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Area-wide traffic calming for preventing traffic related injuries (Review)

Bunn F, Collier T, Frost C, Ker K, Steinbach R, Roberts I, Wentz R

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[Intervention Review]

Area-wide traffic calming for preventing traffic related injuries

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ABSTRACT

Background

It is estimated that by 2020 road traffic crashes will have moved from ninth to third in the world disease burden ranking, as measured in disability adjusted life years, and to second in developing countries. Area-wide traffic calming schemes that discourage through traffic on residential roads is one strategy for preventing traffic related injuries.

Objectives

To assess the effects of area-wide traffic calming for preventing traffic related crashes, injuries, and deaths.

Search methods

We searched the the Cochrane Injuries Group Specialised Register, Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE and TRANSPORT. We searched the web sites of road safety organisations, handsearched conference proceedings, checked reference lists of relevant papers and contacted experts in the area. The search was not restricted by language or publication status. The searches were last updated in 2008.

Selection criteria

Randomised controlled trials and controlled before-after studies of area-wide traffic calming schemes.

Data collection and analysis

Two authors independently extracted data on type of study, characteristics of intervention and control areas, and length of data collection periods. Before and after data were collected on the total number of road traffic crashes, all road user deaths and injuries, pedestrian-motor vehicle collisions and road user deaths. The results of each study were expressed as rate ratios.

Main results

We found no randomised controlled trials, but 22 controlled before-and-after studies met our inclusion criteria. Seven studies were conducted in Germany, seven in the UK, two in Australia, two in the Netherlands, two in Denmark, one in Japan, and one in Spain. There were no studies in low or middle income countries. Nine trials reported the number of road traffic crashes resulting in deaths; pooled rate ratio 0.79 (95% CI 0.23 to 2.68). Eighteen studies reported the number of road traffic crashes resulting in injuries (fatal

and non-fatal); pooled rate ratio 0.85 (95% CI 0.75 to 0.96). Twelve studies reported the total number of road traffic crashes; pooled rate ratio 0.89 (95% CI 0.76 to 1.05). Fourteen trials reported the number of pedestrian-motor vehicle collisions; pooled rate ratio 1.01 (95% CI 0.88 to 1.16). There was evidence of significant heterogeneity for the total number of crashes and road user injuries outcomes.

Authors' conclusions

The results from this review suggest that area-wide traffic calming in towns and cities may be a promising intervention for reducing the number of road traffic injuries and deaths. However, further rigorous evaluations of such interventions are needed.

PLAIN LANGUAGE SUMMARY

Area-wide traffic calming (such as introducing road/speed humps) may reduce death and injury from road traffic crashes but more research is needed

Road traffic crashes are a major problem worldwide. In high-income countries, traffic calming schemes aim to make the roads safer (particularly for vulnerable road users such as pedestrians and cyclists) in areas that are particular 'hot spots'. Strategies include slowing down traffic (eg road/speed humps, mini-roundabouts, reduced speed limit zones), visual changes (road surface treatment, changes to road lighting), redistributing traffic (blocking roads, creating one-way streets), and/or changes to road environments (such as trees). This review found that area-wide traffic calming may have the potential to reduce death and injuries, but more research is needed particularly in low and middle income countries.

BACKGROUND

Description of the condition

The global epidemic of road traffic deaths and injuries is only just beginning. At present, an estimated 1.23 million people die each year and between 20 and 50 million suffer non-fatal road injuries (WHO 2009). For people under 44 years, road traffic crashes are a leading cause of death and disablement second only to HIV and AIDS (Krug 2002). Moreover, many developing countries are still at comparatively low levels of motorisation and the situation in these countries can only be expected to get worse as motorisation increases. In 1995, road death rates in China were similar to those in the United States, but there were only five vehicles per 1000 population in China compared with 770 vehicles per 1000 in the United States (Roberts 1995). It is estimated that by 2020 road traffic crashes will have moved from ninth to third in the world disease burden ranking, as measured in disability adjusted life years (Murray 1997). Most of the road deaths in developing countries involve vulnerable road users such as pedestrians and cyclists. In Ethiopia, pedestrian injuries account for 84% of all road traffic fatalities compared with 32% in Britain and 15% in the USA (Barss 1998). In the heavily motorised countries drivers and passengers account for the majority of road deaths but pedestrians account for a large proportion of road deaths involving children. The identification of effective strategies for the prevention of road traffic injuries is of global health importance.

Description of the intervention

In urban areas many road traffic crashes are scattered widely, and in such situations traditional treatments for high-risk sites are not appropriate. In high income countries, area-wide traffic calming schemes, including the treatment of both main roads and residential roads, have been proposed as one strategy for reducing scattered crashes. Such schemes aim to discourage through traffic on residential roads and make the roads safer, particularly for vulnerable road users such as pedestrians and cyclists.

Why it is important to do this review

A previous meta-analysis found that area-wide traffic calming schemes on average reduce the number of injury crashes by about 15% (Elvik 2001). However, this study included uncontrolled before-after studies in which the effect of traffic calming could be confounded by the effect of other concurrent changes in road traffic injury rates. For example, in many high income countries

pedestrian injury rates have fallen because walking has become a less popular way of travelling. In this case, the inclusion of uncontrolled studies could exaggerate the apparent effect of traffic calming. We conducted a systematic review of area-wide traffic calming including only controlled before-after studies.

OBJECTIVES

To assess the effects of area-wide traffic calming measures on the prevention of traffic related injuries.

METHODS

Criteria for considering studies for this review

Types of studies

Studies were included if they involved either of the following research designs:

- Randomised and quasi-randomised controlled trial (RCT)
- Controlled before and after study (CBA)

The definition of CBA is based on that used by the Cochrane Effective Practice and Organisation of Care Group and is given below:

- RCT: A study involving at least one test and one control treatment, concurrent enrolment and follow-up of the test- and control-treated groups, and in which the treatments to be administered are selected by a random process, such as the use of a random numbers table (coin flips are also acceptable). If the author(s) state explicitly (usually by using some variant of the term 'random' to describe the allocation procedure used) that the groups compared in the trial were established by random allocation, then the trial is classified as 'RCT'. Treatment allocations using odd-even numbers, days of the week, or other such pseudo- or quasi-random processes, are designated as quasi-randomised.
- CBA: A design where there is contemporaneous data collection before and after the intervention and an appropriate control site or activity.

Types of participants

Areas covering a number of different streets, including residential and main roads, treated with traffic calming measures.

