Societal Costs of Providing School Children Safe Bus Stops on High Speed Roads.

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Abstract

Purpose: Most school bus related injury events in Sweden take place when the child is outside the bus. In order to enhance their safety, the societal costs of four different measures applied on “bus stops” on high speed roads were investigated.

Methods: From a door-to-door perspective, a measure hierarchy, comprising the four existing measures, viz.: Rerouting using the current operating vehicle, New construction, Rerouting using a different operating vehicle, and Speed reduction in the vicinity of the “bus stop” was applied.

Results: By allocating AUS$ 9.1 per child per school day, almost 9 out of 10 children’s transportation safety may substantially be enhanced, simply by rerouting the current operating vehicle or using alternative operating vehicles.

Conclusions: In the investigated municipality it was feasible to enhance school transportation safety for children by implementing cheap and alternative measures.

Keywords:

Child safety, Cost-benefit analyses, Road safety, School bus

1. Introduction

Sweden, with approximately 9 million inhabitants, has a mixed school transportation system (Sörensen et al., 2002). Two thirds of the children that need transportation are transported by school buses that are provided as such, i.e., contracted school transportation. The remaining third of the children are transported by the regular public transport system. (Sörensen et al., 2002). Both systems operate on rural and urban roads. Sweden has a school law that states that the local authority has to provide free transport for the student if:

i, the distance between the child’s home and school is more than a specified distance; a typical distance being 2-4 kilometres for primary school children (Rusk et al., 1994);

ii, it is required due to the traffic conditions or;

iii, a child’s disability (if any), as well as other special circumstances require it.

As a tool for how to decide on whether or not a child has the right to achieve free school transportation, most local authorities have school transport regulations (Wretling et al., 2001). Local authorities can choose contractors and also prescribe how these services should be operated, e.g., where to pick up and let off a specific child, i.e., where the “bus stops” should be placed. These “bus stops” are sometimes simply being a predefined unmarked spot next to the road. Furthermore, at the time of the present study, the highest speed limit on roads was 110 km/h (~70 mph), followed by 90 km/h (~55 mph) in Sweden. Such roads are hereafter denoted as high speed roads. Some children do, in fact, have their designated “bus stop” at such roads, predominantly in rural areas (Anund, Larsson et al., 2003).

Extensive monetary costs are most often referred to by local authorities as the reason not to infer measures to enhance school children’s’ safety. However, both the effects and the “true” societal costs of such measures are actually unknown. Hence, in order to enhance safety for children having their bus stop at high speed roads, the effects and the societal costs of relocating their bus stops, by suggesting four different measures, were investigated in the present study.

2. Materials and Methods

A northern Swedish community with vast rural areas was selected for the present study. The local authority recounted for a total of 58 children in various ages, 55% of them older than 12, and entitled to school transportation from “bus stops” at high speed roads, both in the mornings and in the afternoons. School transportation by contracted operators, as well as public transport was covered.

From a door-to-door perspective (Carlsson, 2004), for each child, an at-site inventory of the school transportation location was performed using an inventory template (Renner & Anund, 2008). Possible measures were identified, discussed, prioritized and finally agreed upon among stakeholders. This procedure took its starting point in each child’s situation and individual needs. Secondly, the “bus stop” came in focus, whereas, lastly, the bus traffic lines were considered. The individual relocation situation for each “bus stop” assigned to a child was then considered from a measure hierarchy, comprising the four possible measures, viz.:

1. Rerouting using the current operating vehicle

   This measure was assigned top priority, since it is cost-effective and relatively simple to carry out. Furthermore, it did not affect the current operating line structure. Since children constituted a large part of the public transport users in many northern Swedish communities, rerouting was considered possible even for public transport buses.

2. New construction

   This measure was prioritized when such a large number of children were affected, i.e. >5, that it could be argued to be economically realistic. Measure 2 implied that a new bus stop was built on a spot requiring no crossing of the nearby high speed road. In certain cases it could mean that new pedestrian trunk walks were needed. The cost of this measure was averaged over nine years, i.e., the number of years a child attends compulsory school in Sweden.

3. Rerouting using a different operating vehicle

   This measure was a much less cost effective, but far safer than the other measures, since the child was picked up at home by a small vehicle, e.g., a taxi. This measure was chosen if the situation only applied to one single or only a few children in locations where it was not possible to operate the line with a larger vehicle.

4. Speed reduction in the vicinity of the “bus stop”

This measure was considered lowest in rank for two reasons. The first reason was that the traffic flow could be negatively affected by this measure. The second reason was that partially reduced speed limits are usually not followed to a large extent by the general public. For the latter reason, if measure 4 was implied, it required speed camera surveillance and a specially designed bus stop (Anund, Falkmer, & Hellsten, 2003), which were costs added to the basic cost of changing the speed limit signs of that particular part of the road.

