Traffic environment for children and elderly as pedestrians and cyclists

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Abstract

Vehicle speeds should be 30 km/h or less wherever children (regularly) cross streets. However, safety can be further improved at sites already reconstructed to ensure low speeds. Results based on field data collected at sites close to schools in Malmö, Trollhättan and Borås in Sweden, and analyses of Finnish and Swedish police-reported crashes including in-depth studies, suggest that safety for children and elderly is further improved at sites where visibility, orientation and clarity are sufficient. Also, marked crosswalks may increase yield rates towards pedestrians and speed cushions situated at a longer distance from the zebra crossing increase yield rates towards pedestrians and cyclists.

It is also concluded that bicycle facilities promote biking and that the risk for bicyclists and pedestrians decrease with increasing bicycle and pedestrian flows. Some key issues are here outlined for the design of a safe, non-restrictive cycle network.

Key words: Traffic Safety, Mobility, Child, Behaviour, Road design, Speed reducing devices, Speed cushions, visibility, orientation, clarity

1 BACKGROUND

Adequate pedestrian and especially cycle infrastructure is often missing in Europe, except in the Netherlands and Denmark, and if it exists, it often does not comply with the best practise. Furthermore to be successful, special concern has to be taken to accommodate children and elderly, see *e.g.* Johansson, 2004. Both European and American experiences show that pedestrian and bicycle facilities promote walking and biking, see Nelson *et al* ((1997); Nettelblad (1987) and Leden, Gårder & Pulkkinen (1998). This is crucial for safety as large numbers of pedestrians and cyclists change the traffic process and make other road users more aware of them and affects driver expectations in a favourable way. Risk decrease with increasing pedestrian and cycle flows, see for example Ekman (1996), Leden (1998), Gårder, Leden & Pulkkinen (1998) and Hydén, Nilsson & Risser (1998).

2 TRAFFIC ENVIRONMENT FOR CHILDREN

The UN Convention on the Rights of the Child confirms that children have a right to express their views and a right to survive and develop in a sustainable community. Below follows suggestions on how to achieve a better traffic environment for children.

2.1 Vehicle speeds should be 30 km/h or less wherever children (regularly) cross streets

The main principle proposed here is that vehicle speeds should be no more than 30 km/h wherever children or elderly (regularly) cross streets. There is a lot of evidence supporting this conclusion. For example, during the three-year period studied if crashes with heavy traffic are excluded, no children were killed at speeds below 30 km/h according to Finnish and Swedish crash data (Johansson, Gårder and Leden, 2004).

There are a lot of possible countermeasures that can be implemented to fulfil the principle. Very efficient ones are humps and speed cushions, see e.g. results of a meta-analysis of the effect of speed reducing devices by Elvik and Vaa (2004), who estimated that humps reduce the number of crashes by 48% (95% confidence interval of effectiveness: -54%;-42%).

Safe walking and cycling along main streets across minor streets (residential streets or "woonerfs") implies a raised marked crosswalk to the level of the sidewalk and one directional tracks. Leden, Gårder & Pulkkinen (1998) studied the effect on bicyclists' safety of raising urban bicycle crossings to the level of the sidewalk. In total, 44 junctions were reconstructed in this way in Gothenburg, Sweden. Before the implementations, bicyclists were either riding in the roadway or on separate paths parallel to the roadway. The paths then ended with short ramps or curb cuts at each cross street, and bicyclists used non-elevated, marked bicycle crossings, similar to pedestrian crosswalks but delineated by white painted rectangles rather than zebra stripes. The results show that the paths with raised crossings attracted more than 50 percent more bicyclists, and that the safety per bicyclist was improved by approximately 20% due to the increase in bicycle flow and with an additional 10 to 50% due to the improved layout. However, the increased bicyclist volume means that the total number of bicycle accidents at these locations is expected to increase. Migration of flows should mean that accident numbers are reduced at other locations.