Types of interventions

Area-wide traffic calming measures designed to discourage the use of residential streets for through travel; and to create an environment where residential streets are safe. Eligible schemes included those that involved a number of specific named changes to the road layout, road hierarchy, or road environment, such as:

- Vertical and horizontal shifts in traffic (e.g. road humps, speed cushions, raised crosswalks, raised sections of road, chicanes, mini-roundabouts, road narrowing, channelised slip lanes, etc.)
- Optical measures (chevron road sings, road surface treatment (colour, texture), reduced horizontal visibility (shortened sightlines); audible measures (rumble areas, jiggle bars), alterations to road lighting
- Redistribution of traffic or alteration to road hierarchy, (e.g. permanent or temporary blocking of road, diagonal blocks, gateways, creation of one-way streets, re-introduction of two-way streets, four-way stops)
- Changes to road environment (increased vegetation (trees, shrubs) along road, introduction of street furniture).
- Reduced speed limit zones (e.g. 20-mph zones, 30 km/h zones) where speeds are physically limited by traffic calming measures.

We excluded studies evaluating single interventions or those looking solely at the following interventions:

- Enforcement of legal interventions (enforcement of speed limits, increased fines for speeding, speed cameras (mock or real), educational programmes aimed at altering driver or pedestrian behaviour, or interventions involving vehicle design changes).
- Fiscal/financial incentives/disincentives (local tolls to reduce extraneous traffic).
- Studies solely describing intervention which separate different road users (cycle lanes, elevated pedestrian walkways, red (bus) lanes etc.).
- Effects of improved public transport facilities.
- Interventions investigating the effect of alterations to road signs or traffic lights alone.
- "Road Diet" interventions (conversions of, for example, four lane undivided roads into three lanes- two through lanes and a centre turn lane).

Comparison of interventions in studies eligible for this review:

- Area-wide traffic engineering intervention versus no intervention
- Area-wide traffic engineering intervention versus legal and/or educational and/or fiscal measures

Types of outcome measures

Primary outcomes

- Road user deaths.
- Road user injuries.
- Road traffic crashes.
- Pedestrian-motor vehicle collisions.

Our definition of 'road users' included all road users not just drivers and occupants of motor vehicles.

Secondary outcomes

- Perceived quality of urban environment.
- Perceived safety.

Search methods for identification of studies

Electronic searches

We searched the following electronic databases;

- Cochrane Injuries Group Specialised Register (searched January 2008),
- Cochrane Central Register of Controlled Trials (*The Cochrane Library* 2007, Issue 1),
- MEDLINE (to December 2007, week 4)
- EMBASE (to 2008, week 1),
- Sociological Abstracts (to 2000),
- Science (and Social Science) Citation Index,
- TRANSPORT (pre-1980 to 2006 issue 12)
- Psychlit (to 2000),
- National Research Register (2007, Issue 1),
- International Bibliography of the Social Sciences (1951 to 2007/10).

The search strategies used for the updated searches performed in 2007/08 are presented in Appendix 1; Appendix 2; Appendix 3; Appendix 4; Appendix 5.

We searched the web sites of the following road safety organisations (searches performed in 2001):

- AAA Foundation for Traffic Safety (USA) - www.aaafoundation.org
- ARRB - Australian Road Research Board - www.arrb.org.au
- Australian Transport Safety Bureau - www.atsb.gov.au
- CROW - Information and Technology Centres for Transport and Infrastructure (Netherlands) - www.crow.nl
- Danish Council for Road Safety Research - www.trm.dk/eng/veje/rft
- Danish Transport Research Institute - www.dtf.dk
- DETR -www.detr.gov.uk/
- DVR - Deutscher Verkehrssicherheitsrat Road Safety Institute (Germany) - www.dvr.de/
- FINNRA - Finnish National Road administration - www.tieh.fi
- INRETS - Institut National de Recherche sur les Transports et leur Sécurité (France) - www.inrets.fr
- ITE - Institute of Transportation Engineers (USA) - www.ite.org
- LET - Laboratoire d'economie des transports (France) - www.lsh-lyon.cnrs.fr
- NHTSA - National Highway Traffic Safety Administration (USA) - www.nhtsa.dot.gov
- Swedish National Roads Administration - www.vv.se/for_lang/english/
- SWOV - Institute for Road Safety Research (Netherlands) - www.swov.nl
- TOI - Institute of Transport Economics (Norway) - www.toi.no
- TC - Transport Canada - www.tc.gov
- TRB- Transportation Research Board- www.nas.edu/trb/
- TRL- Transport Research Laboratory (UK) - www.trl.co.uk
- US Department of Transport - Federal Highway Administration (USA) - www.fhwa.dot.gov
- VTI - Swedish National Road and Transport Research Institute - www.vti.se
- VTT - Finland www.vtt.fi/indexe.htm

Searching other resources

We handsearched the following conference proceedings:

- Australian Road Research Board (ARRB). Proceedings of the 12th ARRB conference, Hobart Tasmania 27th to 31st August 1984.
- Australian Road Research Board (ARRB). Proceedings of the 15th ARRB conference, Darwin, 26th to 31 August 1990.
- Institution of Professional Engineers New Zealand (IPENZ). Annual conference Christchurch February 1992 Volumes 1 & 2.
- Institution of Professional Engineers New Zealand (IPENZ). Proceedings of the technical session of the group at the annual conference of IPENZ, Auckland 8th to 12th February 1982.
- Institute of Transportation Engineers (ITE). Proceedings of the 45th to 71st ITE annual meeting, 1975 to 2001.
- Institute of Transportation Engineers (ITE). Transportation and traffic theory 9th international symposium, Netherlands 1984.
- Institute of Transportation Engineers (ITE). Residential street design and traffic control 1989.
- Israel Institute of technology. International conference on pedestrian safety. Haifa 20th to 23rd December 1976.
- Landor Publishing Ltd. The third national traffic calming conference. London 18th October 1996.
- Organisation for economic co-operation and development (OECD). Proceedings of the symposium on techniques of improving urban conditions by restraint of road traffic; 25th to

27th October 1971.

- PTRC Transport, Highways and Planning Summer 13th to 18th Annual Meetings, 1985-1990.
- Swedish Road and Traffic Research Institute. Proceedings of the conference on strategic highway research program and traffic safety on two continents; Gothenburg Sweden, September 18th to 20th, 1991.
- Swedish Road and Traffic Research Institute. Proceedings of the conference on strategic highway research program and traffic safety on two continents; Gothenburg Sweden, September 27th to 29th, 1989.
- Swedish Road and Traffic Research Institute. Proceedings of the conference on road safety and traffic environment in Europe, Gothenburg Sweden, September 26th to 28th, 1990.
- The Technion Israel Institute of Technology. The second international conference on new ways for improved road safety and quality of life, 7th to 10th October 1991, Tel-Aviv Hilton Hotel, Israel.
- Transportation Research Institute. International conference on new ways and means for improved safety, Tel Aviv, Israel, Feb 20th to 23rd 1989.
- Transport Research Laboratory. Safety 91 Papers on vehicle safety, traffic safety and road user safety research, TRL Laboratory Berks 1st to 2nd May 1991.

