# Safety education of pedestrians for injury prevention: a systematic review of randomised controlled trials

Olivier Duperrex, Frances Bunn, Ian Roberts

## Abstract

**Objectives** To quantify the effectiveness of safety education of pedestrians.
**Design** Systematic review of randomised controlled trials of safety education programmes for pedestrians of all ages.
**Main outcome measures** Effect of safety education on pedestrians' injuries, behaviour, attitude, and knowledge and on pedestrian-motor vehicle collisions. Quality of trials: methods of randomisation; and numbers lost to follow up
**Results** We identified 15 randomised controlled trials of safety education programmes for pedestrians. Fourteen trials targeted children, and one targeted institutionalised adults. None assessed the effect of safety education on the occurrence of pedestrian injury, but six trials assessed its effect on behaviour. The effect of pedestrian education on behaviour varied considerably across studies and outcomes.
**Conclusions** Pedestrian safety education can change observed road crossing behaviour, but whether this reduces the risk of pedestrian injury in road traffic crashes is unknown. There is a lack of good evidence of effectiveness of safety education for adult pedestrians, specially elderly people. None of the trials was conducted in low or middle income countries.

## Introduction

Each year about one million people die and about 10 million are seriously injured on the world's roads.[1] The World Health Organization has indicated that, for people aged 3-35 years, road traffic crashes are now the leading cause of death and disablement. The global economic burden of road traffic crashes is estimated at \$500bn (£300bn, €500bn).[2] Most of the casualties are in low and middle income countries, and most are vulnerable road users: pedestrians, cyclists, and riders of two wheeled motor vehicles. Children as pedestrians are particularly vulnerable, and pedestrian injuries account for most of the 280 000 childhood road deaths each year.[1 3 4] Elderly pedestrians constitute another particularly vulnerable group.[4]

In the prevention of pedestrian injuries, educational measures to teach pedestrians how to cope with the traffic environment are considered to be an essential component of any strategy, and pedestrian education has been recommended in high, middle, and low income countries.[2] Because the resources available for road safety are limited, a key question for road safety policy concerns the relative effectiveness of different prevention strategies. The aim of this systematic review of randomised controlled trials was to quantify the effectiveness of safety education programmes for pedestrians in improving their knowledge, attitudes, and behaviour and, most importantly, in preventing pedestrian-motor vehicle collisions.

## Methods

### Identification of trials

We aimed to identify all randomised controlled trials of road safety education programmes for pedestrians of all ages. We also included community based interventions such as media awareness campaigns and parental education programmes. We excluded studies where safety education of pedestrians was confounded by another intervention and studies that tried to modify the behaviour of drivers towards pedestrians.

We identified trials by computerised searches of the Cochrane Injuries Group specialised register, Cochrane Controlled Trials Register, Transport, Medline, Embase, ERIC, PsychLit, Spectr, and the World Health Organization's database on the internet; by checking the reference lists of relevant reviews, books, and articles; by contacting authors of relevant papers; by use of the citation analysis facility of the Science Citation Index and Social Sciences Citation Index; and by contacting relevant professionals, organisations, and voluntary agencies. No methodological filters were used, and we made no language restrictions and repeated searches with key words translated into French, German, Italian, Spanish, Dutch, and Danish.

### Outcome measures and data extraction

Two reviewers independently extracted data on pedestrians' injuries, behaviour, attitude, and knowledge; pedestrian-motor vehicle collisions; methods of randomisation; and numbers lost to follow up. We assessed trial quality using the method proposed by Schulz.[5] Disagreements were resolved by discussion with a third reviewer. When the method used to conceal allocation of intervention was not clearly reported we contacted the study author, if possible, for clarification.