Another efficient road design feature which also reduces speeds is the mini roundabout. There are three common ways of accommodating bicyclists through such facilities:

1. no special facility for cyclists (appropriate for roundabouts with one lane approaches)
2. separate cycle track with ordinary pedestrian and cycle crossings outside the roundabout,
3. a special cycle lane within the roundabout (for one-lane approaches)

Brüde & Larsson (1996) and Hydén, Odelid & Várhelyi (1995) recommend Design 1; a single-lane and comparatively small roundabout with no cycle lanes. According to "Sign Up for the Bike" (1993, p. 183), Design 1 can be feasible for motor vehicle flows up to 8 000 motor vehicles/24 hours. For higher motor vehicle flows, Design 2 (separate cycle track with ordinary pedestrian and cycle crossings around the roundabout) is recommended. Design 3 (a special cycle lane within the roundabout with one lane approaches) is not recommended under any conditions (Schoon and van Minnen, 1993, Brüde & Larsson, 1996, and Herrstedt *et al*, 1993). Proper design of mini roundabouts that function well for children and elderly as well as for people with handicaps are to be investigated further.

However, safety can be further improved at sites already reconstructed to ensure low speeds. The outcome of crashes when heavy vehicles are involved is more or less independent of the motor vehicle speed, see e.g. Leden, Gårder and Pulkkinen (2000). Therefore, low speeds are not sufficient the countermeasures presented below have to be trusted to avoid fatal crashes with heavy vehicles.

2.2 The effect of marking zebra crossing

Leden, Gårder and Johansson (2005) analysed the effect of keeping only one of the zebra crossing at an intersection close to a school after a reconstruction to a 30-km/h-street across a site Sjöbotorggatan in Borås, Sweden. The reconstruction had a strong effect on the percentage of pedestrians being given way to by car drivers along Sjöbotorgsgatan. Before reconstruction, 21% of the pedestrians were given priority at the crosswalks. This can be compared to 45% after the reconstruction on the west side where the zebra crossing was kept (a statistically significant increase, $p<0.0005$). On the east side where the zebra crossing was removed, 39% of pedestrians were given priority in the after situation (also a significant improvement compared to the before situation, $p<0.001$). The location where the crosswalk was removed now has a 6 percentage points lower give-way rate than the location with the marked crosswalk. However, the observed number of pedestrians is small, and the 95%-confidence interval for the difference in give-way rates between marked and unmarked crosswalks spans from - 22% to + 29% at the marked location. In other words, it is far from statistically proven that marking a crosswalk will increase the rate with which drivers yield to pedestrians. Still, the results suggest that interactions between drivers and pedestrians may be further improved at locations where a crosswalk is marked.

At another site in Trollhättan, Sweden a new pedestrian crossing facility type was introduced. It indicates where pedestrians are supposed to cross but it does not give them the priority pedestrians have in marked crosswalks (as zebra markings and road signs are missing). The hypothesis behind introducing this facility type is that it will not give pedestrians the false sense of security that zebra markings may give in certain environments, especially across high-speed, wide streets, see e.g. Ekman (1997) and Zegeer *et al* (2002). Elvik and Vaa (2004) estimate in a meta-analysis that pedestrian injury crashes increase by 28% (with a 95% confidence interval of 19% to 39%) if crosswalks are marked on 50-km/h-streets. At the two test sites at Trollhättan, no zebra crossings remained after the reconstructions. All measurements were done after the code change. The absence of marked zebras makes motor vehicle drivers less keen to give way to pedestrians, compared to reconstructed sites with marked zebras in Malmö and Borås. At the Trollhättan test sites, 31% of the children were given priority shortly after reconstruction and 43% two years later. These numbers can be compared to 52% ($p<0.2$) and 75% ($p<0.1$) at the test site Malmö T for the same time periods. And consistently, at least 70% of the children were given priority at two other reconstructed sites (one in Malmö and one in Borås). Also these differences are statistically significant ($p < 0.05$).