We identified further potential published or unpublished studies by checking references of relevant papers and reviews; contacting authors of relevant papers; and contacting international road safety organisations.

Data collection and analysis

Selection of studies

One author examined titles, abstracts, and keywords of citations, as given on electronic databases, for eligibility. Where possible, we obtained the full text of all possible relevant citations. One author decided whether studies met the inclusion criteria, and this was checked by a second author.

Data extraction and management

Two authors independently extracted data from each eligible study using a standard form. Data were extracted on the type of study (e.g. RCT, CBA), characteristics of intervention and control areas, the types of intervention, duration of follow up and the outcomes evaluated. Differences found in data extraction were resolved by discussion. Where necessary, we sought additional information from researchers involved in the studies.

Assessment of risk of bias in included studies

The assessment of the quality of non-randomised trials is problematic. Controlled before-after studies are recognised to be methodologically weaker than randomised controlled trials, and few quality assessment tools exist. In this review we assessed the quality of the CBAs by extracting data on how well the intervention and control areas were matched, and the length of the before and after data collection periods. Because of the potential for contamination, we also noted the distance between the intervention and control areas.

Measures of treatment effect

The results of each study are expressed as rate ratios. The rate ratio is the ratio of event rates post and pre intervention in the intervention area divided by the corresponding post to pre intervention event ratio in the control area. Provided that any changes in the population at risk are the same in both control and intervention areas, the rate ratio gives the reduction in the event rate in the intervention area compared to that in the control area. For example, a rate ratio of 0.8 corresponds to a 20% reduction in events in the intervention area compared to that predicted from the rates in the control area.

We calculated standard errors for logarithms of rate ratios and hence 95% confidence intervals for rate ratios, assuming that the number of events in each area in each period followed a Poisson distribution.

Assessment of heterogeneity

We examined statistical heterogeneity by using both the I-squared and Chi^2 tests. The I^2 test describes the percentage of total variation across studies due to heterogeneity rather than chance. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity; substantial heterogeneity is considered to exist when $I^2 > 50\%$ (Higgins 2008). For the Chi^2 statistic, we used a P value of < 0.10 to indicate the presence of statistically significant heterogeneity.

Data synthesis

Using the generic inverse variance method in Review Manager, we combined the rate ratios on a logarithmic scale using a random effects meta-analysis model. The assumption of random effects both allows for the anticipated heterogeneity between effects across studies and provides robustness if the assumption that events follow Poisson distributions is violated through overdispersion.

In the analysis of road user deaths, where the majority of studies had no events in at least one period, no test of heterogeneity was carried out and a pooled estimate of the rate ratio was obtained from the column totals. The confidence interval for this estimate would, in expectation, be too narrow since the method ignores the

likely heterogeneity between studies. However, under the circumstances of many zero observations, this method has some advantage over the alternative of adding 0.5 when observing zero.

RESULTS

Description of studies

Results of the search

Our searches identified 13,520 published and unpublished reports. We obtained the full text of 635 reports and of these 22 controlled before-after studies met our inclusion criteria (Charlottenburg 1990; Denmark 1992; GST-Buxtehude 1993; GST-Esslingen 1993; GST-Borgentreich 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; London 2007; Madrid 2006; Mørkhøj 2001; Osaka 1998; Rijswijk/Eindhoven 1991; Swindon 1981; Sydney-Canterbury 1990; Sydney-Willoughby 1990; The Netherlands 1992; USP Bradford 1989; USP Bristol 1989; USP Nelson 1989; USP Reading 1989; USP Sheffield 1989). We found no randomised controlled trials.

Included studies

In all the studies in this review the areas involved were predominantly residential, often located close to the central commercial sector of a large town or city. Area-wide traffic calming involved a reclassification of the streets in the area, aiming to move through traffic away from residential streets and concentrate it on roads that were classified as main roads. In all studies a combination of traffic calming measures was used, including interventions such as road closures, changes to junctions, changes to the road environment (for example with traffic humps or chicanes), improvement in pedestrian crossing facilities and the use of mini-roundabouts. Seven studies were conducted in Germany (GST-Borgentreich 1993; GST-Buxtehude 1993; Charlottenburg 1990; GST-Esslingen 1993; GST-Mainz 1993; GST-Moabit 1993; GST-Ingolstadt 1993), seven in the UK (London 2007; Swindon 1981; USP Bradford 1989; USP Bristol 1989; USP Nelson 1989; USP Reading 1989; USP Sheffield 1989), two in Australia (Sydney-Canterbury 1990; Sydney-Willoughby 1990), two in the Netherlands (Rijswijk/Eindhoven 1991; The Netherlands 1992), two in Denmark (Denmark 1992; Mørkhøj 2001), one in Japan (Osaka 1998), and one in Spain (Madrid 2006). One of the German studies (Charlottenburg 1990) was a pilot scheme for the other six German towns; Borgentreich, Buxtehude, Esslingen, Mainz, Moabit, and Ingolstadt. One of the studies in the UK (Swindon 1981) was a pilot scheme for the other five Urban Safety Project towns; Bradford, Bristol, Nelson, Reading and Sheffield. The two Australian studies both took place in Sydney.
More details about individual studies can be found in the Characteristics of included studies table.

Risk of bias in included studies

As there is not an accepted instrument for appraising the quality of controlled before-after-studies we have not attempted a formal quality score or appraisal of the studies. Where possible we collected information on:

- the length of data collection before and after the intervention;
- how intervention and control areas were matched; and
- proximity of control area to intervention area.

Berlin Charlottenburg (Charlottenburg 1990):
A controlled before-after study with two years before and two years after data. Berlin Moabit was chosen as the control area. Little information was given about the control area. Data on the number of crashes and injuries were collected from police records. Incidence of crashes and injuries in the before period were much higher in the control area than the intervention area.
Denmark 1992:
A controlled before-after study with three years before data and three years after data. The control areas were selected to match the intervention areas. There was no significant difference in the mean speeds of motor vehicles in the control and intervention areas.
German six towns study (GST-Esslingen 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; GST-Borgentreich 1993; GST-Buxtehude 1993):
Controlled before-after studies with two years before data and two years after data; except for Borgentreich where the after period was extended to three years to obtain a sufficient sample size. The controlled areas for each town are in brackets. Berlin-Moabit (Berlin-Wedding), Borgentreich (Borgholz), Buxtehude (Buxtehude-Sud), Esslingen (Nurtingen), Ingolstadt (Regensburg), Mainz-Bretzenheim (Mainz-Finthen). Data on the number of crashes and injuries were collected from police records. The criteria for choosing the control areas were:

- similar sized cities;
- same region of Germany;
- similar structure to the area under study;
- no traffic calming measures;
- availability of data from police records; and
- readiness of the city authorities to co-operate.