The costs for the different measures were, for the utmost possible extent, based on available contracts and projected costs. The actual costs used are shown in Table 1.

Table 1, The relocation costs for the four different measures.

	Measure			
	1[a]	2[b]	3	4
Fixed costs (AUS$)	31.5 (-)	549,862	5.9	64,670
Flexible costs (AUS$/km)	2.2 (7.5)	-	1.2	-

[a] Presented for contracted school transportation vehicles, public transport buses in brackets. The fixed cost is related to each new tour.
[b] The total cost for the new construction.

For the measures chosen for the children, the net cost was calculated per day and per child per day. A Swedish child attends school 178 days per year, and the net cost calculations used that figure as denominator.

3. Results

As mentioned, 58 children in the municipality boarded and/or alighted buses at high speed roads, i.e., with a speed limit of 90 km/h or higher than; 45% of them were younger than 13 years old. The 58 children used 53 pre-defined “bus stops” at high speed roads for pick-up in the mornings and/or let-off in the afternoons, utilizing 13 different operating lines. In total, 52% of the children used public transport operating lines. Of the 58 children, 48 used the very same “bus stop” each morning and 44 used the same “bus stop” each afternoon. For seven of the children, it was unclear whether the same “bus stop” was used or not. The vast majority of these high speed road “bus stops” (96%) were actually situated on roads with 90 km/h speed limit. Half of them (48% in the mornings and 50% in the afternoons) were one-child “bus stops” and all except one were used by no more than three children.

Of the 53 “bus stops”, only ten were bus stops in the traditional sense of the word, meaning that an approaching bus would deviate from the drive lane into a designated bay marked with a bus stop sign. The design of the remaining 43 (81%) are illustrated in Figure 1 by the arrows. The cones of the arrows are pointing towards were only placed there to represent a child/children on the photo. The right hand side arrow indicates a cone placed to mark a “bus stop” with no space for the child to stand and wait, while the left hand side arrow indicates a similar “bus stop” but with some waiting space area for the child. Mainly located on other roads, 31 (72%) of them had waiting space areas.

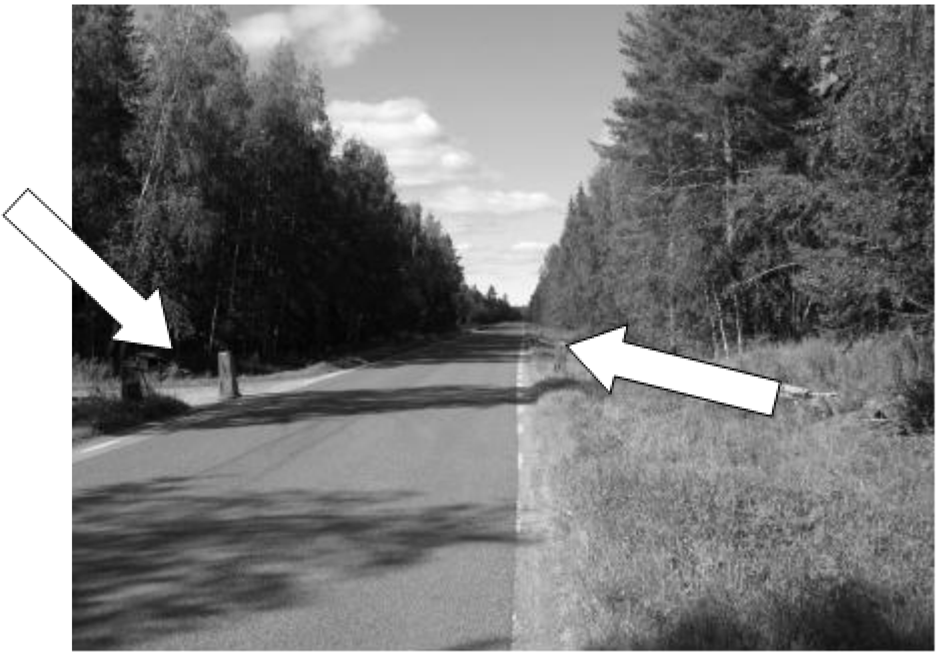

Figure 1: Commonly used "bus stops" at a high speed road (n=43). The arrows are pointing at the cones representing children at the "bus stop", which in reality is just an unmarked spot next to a high speed road. The "bus stop" to the left has some waiting space for the children.

With no zebra crossings available, 96% of the children had to cross the high speed road either in the morning or in the afternoon to access their "bus stops", while 22% of them twice a day had to walk along it on the shoulder with no sidewalks available. On average, they walked 57 metres on the road each time in the mornings. The corresponding figure was 43 metres in the afternoon. The distances from home to the "bus stop" was on average 390 metres in the morning and 380 metres in the afternoon (range 30-2,100 metres). Of the 58 children, 12 (21%) lived next to the high speed road.