Institut de Médecine Sociale et Préventive, CMU, CH-1211 Geneva 4, Switzerland
Olivier Duperrex *research fellow in community paediatrics and public health*
Public Health Intervention Research Unit, London School of Hygiene and Tropical Medicine, UK
Frances Bunn *review group coordinator of Cochrane Injuries Group*
Ian Roberts *professor of epidemiology and public health*
Correspondence to: O Duperrex Olivier.Duperrex@imsp.unige.ch

bmj.com 2002;324:1129

### Data analysis and statistical methods

Wherever possible we performed an intention to treat analysis. Meta-analysis was not considered appropriate because of the differences across studies in the types of interventions and the types of outcomes. We calculated effect estimates with RevMan version 4.1 and report these as relative risks (95% confidence intervals) for dichotomous outcomes (relative probability of presenting the measured outcome in trained pedestrians compared with non-trained ones) and as standardised mean difference (95% CI) for continuous outcomes. If the variance for the change score was not presented and could not be obtained from the authors, we ascribed a value using a correlation factor between pretest and post-test scores of r=0.50.[6 7] We report the post-test data or the change between pretest and post-test when available, grouped by age categories and by type of outcomes. Outcomes are expressed as "positive" expected behaviour, attitude, or knowledge, so that a relative risk of >1 and a standardised mean

**Table 1** Characteristics of included randomised controlled trials of safety education of pedestrians

| Study and country | Participants | Allocation concealment* | Interventions | Outcomes | Loss to follow up |
|---|---|---|---|---|---|
| Ampofo Boateng et al (1993),[10] UK | 26 children aged 5 | C | Direct education:<br>1—Trained using a tabletop model of traffic environment<br>2—Trained in a real traffic environment<br>3—No training | Child's perception about safest place to cross road in real traffic situation (attitude) | 37.5% for intervention group |
| Bouck (1992),[11] UK | 40 children aged 8-11 | C | Indirect education provided by teachers<br>1—Trained in classroom and in semi-real environment<br>2—No training | Child's knowledge | 20% for both groups |
| Cross et al (1988),[12] Australia | 138 children aged 7-8 | C | Direct education<br>1—Trained in classroom during teaching unit on speed<br>2—No training | Child's response and documentation of verbal explanation in a play situation (tabletop model) (attitude) | Not stated |
| Downing et al (1981),[13] UK | 1560 children aged 3 and their parents | A | Indirect education provided by parents<br>1—Road safety booklet after an interview<br>2—Interview but no booklet<br>3—Road safety booklet with a letter<br>4—No intervention | Child's knowledge | 44% overall |
| Limbourg et al (1981),[14] Germany | 658 parents volunteered to teach their children aged 3-6 | C | Indirect education provided by parents<br>1—Behavioural road safety training by parent with psychologist's supervision<br>2—Behavioural road safety training by parent without psychologist's supervision<br>3—Parents shown a film and given a booklet on road safety problems in childhood<br>4—No training | Child's behaviours in real traffic situations with and without distraction | 15% overall |
| Luria et al (2000),[15] USA | 246 children aged 5 | C | Direct education<br>1—Trained with Safety City programme<br>2—No training | Child's knowledge | 26% for both groups |
| Matson (1980),[16] USA | 30 "mentally retarded" institutionalised adults aged 21-55 | B | Direct education<br>1—Individual training in classroom using tabletop model<br>2—Independence training in a semi-real traffic situation<br>3—Training in how to cook and to make the bed | Steps performed correctly on a set of target behaviours | Not stated |
| Miller et al (1982),[17] USA | 550 children (2nd grade) | A | Indirect education provided by teachers<br>1—Beltman programme<br>2—Beltman programme with booster course at 4 months<br>3—Normal safety teaching | Child's safety knowledge and behaviour | 6% for knowledge test and 65% and 77% for reported behaviour |
| Nishioka et al (1991),[18] Japan | 79 children aged 4-5 | A | Direct education<br>1—Caution advising how to behave safely ("A motorcycle is running. If you come around here, stop and look at the right and left side, as it is dangerous")<br>2—Simple caution ("A motorcycle is running. Be careful as it is dangerous")<br>3—No caution ("A motorcycle is running") | Child's behaviour | 10% |
| Renaud et al (1989),[19] Canada | 136 children aged 5 | C | Direct education<br>1—Simulation game, targeted attitude<br>2—Simulation game, targeted behaviour<br>3—Simulation game, targeted attitude and behaviour<br>4—No simulation game | Child's behaviour, attitude, and knowledge | None |
| Singh (1979),[20] UK | 4024 children aged 5-13 | B | Indirect education provided by teachers<br>1—Traffic education materials used by class teachers<br>2—No road safety education | Child's knowledge | 7 classes in intervention, none in control group |
| Thomson et al (1992),[21] UK | 30 children aged 5 | C | Direct education<br>1—Trained in a real traffic environment<br>2—Trained using tabletop model of traffic environment<br>3—No training | Child's perception about safest place to cross road in real traffic situation (attitude) | None |
| Thomson et al (1997),[22] UK | 201 children aged 5: 104 in year 1, 97 in year 2 | C | Indirect education provided by 10 parent volunteers<br>1—Trained in a real traffic environment<br>2—No training | Child's behaviour when crossing between parked cars, and when crossing near junction. Child's perception about safest place to cross road in real traffic situation (attitude) | None |
| Thomson et al (1998),[23] UK | 60 children aged 5 | C | Direct education<br>1—Trained using tabletop model of traffic environment and real traffic environment<br>2—No training | Child's perception about safest place to cross road in real traffic situation (attitude) | None |