N.B. additional information provided by one of the study authors.
London 2007:
A controlled before-after study with five years of before data on both the intervention and control group, between one and five years of after data on the intervention group, and three years of after

data on the control group. The control roads were all unclassified roads in London.

Madrid 2006:

A controlled before-after study with two years of before data and two years of after data. The control areas and intervention areas were similar in that they both belonged to the highway network of the Autonomous Community of Madrid and both eventually received traffic calming. The control areas received traffic calming at a later date than the intervention areas.

Mørkhøj 2001:

A controlled before-after study with three years of before data and three years of after data. The control area was the remainder of the municipality where the intervention was situated. No other information was given about the control area.

Osaka 1998:

A controlled before-after study with six years of before data and six years of after data. No other information was given on the control areas.

Rijswijk/Eindhoven 1991:

A controlled before-after study with six years before data and five years after data. The control and intervention areas were similar in that they were both residential districts, built before 1972, with adjacent main traffic arteries. To avoid contamination the control areas were not in the immediate vicinity of the demonstration areas. Data on the number of crashes and injuries were collected from police records.

Swindon 1981:

A controlled before-after study with four years before data and two years after data. The controls chosen were similar routes where the local council agreed as far as possible to keep roadworks to a minimum. However, the authors note that the 'behaviour' of the control routes was not typical of other types of roads in Swindon during the two year after period. They concluded that the control technique had broken down. Data on the number of crashes and injuries were collected from County Council records.

Sydney-Canterbury 1990:

A controlled before-after study with three years before data and two and a half years after data. Although efforts were made to match the control and intervention areas they had different land use characteristics and, unlike the intervention area, the control had no industrial zone. Areas were of a similar size. The areas were close but not immediately adjacent. Data on the number of crashes and injuries were collated from the Traffic Authority of New South Wales records. There was a lower incidence of crashes and injuries in the before period in the intervention area, than in the before period in the control area.

Sydney-Willoughby 1990:

Controlled before-after study with two years before data and two years after data.The control area was selected because of its similar traffic problems to the intervention area, although it did not reflect the grid pattern of the study area. Areas were of a similar size.

Data on the number of crashes and injuries were collected from the records of the Traffic Authority of New South Wales.

In the before period the incidence of crashes was much higher in the intervention area than in the control area.

The Netherlands 1992:

A controlled before-after study with three years before data and three years after data. The control areas were roads in built-up areas, excluding arterial roads, in the same municipalities that the intervention areas were situated in.

Urban Safety Project (USP Bradford 1989; USP Bristol 1989; USP Nelson 1989; USP Reading 1989; USP Sheffield 1989):

These were controlled before after studies with matched comparison groups. For each town a five year 'before' period was used to detect trends and seasonal variation in the crash pattern and so to establish a range of crashes that might be expected in the 'after' period had the project not taken place. Two years of after data were collected. Any differences in crash-rate between the 'before' and 'after' periods was taken to be due to a combination of system-wide secular effects, random effects and the effects of the scheme itself. The criteria used for choosing the areas in the project were that they were of average risk, had a range of residential network types, and were large enough to show the interaction between main road and residential road traffic redistribution. A second area with similar crash and network characteristics was chosen for the control. The areas were not immediately adjacent. Data on the number of crashes and injuries were collected from police records. Incidence of crashes and injuries in the intervention and control areas were fairly well matched for the before period.

Effects of interventions

Road user deaths

Nine studies reported the number of road traffic crashes resulting in deaths (Denmark 1992; GST-Borgentreich 1993; GST-Buxtehude 1993; GST-Esslingen 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; Sydney-Canterbury 1990; Sydney-Willoughby 1990). The pooled rate ratio was 0.79 (95% CI 0.23 to 2.68), which was calculated from the column totals, due to zero counts observed in a number of the studies. Individual results for each study are presented in Table 1. The results should be interpreted with caution; the method of using the column totals to calculate the rate ratio ignored the likely heterogeneity between the studies, and the estimate is likely to be too narrow.

Road traffic injuries (fatal and non fatal)

Eighteen studies (Charlottenburg 1990; Denmark 1992; GST-Borgentreich 1993; GST-Buxtehude 1993; GST-Esslingen 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; London 2007; Rijswijk/Eindhoven 1991; Swindon 1981; Sydney-Canterbury 1990; Sydney-Willoughby 1990; USP Bradford 1989;

USP Bristol 1989; USP Nelson 1989; USP Reading 1989; USP Sheffield 1989) reported the number of road traffic crashes resulting in injuries. The pooled rate ratio was 0.85 (95% CI 0.75 to 0.96). Individual results for each trial can be seen in Table 2. There was significant statistical heterogeneity between trials (Chi ^{2} = 52.24, df = 17, P = <0.0001, I^2 = 67%).

Road traffic crashes

Twelve studies (Charlottenburg 1990; GST-Borgentreich 1993; GST-Buxtehude 1993; GST-Esslingen 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; London 2007; Mørkhøj 2001; Osaka 1998; Sydney-Canterbury 1990; Sydney-Willoughby 1990) reported the total number of road traffic crashes. The pooled rate ratio was 0.89 (95% CI 0.76 to 1.05). Individual results for each trial can be seen in Table 3. There was significant statistical heterogeneity between trials (Chi^2 = 74.59, df = 11, P = <0.00001, I^2 = 85%).

Pedestrian-motor vehicle collisions

Fourteen trials reported the number of pedestrian crashes (GST-Borgentreich 1993; GST-Buxtehude 1993; GST-Esslingen 1993; GST-Ingolstadt 1993; GST-Mainz 1993; GST-Moabit 1993; Osaka 1998; Sydney-Canterbury 1990; Sydney-Willoughby 1990; USP Bradford 1989; USP Bristol 1989; USP Nelson 1989; USP Reading 1989; USP Sheffield 1989). The pooled rate ratio was 1.01 (95% CI 0.88 to 1.16). Individual results for each trial can be seen in Table 4. The results should be interpreted with caution; the method of using the column totals to calculate the rate ratio ignored the likely heterogeneity between the studies, and the estimate is likely to be too narrow.