It seems that zebra markings at 30-km/h-streets improves mobility and provided that the 90-percentile of the speed is lower than 30 km/h safety does not deteriorate safety as the case often is if speed is higher.

2.3 The effect of a longer distance between the speed cushion and the crosswalk

Leden, Gårder and Johansson (2005) analysed the effect of locating speed cushions at a longer distance, approximately 9 meters compared to 5 meters ahead of the marked pedestrian crosswalk. A school survey had revealed that some children had problems to predict whether motor vehicle drivers intended to stop or not at the pedestrian crosswalks at Regementsgatan. Two of the children interviewed at location had pointed out this problem at the Dragonstigen crossing. They stated that it was problematic to foresee if motor vehicle drivers intended to stop or not when they slowed down for the speed cushion. The problem seemed accentuated when the speed cushion was situated close to the crosswalk (5 meters ahead).

Results indicate that a higher share of children and elderly were given priority where the speed cushion is located at a further distance from the marked crosswalk. Also, a higher share of bicyclists was given priority when motor vehicles were approaching from the direction where the speed cushion was located at a further distance from the cycle crossing. The difference was statistically significant for bicyclists but not for pedestrians. Obviously, the distance between the cushion and the crosswalk should not be too long, and only the distances of 5 and 9 meters have been studied here.

Motor vehicle speeds were measured at the marked crosswalk for vehicles approaching from both directions. The 90-percentile speed was about 5 km/h higher when the speed cushion was located at the further away distance. However, the speed 10 meters before the crosswalk would typically be lower when the speed cushion was located at the further distance from the crosswalk.

2.4 Visibility, orientation and clarity improve safety

Johansson, Gårder and Leden (2004) analyzed 17,843 police reported fatalities and injuries with pedestrians and bicyclists in Finland that occurred during the years 1989-2002 with respect to how visibility, orientation and clarity influence safety. At sites with no marked pedestrian crossings, children were more often injured, compared to the other age groups ($p<0.1e-25$), when stepping out into the street between two parked cars. Approximately 24 % of the crashes involving children on sections between intersections were of this type. Elderly were significantly less involved in these types of crashes (9%) compared to other age groups. The conclusion is that children were more often struck by a car when they were stepping out between parked cars compared with other age groups.

In Finland, children were also more often ($p<1.0e-3$) involved in crashes involving overtaking vehicles at mid-block, marked pedestrian crossings on multi-lane sections compared to other age groups. About 17% of the crashes away from intersections that involve children were of this type. Elderly were less often involved in these types of crashes, 9%; while 13% of all crashes at marked mid-block pedestrian crossings in Finland involved overtaking vehicles. Intersection approaches should have only one entry lane since multi-lane approaches create problems especially for children.

At signalized multi-lane approaches, stop lines should be withdrawn (pulled back) at least 5 meters to improve sight distances. Recessing the stop line for vehicles can give bicycles an advanced stop line, which reduces the number of accidents involving vehicles turning right and cyclists travelling straight ahead in the situation where traffic light change from red to green. Conflicts between vehicles turning right and pedestrians and cyclists having green light at the same time are especially confusing for children, see Leden (1989). An example from Great Britain is given in Figure 1. Elvik & Vaa (2004) estimates the effect of advanced stop lines on cycle accidents to be a reduction of 27 %.

Another way improving interactions between vehicles turning right and cyclists is to truncate the cycle track. One way of doing it is by locating the cycle crossing at an intersection immediately next to the adjacent street and remove the curb stone at a distance of 20 – 30 m. However according to Danish experience truncated tracks often makes cyclists feel less safe. A solution to the problem is to continue the cycle track into a cycle lane separated from vehicle lanes by a wide painted rumble line, see Figure 5. The interaction can be further improved by adding a rumble pavement in the separation area between the lane and the pedestrian pavement the last 20 - 30 meters to make cyclists ride closer to the vehicles. The idea is to make the road users approaching a junction more visible to each other and thereby seen earlier. The risk of unexpected appearance is then reduced and safety improved. (Herrstedt *et al* ,1993). Usage of truncated cycle tracks force bicyclist of one-directional use of cycle tracks. Cycle tracks in urban areas shall be designed one-directional. Drivers do not expect cyclists from the ”wrong” direction. Two-directional cycle-tracks deteriorate safety, see e.g. Linderholm (1992), Nettelblad (1987), Pasanen (1992), Summala *et al* (1996) and Räsänen & Summala (1998). However appropriate design for children of different ages has to be explored further.