*Score of quality on scale used by Schulz et al[5] assigning A to best quality and C to poorest quality: A=trials deemed to have taken adequate measures to conceal allocation (that is, central randomisation, numbered or coded bottles or containers, drugs prepared by the pharmacy, serially numbered, opaque, sealed envelopes, or other description that contained elements convincing of concealment); B=trials in which authors either did not report allocation concealment approach or reported an approach that did not fall into one of the other categories; C=trials in which concealment was inadequate (such as alternation or reference to case record numbers or to dates of birth).

difference of $>0$ represent a beneficial effect of the intervention programme.

In the included studies, training was provided either directly to the target population (direct education) or by training "intermediate" educators such as parents or teachers (indirect education). The way safety education is provided and the age of the target group are potential effect modifiers, but we did not explore their influence because we did not perform a meta-analysis.

For cluster randomised trials, we calculated an "effective sample size" if the intra-cluster coefficient was available.[8] We excluded studies in which there were less than five randomised clusters because, in order to analyse at the individual level, one would have to assume that there is no clustering of individual responses within the community, which is almost always untenable.[9]

## Results

We identified 13 899 studies, of which 674 (5%) were potentially relevant based on the title or abstract of the report. After a full text review, we identified 15 trials that met our inclusion criteria,[10–23] two of which are reported in the same document.[22] Table 1 shows the basic characteristics of these trials.

The methodological quality of the included trials was generally poor. The method of allocation concealment was adequate in only three trials,[13 17 18] outcome assessment was blinded in eight,[10 11 14–16 21–23] and in most of the studies large numbers of participants were lost to follow up. The participants were children in 14 of the studies and institutionalised adults in one.[16] No trial focused on the other vulnerable pedestrian group, elderly people. All trials were conducted in high income countries. Eight studies involved the direct education of study participants,[10 12 15 16 18 19 21 23] and seven involved the use of parents[13 14 22] or teachers[11 17 20] as educators. Outcomes were measured before and after the intervention in 12 studies[10 12–17 20–23] and only after the intervention in three studies.[11 18 19] None of the trials assessed the effect of safety education on the occurrence of pedestrian injury, but five assessed the effect on observed behaviour,[14 16 18 19 22] one assessed reported behaviour,[17] six assessed attitude,[10 12 19 21–23] and five assessed knowledge.[11 13 15 17 20]

Each research group used different tools to measure outcomes, and the delay for the post-test measurement varied from less than one month to eight months. Six trials measured the effect of safety education at different times after the intervention.[14 17 21–23] The effect of the intervention was lower in the later follow up period for 18 of the 24 behavioural outcomes,[14 22] for two of the four attitude outcomes,[21–23] and for the two knowledge outcomes.[17]

In some studies, the post-test conditions varied and influenced the results. For example, Limbourg and Gerber[14] reported that 5-6 year old children given safety education were, at five months after intervention, more likely to stop and look at the line of vision when crossing roads than controls (relative probability 1.79 (95% confidence interval 1.18 to 2.72) for children without distraction). However, when the children were distracted by racing with another child the relative probability increased to 2.80 (1.39 to 5.64).