In total, 60% of the roads were 6 metres wide, but the road width ranged from 5.5 up to 8 metres. The range of line sight distance with respect to the 53 "bus stops" is shown in Figure 2. The median for the line of sight distances were 400 metres both for oncoming and same direction traffic.

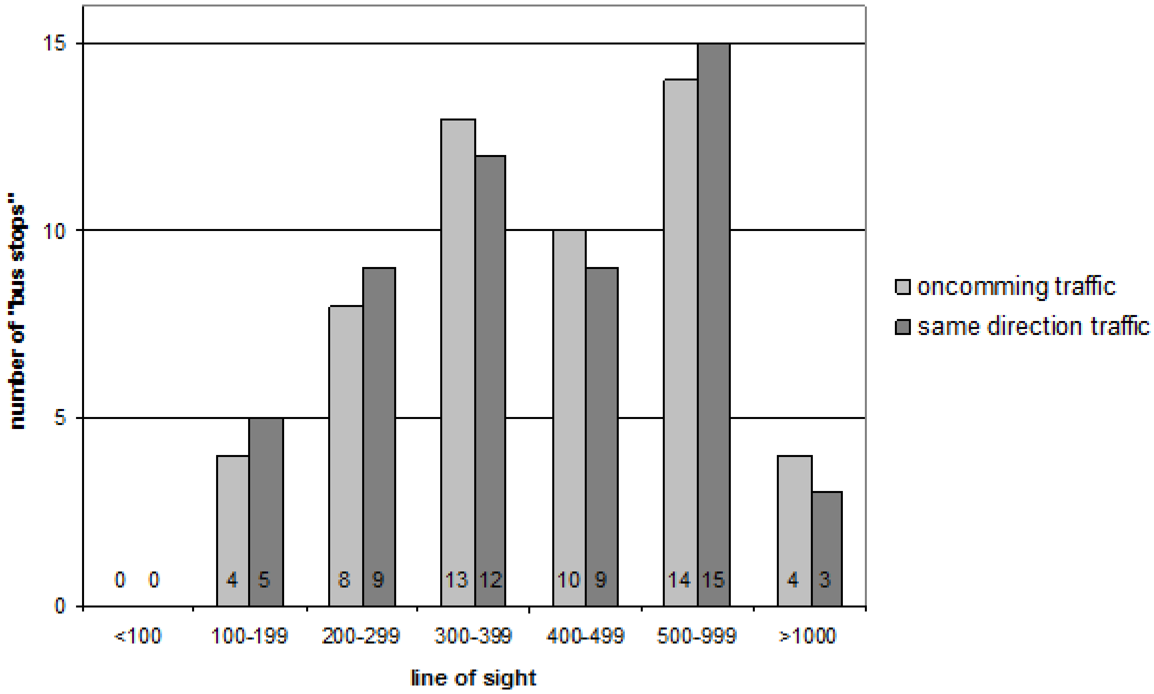

Figure 2: Line of sight in metres at the 53 bus stops.

On six of these 90 km/h high speed roads, the average vehicle speeds were actually measured prior to the study, showing an average speed of 88-92 km/h. The annual average number of vehicles passing the 53 “bus stops” per day was substantial, i.e. 1,419 vehicles (median 560, SD=2.113, skewness 2.46).

The suggested measures are shown in Table 2, divided into: “going to school” in the mornings and “coming home from school” in the afternoons. They were based on the individual situation for each child and the hierarchy measure previously described.

Table 2, Suggested measures 1-4, for the 58 children. The cells contains the number of children recommended for this particular measure, with a total sum of that particular measure in brackets.

Type of transportation	Measure 1	2	3	4
		Going to school		
Contracted	7(4)	8 (1)	11 (3)	-
Public transport	23 (12)	-	9 (2)	-
		Coming home from school		
Contracted	9 (5)	8 (1)	11 (3)	-
Public transport	21 (11)	-	9 (3)	-
Total to/from school	30/30 (16/16)	8/8 (1/1)	20/20 (3/3)	0/0 (0/0)

Based on the suggested measures in Table 2, the net cost was calculated as average costs per day and per child per day:

- For measure 1 the net cost per day was AUS$ 204 and AUS$ 6.7 per child per day
- For measure 2 the net cost per day was AUS$ 343 and AUS$ 42.9 per child per day
- For measure 3 the net cost per day was AUS$ 249 and AUS$ 12.4 per child per day
- If measure 4 would be used, the net cost per day per "bus stop" would have been AUS$ 363

The total net costs for implementation of the all measures was calculated to be AUS$13.7 per day per child, or AUS$ 793 per day for all 58 children, adding up to a grand total per year of about AUS$ 141,086.