Cycle tracks are *not* needed on streets with speed limit 30 km/h. However a 30 km/h street signed as a cycle streets promote safe cycling. Cycle streets is a new street design promoting cycling and calming motorised traffic, where cyclists may make use of the whole street and cars have to stay behind. Usage of the corresponding road sign and road markings should be made legal in all EU countries.

Figure 1. Advanced stop line. Photo Edinburgh council.

It is obvious that introducing no-parking zones and prohibited parking for cars close to marked crosswalks to achieve sufficient sight distances is more urgent for children than for other age groups and also more efficient (as small children due to their size sometimes are completely hidden behind cars). Streets with allowed parking should have curb extensions (chokers) to narrow down the roadway at pedestrian crossings. Elvik and Vaa (2004) estimated that curb extensions reduce crashes by about 5% (confidence interval: -58; +117).

Refuge islands in the middle of streets is suggested to prevent overtaking at marked pedestrian crossings and to make it possible for pedestrians to divide the road crossing task into two stages, where only one direction of traffic requires attention at each stage. The island also acts as an extra signal making pedestrian and bicycle crossings more visible to vehicle drivers, especially at night and during winter. Elvik and Vaa (2004) estimated that refuge islands reduce the number of pedestrian injury crashes by about 18% (-30;-3).

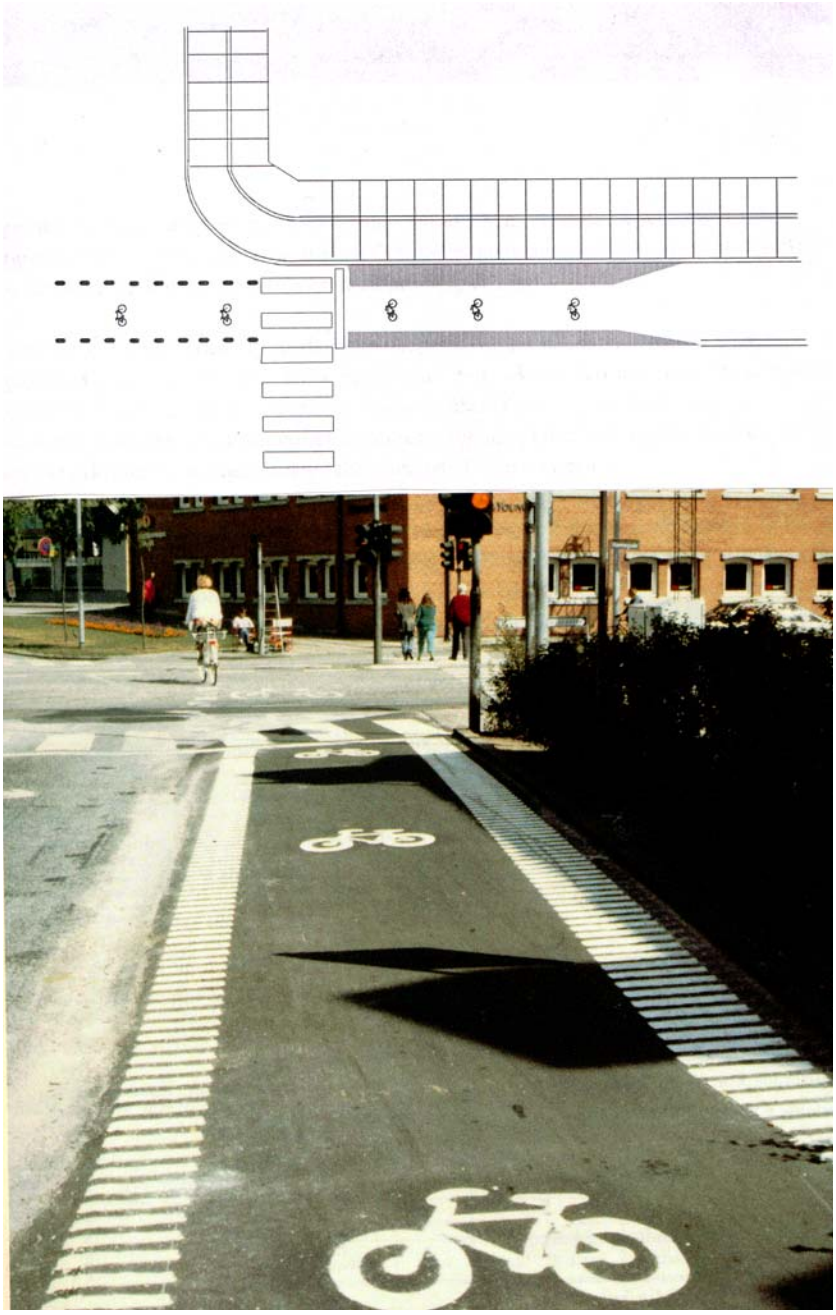

Figure 2. Design of truncated cycle track (Herrstedt et al, 1994)

Children below the age of 12 have been found to have particular problems perceiving the direction of moving traffic (MacGregor et al., 1999; Piaget 1969; Von Hofsten, 1980 and 1983; Foot et al., 1999; and Leden, 1989). To improve clarity and orientation it is suggested that pedestrian and bicycle crossings are relocated to (low-speed) mid-block locations to limit the number of directions vehicles can approach from.

As mentioned above (p. 6) and below (p. 10) signalized multi-lane approaches, stop lines should be withdrawn (pulled back at least 5m) to improve sight distances. For example in