Table 2 shows the most pertinent outcomes and only the longest period to post-test measurements. (More detailed results are available in the *Cochrane Library*.) Overall, the effect of safety education on

**Table 2** Selected outcomes of randomised controlled trials of safety education of pedestrians

| Population | Injuries, deaths, collisions | Behaviour | Attitude | Knowledge |
|---|---|---|---|---|
| Children and adolescents: | | | | |
| <5 years old | No RCT found | Trained children more likely to stop and look at line of vision than controls (RR 1.71 (95% CI 0.62 to 4.70))[14] | No RCT found | Trained children knew slightly more often that they had to "walk or stay on pavement" than controls (RR 1.05 (0.79 to 1.39))[13]*† |
| 5-9 years old | No RCT found | Trained children more likely to stop and look at line of vision than controls (RR 1.79 (1.18 to 2.72))[14]<br>Trained children more likely to stop at line of vision when crossing between parked cars than controls (RR 1.73 (1.39 to 2.14))[22]*<br>Trained children more likely to "always cross in crosswalks" according to their parents than controls (RR 1.63 (0.89 to 3.00))[17]*<br>Trained children more likely to exhibit "safe behaviour" than controls (RR 2.13 (1.01 to 4.47))[18]*<br>Trained children had better "post-test transfer score" than controls (SMD 0.83 (0.31 to 1.35))[19] | Trained children had greater proportion of routes categorised as "safe" at post-test than controls (SMD 1.28 (0.30 to 2.26))[10]<br>Change between pretest and post-test in proportion of routes categorised as "safe" greater in trained children than controls:<br>(SMD 0.80 (−0.12 to 1.72))[21]‡<br>(SMD 0.17 (−0.21 to 0.55))[22]‡<br>(SMD 0.92 (0.39 to 1.46))[23]‡<br>Trained children had better "post-test attitude score" than controls (SMD 0.85 (0.35 to 1.35))[19]<br>Trained children more likely to apply "concept of speed" than controls (RR 1.27 (1.07 to 1.50))[12] | Change between pretest and post-test scores of "crossing the street" test slightly greater in trained children than controls (SMD 0.16 (−0.13 to 0.45))[15]<br>Change between pretest and post-test in score of "traffic safety knowledge" test was greater in trained children than controls (SMD 0.81 (0.60 to 1.02))[17]‡<br>Change between pretest and post-test scores of "cognitive" test greater in trained children than controls (5-7 year olds, SMD 0.47 (0.36 to 0.57); 7-9 year olds, 0.96 (0.85 to 1.08))[20]‡ |
| 10-14 years old | No RCT found | No RCT found | No RCT found | Change between pretest and post-test scores of "cognitive" test greater in trained children than controls (SMD 0.57 (0.46 to 0.68))[20]‡<br>Trained children had better post-test score of "conspicuity, mass, speed and control" test than controls (SMD 2.39 (1.46 to 3.33))[11] |
| 15-20 years old | No RCT found | No RCT found | No RCT found | No RCT found |
| Adults | No RCT found | Trained institutionalised adults had higher "post-test mean proportion of steps correctly performed" than controls (RR 5.17 (3.48 to 7.67))[16]* | No RCT found | No RCT found |
| Elderly people | No RCT found | No RCT found | No RCT found | No RCT found |

RCT=randomised controlled trial (only most relevant outcomes are reported here with longest period to post-test measurements). RR=relative risk. SMD=standardised mean difference
*Intervention groups pooled. †Control groups pooled. ‡Variance of change between pretest and post-test measurements ascribed.

pedestrian behaviour varied considerably. The relative probability of trained pedestrians behaving correctly compared with controls ranged between 1.63 and 2.13 for the selected outcomes in table 2 but varied overall between 0.49 (control group performed better than trained group) and 9.29 for all the studies and outcomes (data not shown). Safety education improved pedestrians' attitude and intentions (with standardised mean differences ranging from 0.17 to 1.28) and their knowledge about road safety when outcomes were measured before and after intervention (standardised mean differences from 0.16 to 2.39), but for dichotomous outcomes the range of effect was wide (relative probability ranging from 0.72 to 1.66) (data not shown).