Excluding the costs for measure 2, new construction, the net cost for implementation of the other two measures for the remaining 50 children was AUS$ 9.1 per day per child, or AUS$ 454 per day for all 50 children, adding up to a grand total per year of about AUS$ 80,735.

4. Discussion

The present study clearly shows that it is feasible, both with respect to effects and to societal costs, to enhance school transportation safety for children by implementing alternative measures for their morning pick-up and afternoon let-off procedures. The societal costs for these measures must, however, be compared with the statistical cost for a lost life, due to a traffic related fatality.

The Swedish Road Administration (SRA) has adopted the Willingness To Pay (WTP) concept (Jones-Lee, 1989; Persson, 2004) when estimating society's marginal benefit for every casualty avoided. This valuation consists of several dimensions, material costs representing only a minor part of the total valuation of safety. Currently, the value of a statistical life is set by SRA to AUS$ 2,293,526, a value not significantly different than those set by the equivalents of SRA in U.K. and in the U.S. (Bylund et al., 2007). Mirrored towards this figure, the suggested measures costing AUS$ 141,086 per school year suggests that if only one child's life is saved over a period of 16 years in the target community of the present study, it is, in fact, not only from a humanity aspect but also from a strict economical aspect, a sound implementation strategy. One could argue that implementation of measure 2 could be viewed upon as a measure not only supporting school transportation, but also other road users. Hence, the school transportation system should share the costs for new construction with others. If excluding measure 2 related costs, the suggested measures required AUS$ 80,735 per school year for implementation, suggesting that if only one child's life is saved over a period of 28 years, this is a sound implementation strategy.

The present study only covered children with "bus stops" at high speed roads. Since these children use the same buses as children with "bus stops" at other roads within the community, it is not possible to use route optimizing to reroute the operating lines. If taking into account the total school transportation system within a community, route optimizing most likely would make it possible to relocate "bus stops" from high speed roads at even lower costs. The results related to the cost should be regarded as the maximum cost, since the current cost for the children's travel is not deducted from the cost for the proposed measures. Admittedly, this is a limitation of the present study.

Most of the suggested measures are relatively easy to implement, i.e., all but measure 2. The least expensive one, measure 1, costing approximately the same as an ordinary lunch, is also the one most suitable for the majority of children. Together with measure 3, also being both simple to implement and fairly cheap, these two measures covered the need of 86% of the included children. The present study showed that by allocating a small sum per child per school day, almost 9 out of 10 children's transportation safety may substantially be enhanced.

The present study highlights the dangers presented each day to the children within the school transport system. Almost all of the children needed to cross the high speed road at unmarked spots each day and one fifth of the children had to walk along on the shoulder with vehicles passing in speeds about 90 km/h. Equally alarming were the design and location of the "bus stops", shown in Figure 1, and the fact that one third of them lacked waiting space areas.

This study covered all children at high speed roads known by the local authority in the targeted community. Such an approach suggests that generalization of the results may be questioned, since we do not compare the results with a random sample of children in school transportation in Sweden. However, for such an investigation, it would be possible to use the same procedures as is used in the present study. The targeted northern community was chosen due to its rural nature, rendering a substantial number of children on high speed roads. Southern communities with more urban settings may have fewer "bus stops" on roads with 90 km/h. A shift in proposed measures is in that case also likely to be found. For example, it is highly unlikely that it is possible to suggest rerouting of public transport, due to a significant number of passengers being other types of passengers than the target group of the present study. Instead, measures 2, and 4, would rather be preferred.

It is interesting to notice that, despite the fact that one of the reasons behind the child achieving free school transportation is if it is required due to the traffic conditions, children are urged to use this service on high speed roads that they most often also have to cross or walk along. One may argue that this situation hopefully applies to the older children rather than the younger. However, in the present study 45% of the children were younger than 12 years old, indicating that also the younger children are on high speed roads on an everyday basis. Now, regardless of whether this holds true or not on a national level, the age of the child does not seem to be the crucial factor. As shown by Anund et al. (2003), half of the injured children in school transportation were older than 12. As a matter of fact, the present study supports the idea that no child should be present as pedestrian on or in the vicinity of high speed roads, regardless of age.

5. Conclusions

It is feasible, both with respect to effects and to societal costs, to enhance school transportation safety for children at high speed roads by implementing alternative measures for their morning pick-up and afternoon let-off procedures. By allocating AUS 9.1 per child per school day, almost 9 out of 10 children's transportation safety may substantially be enhanced, simply by rerouting using either the current operating vehicle or different vehicles.

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