Perceived safety

Two trials looked at residents' perceptions of safety before and after the schemes. In one (Sydney-Willoughby 1990), almost 80% of those who responded (response rate of 43%) supported the council's policy of improving residential safety by reducing the volume of through traffic. However, only 64% supported the permanent installation of the trial scheme. In the other study (Sydney-Canterbury 1990), the majority of residents who responded (65%) felt that the level of safety had remained constant or diminished.

DISCUSSION

Summary of main results

The results of this systematic review of controlled before-after studies shows that area-wide traffic calming schemes may have the potential to reduce road traffic deaths and injuries. Although the effect on road traffic injury deaths alone was in the same direction and of a similar magnitude, the number of road deaths in the included studies was low, and the estimate is likely to be too narrow since the method used ignored the likely heterogeneity between the studies. As very few studies reported the number of deaths and injuries for the different categories of road user (pedestrians, cyclists and vehicle occupants) it was not possible to examine the effect of traffic calming by road user category. Although there was no evidence that traffic calming schemes prevent pedestrian-motor collisions, the possibility that they might reduce the occurrence of pedestrian injury cannot be excluded. An important effect of traffic calming schemes is to reduce the speed of traffic, in which case traffic calming might still reduce the likelihood of injury in the event of a collision.

Overall completeness and applicability of evidence

Road traffic crashes are a major cause of death and injury in low and middle income countries. With increasing motorisation in these countries the problem is likely to get worse. In low income countries the majority of casualties are not motor vehicle occupants; they are pedestrians, cyclists and riders of motorised two-wheelers. Compared to educationally based road safety interventions, area-wide traffic calming appears to be a more promising intervention for reducing traffic injuries and deaths. However, further rigorous evaluation is required, particularly in middle and lower income countries.

Quality of the evidence

The validity of a systematic review also depends importantly on the validity of the included studies. Although we found no randomised controlled trials of traffic calming schemes, the inclusion of studies with well matched intervention and control areas, with adequate before and after periods, may avoid the problem of confounding by changes in the background rate of injury. All of the included studies collected at least one year before and two years after data, with a number collecting up to six years of before or after data.

Potential biases in the review process

There are a number of methodological issues that could have an important bearing on the validity of these results. Publication and other selection biases are a potential threat to validity in all systematic reviews but this is a particular problem in road safety where a large proportion of the available research information is

published in the grey literature of the road safety research organisations. There are also problems identifying the published controlled studies in the road safety databases (Wentz 2001). Search strategies for identifying controlled studies in medical databases can achieve high sensitivity and positive predictive value because terms describing the study methodology are included among the indexing (descriptor) terms. Road safety databases however, have a very limited range of indexing terms describing the study methodology. Because of these problems we used only limited methodological search terms when searching the TRANSPORT databases but screened all studies of traffic calming schemes for eligibility. Nevertheless, despite our considerable efforts to identity all eligible studies, published and unpublished and irrespective of language of publication, we cannot exclude the possibility of selection bias. Although we chose to pool the data in a random effects meta-analysis, because there was significant heterogeneity for both the pooled number of road traffic crashes and the number of road traffic crashes resulting in injuries, these results should be interpreted with caution. The observed heterogeneity may be due to differences in study design, differences in the types of traffic calming schemes involved, or to differences in the way outcomes were defined and data collected. There was no evidence of statistical heterogeneity for the other outcomes, death and pedestrian motor-vehicle collisions. However, it is still plausible that heterogeneity did exist as there is no reason to assume that differences between studies would cause heterogeneity for some outcomes but not for others.

AUTHORS' CONCLUSIONS

Implications for practice

Area-wide traffic calming appears to be a promising intervention for reducing traffic injuries and deaths in towns and cities. However, further rigorous evaluation is needed before we can answer the question conclusively.

Implications for research

In searching for studies of traffic calming we found numerous uncontrolled before-after studies but only 22 controlled before-after studies and no randomised controlled trials. Traffic calming interventions need to be properly evaluated using well-designed controlled studies, so that we can more accurately estimate their effects. In addition, researchers need to assess the effect of these interventions in middle and lower income countries.

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REFERENCES

References to studies included in this review

Charlottenburg 1990 ***{published data only}***

Brilon W, Blanke H. Traffic safety effects from traffic calming. *VTI Rapport*. Vol. **363A**, 1990:133–48.

Kahrmann B. [Area–wide traffic restraint measures: Analysis of accidents in Berlin–Charlottenburg]. 2nd International conference on road safety Groningen, Netherlands 31/8/87-4/9/87. 1988:424–34.

Column totals ***{published data only}***

Denmark 1992 ***{published data only}***

Engel U, Thomsen LK. Safety effects of speed reducing measures in Danish residential areas. *Accident Analysis and Prevention* 1992;**24**(1):17–28.

GST-Borgentreich 1993 ***{published data only}***

* Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

Brilon W, Blanke H. [Extensive traffic calming: results of the accident analyses in 6 model towns]. ITE Compendium of technical papers. Washington DC, 1993:119–23.

Brilon W, Blanke H. Traffic safety effects from traffic calming. *VTI Rapport*. Vol. **363A**, 1990:133–48.

GST-Buxtehude 1993 ***{published data only}***

* Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

Brilon W, Blanke H. [Extensive traffic calming: results of the accident analysis in 6 model towns]. ITE compendium of technical papers. 1993:119–23.

Brilon W, Blanke H. Traffic safety effects from traffic calming. *VTI Rapport*. Vol. **363A**, 1990:133–48.

GST-Esslingen 1993 ***{published data only}***

* Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

Brilon W, Blanke H. [Extensive traffic calming: results of the accident analysis in 6 model towns]. ITE Compendium of technical papers. Washington DC, 1993:119–23.

Brilon W, Blanke H. Traffic safety effects from traffic calming. *VTI Rapport*. Vol. **363A**, 1990:134–49.

GST-Ingolstadt 1993 ***{published data only}***

* Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

Brilon W, Blanke H. [Extensive traffic calming: results of the accident analyses in 6 model towns]. ITE Compendium of technical papers. Washington DC, 1993:119–23.

Brilon W, Blanke H. [Traffic safety effects from traffic calming]. *VTI Rapport*. Vol. **363A**, 1990:134–49.

GST-Mainz 1993 ***{published data only}***

Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

GST-Moabit 1993 ***{published data only}***

* Blanke H. Speed behaviour and traffic security at regionally smoothed traffic [Geschwindigkeitsverhalten und Verkehrssicherheit bei flachenhafter Verkehrsberuhigung]. *Ruhr-Universitat Bochum*. 1993:335.