## Discussion

Despite a thorough search in several databases in many languages and by contact with various interested parties, we could not identify good evidence of effectiveness of safety education for adult pedestrians and only limited evidence for child pedestrians. None of the included trials assessed the effect of safety education on the occurrence of pedestrian injury, but six trials assessed the effect on observed behaviour. Some of these trials showed evidence of behavioural change after safety education, but for various reasons it is difficult to predict what effect this might have on pedestrian injury risk.

Firstly, we cannot be sure that the observed behaviour is causally related to the occurrence of pedestrian injury. For example, Nishioka et al[18] considered that slowing down or stopping before crossing a road to be the safe response. However, even if this behavioural change, observed in a simulated traffic environment, was repeated in a real traffic situation it is difficult to estimate what effect it would have on injury risk. Once a child has established that a road is clear, it may be safer to run across before another vehicle approaches because it reduces the time of exposure to risk. Secondly, assuming that the measured behaviours are causally related to risk of pedestrian injury, we have no reliable information about the size of this effect, and so we cannot predict how much a given behavioural change will reduce the risk of injury. Finally, there is uncertainty about the extent to which the observed behavioural changes persist over time, although the apparent declines may have been due to chance alone.

### Limitations of review

Certain methodological issues could have an important bearing on the validity of our findings. In particular, publication and other selection biases may have resulted in the over-representation of studies showing promising intervention effects. This is especially likely in the context of road safety, where a large proportion of the available research information is published in the grey literature of road safety research organisations. Most of the statistical methods that can be used to assess the possibility of publication bias require the use of meta-analysis and so could not be used in this systematic review.

Although we made considerable efforts to identify all eligible trials, published and unpublished irrespective of language, we cannot exclude the possibility of selection bias. The validity of the inferences from any systematic review depends on the quality of the included studies, and in this case many of the studies were of poor quality. It has been shown that inadequate allocation concealment, lack of blinding of outcome assessment, and large losses to follow up can result in the overestimation of intervention effects in randomised controlled trials,[5] and many of these methodological weaknesses were present in the included trials.

Several included studies were conducted more than 10 years ago, and so their relevance to the current situation is open to question. Walking habits and the pedestrian environment have dramatically changed during the past two decades. All the included trials compared groups that were in the same surroundings, allowing the effect of the intervention to be isolated. Another limitation of this study is that we could not identify any randomised controlled trial conducted in low and middle income countries.

### Implications of results

The Global Road Safety Partnership strongly recommends road safety education of children worldwide.[24] Our review indicates that there is no reliable evidence supporting the effectiveness of pedestrian education for preventing injuries in children and inconsistent evidence that it might improve their behaviour, attitudes, and knowledge. While the value of safety education of pedestrians remains in doubt, environmental modification and the enforcement of appropriate speed limits may be more effective strategies to protect children from road traffic.

### Conclusions

Pedestrian safety education can improve children's knowledge of the road crossing task and can change observed road crossing behaviour, but whether this reduces the risk of pedestrian-motor vehicle collision is

### What is already known on this topic

Road traffic crashes are a leading cause of death and disablement, and pedestrians are particularly vulnerable road users

Several organisations strongly recommend road safety education

As resources are limited, a key question concerns the relative effectiveness of different prevention strategies, including road safety education of pedestrians

### What this study adds

This systematic review showed safety education for pedestrians could improve children's knowledge and change their observed road crossing behaviour

However, effects on pedestrian injury were unknown

There is a lack of good evidence of effectiveness of safety education for adult pedestrians, especially elderly people, and in low and middle income countries unknown. No trial focused on the other vulnerable road users, elderly pedestrians. None of the trials was conducted in low and middle income countries.

Large scale, randomised controlled trials with injury outcomes (or end points that are likely to predict injury outcomes, such as near misses) are needed to establish the effectiveness of safety education of pedestrians. Although some existing trials showed evidence of behavioural change after safety education, these changes cannot be assumed to decrease pedestrian injury risk.

We thank Reinhard Wentz and Irene Kwan for help with database searching and obtaining papers; Angela Huertas, Maaike Kruseman, Valdo Pezzoli, and Finn Johnsen for help with translation; Marjan Loep from the Dutch Cochrane Centre for help with the Dutch titles; Toshihiko Yanagawa for help with translation and contacting Japanese experts; and Kathryn Kilburn for proof reading. This review is also published in the *Cochrane Library* where it will be regularly updated to take account of new data and comments on this version.

