets cycling less carefully (faster, paying less attention, in more difficult conditions, children being allowed to cycle on their own more than before, etc.) than cyclists without helmets (Bjørnskau 1994b). If mandatory use of helmets leads to less careful behaviour amongst cyclists, this may lead to cyclists being involved in more accidents per kilometre cycled than before (the behavioural effect). Such an effect can totally or partially offset the protective effect of more cyclists using helmets.

The exposure effect is the effect of mandatory wearing of helmets on the amount of cycling. Mandatory use of bicycle helmets has been found to make cycling less attractive, so that the amount of cycling is reduced. Reduced cycling may reduce the total number of injured cyclists, but is likely to increase the accident and injury rate among cyclists (Erke and Elvik 2007).

The effects on the number of injured cyclists of mandatory wearing of bicycle helmets, and of campaigns for the use of helmets, have been evaluated by:

Wood and Milne (1988) (Australia)
Vulcan, Cameron and Watson (1992) (Australia)
Cameron, Vulcan, Finch and Newstead (1994) (Australia)
Scuffham and Langley (1997) (New Zealand)
Robinson (1996) (Australia)

On the basis of the studies, best estimates of the effect of mandatory wearing of bicycle helmets on the number of cyclists injured are given in Table 4.10.3.

In total, mandatory wearing of bicycle helmets seems to have reduced the number of head injuries among cyclists by around 22%. The results are likely to be affected by publication bias, time trends, and methodological weaknesses that have not been controlled for. Another problem with the results is that no clear relationship can be found between the degree to which the use of bicycle helmets increased and the effect on injuries that has been found. If mandatory wearing of bicycle helmets had caused the reductions of injuries that have been found in the studies, one would expect larger increases of helmet wearing to result in larger injury reductions. Since no such

Table 4.10.3: Effects on injuries of mandatory wearing of bicycle helmets

	Percentage change in the number of injuries		
Injury severity	Types of injuries affected	Best estimate	95% confidence interval
Increased use of helmets	Head injuries	−25	(−30; −19)
Increased risk per km cycled	All injuries	+14	(+10; +17)
Less cycling	All injuries	−29	(−30; −28)
Net effect	All injuries	−22	(−23; −21)

relationship has been found, it is doubtful if the injury reductions actually have been due to mandatory wearing of bicycle helmets.

Four studies have discussed the effects of the introduction of mandatory wearing of bicycle helmets in New Zealand (Povey, Frith and Graham 1999, Robinson 2001, Scuffham and Langley 1997, Scuffham et al. 2000). The analyses show the importance of controlling for long-term time trends in the number of injured cyclists. Robinson (2001) concludes that the injury reductions that have been found in many studies are a result of time trends, and not effects of the bicycle helmet law.

Effects on mobility

If cyclists with helmets cycle faster than other cyclists, this can be interpreted as an increase in mobility. A reduction in the number of cycle trips, which has been found in several studies on the other hand, implies that the cyclists must use other forms of transport, or take exercise in other ways (instead of cycling for exercise).

Effect on the environment

No effects on the environment of the use of bicycle helmets, or the mandatory wearing of helmets, have been documented.

Costs

A child's bicycle helmet in Norway costs around NOK 100–400 in 2005. An adult bicycle helmet costs around NOK 400–1,000 in 2005.

Cost–benefit analysis

A numerical example is calculated for the costs and benefits of using a bicycle helmet for an average adult cyclist. In the example, the cyclist is over 13 years old and has an injury rate of 15 injuries per million cycle kilometres, which is the expected rate according to Bjørnskau (2000). Forty percent of these injuries are expected to be head or facial injuries, resulting in 6.6 expected head or face injuries if no helmet is worn. Most injuries are slight injuries (Schrøder Hansen, Hansen, Walløe and Fjeldsgård 1995). The average cost of cyclist injuries are estimated at NOK 510,000 (Veisten et al. 2007). A bicycle helmet is assumed to cost NOK 600 and to last for 3 or 4 years

Table 4.10.4: Effects on injuries of mandatory wearing of bicycle helmets

Cycle kilometre per day	Expected number of head/face/neck injuries per year	Reduction of head/face/neck injuries per year (%)	Life time of bicycle helmet (years)	Cost–benefit ratio
1	0.002	−10	4	0.66
2	0.004	−10	4	1.31
5	0.011	−10	4	3.28
10	0.022	−10	4	6.56
20	0.044	−10	3	10.05
30	0.066	−10	3	15.08

depending on the amount of cycling. Bicycle helmets are recommended to be replaced after some years, otherwise they will lose much of their potential protective effect. Table 4.10.4 shows the results from the cost–benefit analysis under the assumption that injuries are reduced by 10%. Based on the current assumptions, using a bicycle helmet on all cycle trips is associated with greater benefits than costs if the average number of cycle kilometres is more than ca. 1.5 km per day. In this numerical example, it is not taken into account that the injury rate may be different depending on the annual number of cycling kilometres or in different age groups.

A numerical example is also calculated for a child between 7 and 14 years. On average, a child in this age group has an annual expected number of injuries of around 0.009. Forty percent of these injuries are assumed to be preventable by a bicycle helmet. The proportion of injuries actually prevented is assumed to be 10%. A bicycle helmet is assumed to cost NOK 400 and to hold for 3 years. Under these assumptions, the cost–benefit ratio of always using a bicycle helmet is 2.5. The effect on injuries is, however, most likely larger and the cost–benefit ratio can therefore be regarded as a lower limit.

4.11 Motorcycle helmets

Problem and objective

Riders of mopeds and motorcycles have a high risk of being injured in traffic. Estimates made on the basis of official Norwegian accident statistics (Bjørnskau 1993) suggest that the risk of injury to moped riders and motorcyclists is 8–10 times higher per million person kilometres than for car drivers. However, not all injuries are reported to the police. If injuries recorded by hospitals are used to estimate risk, the injury rate for moped riders and motorcyclists in traffic is 12–15 times as high as for car drivers.