Brilon W, Blanke H. Traffic safety effects from traffic calming. *VTI Rapport*. Vol. **363A**, 1990:133–48.

London 2007 ***{published data only}***

Webster DC, Layfield RE. Review of 20 mph zones in London Boroughs. TRL Published Project Report PPR243 2007.

Madrid 2006 ***{published data only}***

Perez I. Safety impact of engineering treatments on undivided rural roads. *Accident Analysis and Prevention* 2006;**38**:192–200.

Mørkhøj 2001 ***{published data only}***

Agustsson L. Danish experiences with speed zones/variable speed limits. Proceedings of the Conference Traffic Safety on Three Continents: International Conference in Moscow, Russia, 19-21 September, 2001 (Vti Konferens). 2001.

Osaka 1998 ***{published data only}***

Yamanaka H, Yamaguchi Y, Tuchihashi M. Effect of area wide traffic calming in Japan: accident and socio-economic studies of Japanese "road-pia" projects in 1980s. Urban Transport IV: Urban Transport and the Environment for the 21st Century. 1998.

Rijswijk/Eindhoven 1991 ***{published data only}***

Goos JG. Demonstration project and reconstruction of urban road networks (in the municipalities of Eindhoven and Rijswijk) [Demonstratieproject herindeling en herinricting van stedelijke gebieden (in de gemeenten Eindhoven en Rijswijk)]. *SWOV* 1978;**R-78-15**.

Janssen S. [Road safety in urban districts. Final results of accident studies in the Dutch Demonstration projects of the 1970's]. *Traffic Engineering and Control* 1991;**32**:292–6.

Janssen S. Demonstration project and reconstruction of urban road networks in the municipalities of Eindhoven and Rijswijk [Demonstratieproject herindeling en herinrichting van stedelijke gedieden (in de gemeenten Eindhoven en Rijswijk). *Institute for Road Safety Research (SWOV), The Netherlands* 1984;**R-84-29**.

Janssen S. Demonstration project and reconstruction of urban road networks in the municipalities of Eindhoven and Rijswijk [Demonstratieproject herindeling en herinrichting van stedelijke gebieden (in de gemeenten Eindhoven en Rijswijk)]. *Institute for Road Safety Research Netherlands (SWOV)* 1984;**R-84-28-I & R-84-28-II**.

Janssen S. Effects of road safety measures in urban areas in the Netherlands. Contribution to Biecheler et al (eds). "Evaluation 85", International Meeting on the Evaluation of local traffic safety measures. Institute for Road Safety Research SWOV, The Netherlands. Paris, 20–23 May 1985.

Janssen S. Evaluation of the effects of redivision measures in Eindhoven and Rijswijk [Evaluatie van de effecten van herinrichtingsmaatregelen in Eindhoven en Rijswijk]. *Institute for Road Safety Research, The Netherlands (SWOV)* 1980;**R-80-40-I/II**.

* Janssen S. Final results of accident studies in the Dutch demonstration projects of the 1970's. *Traffic Engineering and Control* 1991;**32**:292–6.

Janssen S, Kraay J, Mathijssen M. The effect of traffic measures in Eindhoven and Rijswijk [De effecten van verkeersmaatregelen in Eindhoven en Rijswijk. Demonstratieproject herindeling en herinrichting van stedelijke gebieden]. Artikel Verkeerskunde 36, SWOV 1985; Vol. R–85–31.

Janssen S, Verhoef P. Demonstration project and reconstruction of urban road networks in the municipalities of Eindhoven and Rijswijk [Demonstratieproject herindeling en herinrichting van stedelijke gedieden (in de gemeenten Eindhoven en Rijswijk: Eindrapport van het ongevallen onderzoek]. *Institute for Road Safety Research Netherlands (SWOV)* 1989;**R-89-27**.

Kraay JH, Bakker MG. Experiments in residential areas [Experimenten in verblijfsruimten. Verslag van onderzoek naar de effecten van infrastructurele maatregelen op verkeersongevallen]. *SWOV* 1984;**R-84-50**.

Kraay JH, Remerie F. [Beleving van de verkeersonveiligheid in de herindelingsgebieden van eindhoven en rijswijk. Resultaten van een enquete in het kader van het demonstratie porject herindeling en herinrichting van stedelijke gebieden (in de gemeenten Eindhoven en Rijswijk)]. *SWOV* 1980;**R-80-38**.

Swindon 1981 ***{published data only}***

Dalby E. Application of low-cost road accident countermeasures according to an area-wide strategy. *Traffic Engineering & Control* 1981;**22**:567–74.

Sydney-Canterbury 1990 ***{published data only}***

Fairlie R. Evaluation of the safety benefits of local area traffic management. M.Eng.Sc. Thesis.

Fairlie R, Taylor M. [Evaluating the safety benefits of local area traffic management]. Proceedings of the 15th ARRB conference. 1990; Vol. 7:141–66.

Sydney-Willoughby 1990 *{published data only}*
Fairlie R. Evaluation of the safety benefits of local area traffic management. M.Eng.Sc. Thesis.
Fairlie RB, Taylor MAP. [Evaluating the safety benefits of local area traffic management]. Proceedings of the 15th ARRB conference. 1990; Vol. 7:141–66.

The Netherlands 1992 *{published data only}*
Vis AA, Dijkstra. Safety effects of 30 km/h zones in the Netherlands. *Accident Analysis and Prevention* 1992;**24**(1): 75–86.

USP Bradford 1989 *{published data only}*
Mackie AM. Urban Safety Project. 2. Interim results for area-wide schemes. *Transport and Road Research Laboratory* 1988;**154**.
* Walker R, McFetridge M. Urban safety project: The Bradford Scheme. Transport and Road Research Laboratory, UK 1989; Vol. Contractor report 190.

USP Bristol 1989 *{published data only}*
Mackie AM. Urban safety project 2. Interim results for area wide scheme. *Transport and Road Research Laboratory* 1988; **154**.
* Ward H, Norrie J, Allsop R, Sang A. Urban Safety Project: The Bristol Scheme. *Transport and Road Research Laboratory* 1989;**Contractor Report 192**.

USP Nelson 1989 *{published data only}*
Mackie AM. Urban safety project. 2. Interim results for area-wide schemes. *Transport and Road Research Laboratory* 1988;**154**.
* Walker R, Gardner G, McFetridge M. Urban safety project: The Nelson Scheme. Transport and Road Research Laboratory 1989; Vol. Contractor Report 191.

USP Reading 1989 *{published data only}*
Mackie AM. Urban safety project. 2. Interim results for area-wide schemes. *Transport and Road Research Laboratory* 1988;**154**.
* Ward H, Norrie J, Sang A. Urban safety scheme: The Reading Project. *Transport and Road Research Laboratory* 1989;**Contractor Report 138**.