Contributors: OD designed the protocol, searched databases, screened records, extracted data, contacted authors, and wrote the review. FB helped design the protocol, extract data, and write the review. IR helped design the protocol and write the review. OD is guarantor for the paper.

Funding: Institut de Médecine Sociale et Préventive, Geneva, Switzerland, and the Medical Research Council.

Competing interests: None declared.

1 Murray CJL, Lopez AD. *Global health statistics: a compendium of incidence, prevalence and mortality estimates for over 200 conditions*. Geneva: WHO, 1996.
2 World Bank Group. Road safety. www.worldbank.org/html/fpd/transport/roads/safety.htm (accessed 24 Nov 2001).
3 Rivara FP. Child pedestrian injuries in the United States. Current status of the problem, potential interventions, and future research needs. *Am J Dis Child* 1990;144:692-6.
4 Barss P. *Injury prevention: an international perspective epidemiology, surveillance and policy*. Oxford: Oxford University Press, 1998.
5 Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *JAMA* 1995;273:408-12.
6 Mulrow CD, Oxman AD, eds. *Cochrane Collaboration handbook*. Oxford: Update Software, 1997, Issue 4.
7 Follmann D, Elliott P, Suh I, Cutler J. Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol* 1992;45:769-73.
8 Donner A, Klar N. Confidence interval construction for effect measures arising from cluster randomization trials. *J Clin Epidemiol* 1993;46:123-31.
9 Donner A, Klar N. *Design and analysis of cluster randomization trials in health research*. London: Arnold, 2000.
10 Ampofo Boateng K, Thomson JA, Grieve R, Pitcairn T, Lee DN, Demetre JD. A developmental and training study of children's ability to find safe routes to cross the road. *Br J Dev Psychol* 1993;11:31-45.
11 Bouck LH. Development of a British road safety education support materials curriculum [thesis]. College Station, TX: Texas A&M University, 1992.
12 Cross RT, Pitkethly A. Speed, education and children as pedestrians: a cognitive change approach to a potentially dangerous naive concept. *Int J Sci Educ* 1988;10:531-40.
13 Downing CS, Murray G, Durow C. Trials of a road safety booklet for a pre-school traffic club. *TRRL Laboratory Report* 1981;LR 992:1-27.
14 Limbourg M, Gerber D. A parent training program for the road safety education of preschool children. *Accid Anal Prev* 1981;13:255-67.
15 Luria JW, Smith GA, Chapman JI. An evaluation of a safety education program for kindergarten and elementary school children. *Arch Pediatr Adolesc Med* 2000;154:227-31.
16 Matson JL. A controlled group study of pedestrian-skill training for the mentally retarded. *Behav Res Ther* 1980;18(2):99-106.
17 Miller DA, Davis L. Evaluation of Beltman traffic safety program for children. *J Traffic Safety Educ* 1982;30:13-4.
18 Nishioka N, Ieda S, Watanabe M, Takahashi H, Yamakawa M, Okajima Y, et al. An experimental study on the safety behavior of children in a dashing-out situation: effects of verbal instructions and traffic conditions on safety behavior. *IATSS Res* 1991;15:39-45.
19 Renaud L, Suissa S. Evaluation of the efficacy of simulation games in traffic safety education of kindergarten children. *Am J Public Health* 1989;79:307-9.
20 Singh A. Children and traffic. *Traffic Educ* 1979;4:8-12.
21 Thomson JA, Ampofo Boateng K, Pitcairn TK, Grieve R, Lee DN, Demetre JD. Behavioural group training of children to find safe routes to cross the road. *Br J Educ Psychol* 1992;62:173-83.
22 Thomson JA, Whelan KM. A community approach to road safety education using practical training methods. *Road Safety Res Rep* 1997;3:1-49.
23 Thomson JA, Ampofo Boateng K, Lee DN, Grieve R, Pitcairn TK, Demetre JD. The effectiveness of parents in promoting the development of road crossing skills in young children. *Br J Educ Psychol* 1998;68: 475-91.
24 Global Road Safety Partnership. www.grsproadsafety.org/ (accessed 24 Nov 2001).

*(Accepted 13 March 2002)*