Helsinki in Finland this has been implemented in large scale and proved to be efficient. However, multi-lane *non-signalised* pedestrian crossings are quite common though it obviously deteriorate safety and should be forbidden as in Germany. At present it seems that this is not politically acceptable yet in the Nordic countries. Therefore an interim solution is suggested. Withdrawn stop lines would improve sight also at non-signalised multi-lane pedestrian crossings, especially for children. Research is suggested to evaluate best practise.

3 SAFE TRAFFIC ENVIRONMENTS FOR ELDERLY

As earlier stated (Oxley et al., 1997), older pedestrians place themselves at greater risk when crossing streets with traffic in two directions. The crossing task should therefore be divided. The solution can be a refuge island. Low vehicle speeds are crucial for elderly pedestrians since they often have limited sight distances and move slowly and therefore cannot safely cross where vehicles approach at high speeds. Marked pedestrian crosswalks are recommended to improve orientation and clarity for persons with impaired sight (Leden, 2002). Older persons are also more fragile (Spolander, 2004).

4 FUTURE RESEARCH

Swedish experience suggests that road humps often are located to close to the marker crosswalk. Research is needed to cheque if this is the case also in Finland.

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More research is needed to monitor factors for success and failures of implementing a traffic environment designed for children and elderly. However eight important steps are suggested below:

1. To establish demo-projects Cities for Children and to evaluate their effects
2. To establish a network Cities for Children
3. To evaluate how information campaigns affect traffic behavior and decision making for children, and show how it can be combined with implementation of countermeasures to improve safety and mobility for children
4. To show that children can be involved in the planning process by using innovative tools
5. To develop, formulate and systematize relevant planning indicators regarding life quality, health, environment and safety of children.
6. To show how prerequisites and objectives concerning life quality, health and safety of children can be integrated into the planning process on a comprehensive and detailed level
7. To develop tools promoting analysis of children's life quality, health and safety
8. To develop tools promoting the development of new innovative urban patterns.

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