USP Sheffield 1989 *{published data only}*
Mackie AM. Urban safety project. 2. Interim results for area-wide schemes. *Transport and Road Research Laboratory* 1988;**154**.
* Ward H, Norrie J, Sang A, Allsop R. Urban safety project: The Sheffield Scheme. *Transport and Road Research Laboratory* 1989;**Contractor Report 134**.

References to studies excluded from this review

Amundsen 1984 *{published data only}*
Amundsen FH. Speed Reducing Measures in Residential Areas. *PTRC 12th Summer Annual Meeting* 1984;**Proceeds of seminar L**:91–9.

Brownfield 1980 *{published data only}*
Brownfield DJ. Environmental areas - Interim report on a before-and-after accident study. *Traffic Engineering & Control* 1980;**21**:279–82.

Chick 1994 *{published data only}*
Chick C. An Integrated Approach to Traffic Calming, Road Safety and Environmental Improvements in the London Borough of Hounslow. 22nd European Transport Forum, 12-16 September. Proceedings of seminar J: Traffic Management and Road Safety. 1994:53–69.

Chua 1991 *{published data only}*
Chua CS, Fisher AJ. Performance Measurements of Local Area Traffic Management: A Case Study. *Australian Road Research* 1991;**21**(2):16–34.

Cloke 1999 *{published data only}*
Cloke J, Webster D, Boulter P, Harris G, Stait R, Abbott P, et al. *Traffic calming: Environmental assessment of the Leigh Park Area Safety Scheme in Havant*. Vol. **TRL Report 397**, Transport Research Laboratory, 1999.

Cole 1990 *{published data only}*
Cole A. Traffic calming trail blazers. *Highways* 1990;**58**: 14–5.

Drammen Byplankontor 1980 *{published data only}*
Drammen Byplankontor. [Etterproving av gjennom–kjoringsforbudet i Betzy Kjelsbergs vie]. *Drammen, Drammen Kommune* 1980.

Ebbecke 1977 *{published data only}*
Ebbecke GM, Schuster JJ. Areawide Impact of Traffic Control Devices. *Transportation Research Record* **644**:54–7.

Elmberg 1972 *{published data only}*
Elmberg CM. The Gothenburg Traffic Restraint Scheme. *Transportation* 1972;**5**:1–27.

Engel 1982 *{published data only}*
Engel U. [Short–term and area–wide evaluation of safety measures implemented in a residential area named Osterbro. A case study]. Seminar on short-term and area-wide evaluation of safety measures. 1982:251–9.

Engel 1983 *{published data only}*
Engel U, Krogsgard Thomsen L. [Trafiksanering pa osterbro del 1–Ulykkesanalyse]. *RfT-notat Kobenhavn, Radet for Trfiksikkerheds-forskning* 1983;**1**.

Engel 1989a *{published data only}*
Engel U, Thomsem LK. [En analyse af politirapporterede trafikulykker pa danske 40 gader baseret pa ulykkestaetheder for hhv. efter aendring af gadestatus]. *Radet for Trafiksikkerheds-forskning* 1989.
Engel U, Thomsen LK. Safety effects of speed reducing measures in Danish residential areas. *Accident Analysis & Prevention* 1992;**24**(1):17–28.

Engel 1989b *{published data only}*
Engel U, Thomsen LK. [En analyse af politirapporterede trafikulykker pa 44 40 gader og 52 kontrolgader baseret pa ulykkesfrekvenser for hhv. efter aendring af gadestatus]. Radet for Trafiksikkerheds-forskning 1989.

Engel 1990 *{published data only}*
Engel U, Thomsen LK. [En analyse af bilers korselshastigheder pa 41 40 gader og 13 kontrolgader for hhv. efter aendring af gadestatus]. Radet for Trafiksikkerheds-forskning 1990.

Fager 1984 *{published data only}*
Fager M. Environmental Traffic Management in Stockholm. *ITE Journal* 1984:16–9.

Faure 1992 *{published data only}*
Faure A, Neuville A. Safety in urban areas: the French program "safer city, accident-free district". *Accident Analysis & Prevention* 1992;**24**(1):39–44.
Gambard JM, Premartin M, Wolf G. Traffic calming in France. How to live and move better in town. *Revue Generale des Routes et des Aerodromes* 1989:129–32.

Fisher 1989 *{published data only}*
Fisher AJ, Van Den Dool DF, Ho LK. LATM Operational Successful and Financially Affordable: But are the Users Satisfied?. *National Transport Conference - The Institution of Engineers, Australia* 1989;**89/7**.

Gennaoui 1987 *{published data only}*
Gennaoui FR, Smith EA. Effectiveness of LATM Devices. Fourth National Local Government Engineering Conference. 1987:6–11.

Gunnarsson 1992 *{published data only}*
Gunnarsson S, Hagson A. Traffic Management For a Swedish Historical Town [Visby Innerstad]. *TFB-RAPPORT* 1992:1–62.

Haakenaasen 1982 *{published data only}*
Haakenaasen B. [Trafikksanering i Sandefjord sentrum. Tiltak og virkninger]. TOI-notat, Oslo Transportokonomisk 1982; Vol. 634.

Hagan 1988 *{published data only}*
Hagan WB, Amamoo SE. Residential Street Management in South Australia. *ITE Journal* 1988:35–41.

Hart 1982 *{published data only}*
Hart M. [Effects on accidents, eliminating through traffic of cars in city areas]. Proceedings of seminar on short-term and area-wide evaluation of safety measures, Amsterdam, The Netherlands. Institute for road safety research, April 19–21 1982:127–34.

Heaton 1980 *{published data only}*
Heaton C, Goodman J. Automobile-Restrictive Measures in Central Business Districts: Some Recent Findings and Views. *Transportation Research Record* 1980:24–9.

HRC 1987 *{published data only}*
The Highways Administration. *The Town's Traffic Areas - Road Intersections*. The Highways Regulations Committee, 1987.

HRC 1988 *{published data only}*
The Highways Administration. *The Town's Traffic Areas - Speed Restraints*. The Highways Regulations Committee, 1988.

Kraay 1984 *{published data only}*
Kraay JH, Bakker MG. [Experiments in verblijfsruimten: Verslag van onderzoek naar de effecten van infrastructurele maatregelen op verkeersongevallen]. SWOV 1984; Vol. R–84–50.

Kuemmel 1983 *{published data only}*
Kuemmel DA. A Residential Traffic Management Plan in USA's Snowbelt. ITE 53rd Annual Meeting - Compendium of Technical Papers. 1983.

McDonald 1984 *{published data only}*
McDonald PE. Implementation of Local Area Traffic Management and Streetscape Improvement Scheme in Shire of Corio. *ARRB Proceedings* 1984;**12**(5):34–48.

Meyer 2000 *{published data only}*
Meyer E. Evaluation of Two Strategies for Improving Safety in Highway Work Zones. *Mid-Continent Transportation Symposium* 2000:62–6.

Mok 2003 *{published data only}*
Mok J, Landphair HC, Naderi JR. Comparison of safety performance of urban streets before and after landscape improvements. 2nd Urban Street Symposium, Anaheim California 2003.

Mountain 1989 *{published data only}*
Mountain L, Fawaz B. The area-wide effects of engineering measures on road accident occurrence. *Traffic Engineering & Control* 1989;**30**:355–60.

Muskaug 1976 *{published data only}*
Muskaug R. [Gatebruksplanen i Oslo. Erfaringer fra Ruselokka/Skillebekk (forsok 1)]. Oslo Kommune, Byplankontoret, Gatebruksplangruppa 1976.

Oslo Byplankontor 1978 *{published data only}*
Oslo Byplankontor. [Trafikksaneringen i Skoyen/Oppsal omradet. En vurdering av trafikksituasjonen for/etter trafikkom–legingen og de endringer som har skjedd]. Rapport 2, Oslo Kommune, Byplankontoret 1978.

Pau 2001 *{published data only}*
Pau M, Angius S. Do speed bumps really decrease traffic speed? An Italian experience. *Accident Analysis and Prevention* 2001;**33**:585–97.

Portland 2000 *{published data only}*
Portland City. Portland's city-wide speed bump study: seeing the big picture. *Public Works* 2000;**13**:22–6.

Rimiller 2003 *{published data only}*
Rimiller J, Ivan J, Garrick N. Estimating benefits from specific highway safety improvements: Phase III, safety benefits from left turn treatment.

Scottish Exec. 1999 *{published data only}*
Scottish Executive. Community Impact of Traffic Calming Schemes. Central Research Unit 1999; Vol. Research Findings No 68.
Scottish Executive - Development Department. *Central Research Unit*. Vol. **Research findings no. 68**, 1999.

Stolen 1988 *{published data only}*
Stolan A. [Erfaringer med trafikksaneringer og sammenhengende gang–og sykkelveger. Oslo, Asplan Samferdsel]. Utgitt av Samferdselsdepartementet og Vegdirektoratet 1988.

Tester 2004 *{published data only}*
Tester JM, Rutherford GW, Wald Z, Rutherford MW. A matched case-control study evaluating the effectiveness of

speed humps in reducing child pedestrian injuries. *American Journal of Public Health* 2004;**94**(4):646–50.

TRL 1997 ***{published data only}***
Transport Research Laboratory. Core Calming. *Highways* 1997:28–9.

Vreugdenhil 1972 ***{published data only}***
Vreugdenhil JJ. Residential Street Design with Special Emphasis on the Reduction of Accidents and the Improvement of the Environment. *ARRB Proceedings* 1972; **6**:3–52.

Vreugdenhil 1976 ***{published data only}***
Vreugdenhil JJ. Traffic Managment Schemes For Existing Residential Street Layouts on the Grid System. *ARRB Proceedings* 1976;**8**:1–50.

References to studies awaiting assessment

Grontmij 1991 ***{published data only}***
Grontmij. Evaluation of experimental thirty kilometer-zones: a study into traffic accidents [Evaluatie experiments 30 KM/H Zones: Verkeersongevallenonderzoek].

References to ongoing studies

Towliat ***{published data only}***
Towliat M. Experiments regarding safety measures for pedestrian and cyclist in interactions with cars on main roads in built up areas. Lund University.

Additional references

Barss 1998
Barss P. *Injury prevention: an international perspective epidemiology, surveillance and policy*. OUP, 1998.

Elvik 2001
Elvik R. Area-wide urban traffic calming schemes: a meta-analysis of safety effects. *Accident Analysis & Prevention* 2001;**33**:327–36.

Krug 2002
Krug E (Ed). *Injury a leading cause of the Global burden of disease*. Geneva: World Health Organization, 2002.

Murray 1997
Murray CJL, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. *Lancet* 1997;**349**:1498–504.

Review Manager [Computer program]
The Nordic Cochrane Centre. Review Manager. Version 5.0. Copenhagen: The Cochrane Collaboration, 2008.

Roberts 1995
Roberts, I. Letter from Chengdu: China takes to the roads. *BMJ* 1995;**311**:1311–3.

Wentz 2001
Wentz R, Roberts I, Bunn F, Edwards P, Kwan I, Lefebvre C. Identifying controlled evaluation studies of road safety interventions searching for needles in a haystack. *Journal of Safety Research* 2001;**32**:267–76.

WHO 2009
WHO. Global status report on road safety: time for action. World Health Organization, Geneva. (www.who.int/violence_injury_prevention/road_safety_status/2009) 2009.

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Charlottenburg 1990

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Densely populated residential area with small businesses. C) Berlin-Moabit
Interventions	I) Various traffic calming measures including different levels of road surface, staggered lanes and 30km speed limit. C) No traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes.
Notes	This was a pilot study for the German study on traffic calming in six towns

Column totals

Methods	This does not refer to a separate study. The 'column totals' identifier is used for the pooled analysis of road user deaths and pedestrian-motor vehicle collisions, due to the presence of zero events in $\geq$1 of the study periods
Participants	
Interventions	
Outcomes	
Notes	

Denmark 1992

Methods	CBA 3 yrs before data. 3 yrs after data.
Participants	I) 5 15 km/h streets and 39 30 km/h streets comprising 30km of road C) 52 control streets comprising 35km of road
Interventions	I) Area-wide traffic calming including speed humps, limited road width, lateral dislocation C) No area-wide traffic calming
Outcomes	Road traffic crash related injuries, deaths, and serious injuries

Denmark 1992 (*Continued*)

Notes	Collision data collected from police records

GST-Borgentreich 1993

Methods	CBA 3 yrs before data. 3 yrs after data.
Participants	I) Entire centre of Borgentreich. It is a mixture of residential, commercial and farm properties. C) Borgholz
Interventions	I) Area-wide traffic calming including road narrowing, redesign of major roads, traffic free zones, speed restrictions. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. Injury data collected from police records. No information given on perceived safety or quality of environment

GST-Buxtehude 1993

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) The northern half of the centre of Buxtehude, a mix of shopping and residential areas. C) Areas to the south in Buxtehude.
Interventions	I) Measures included road narrowing, speed restrictions and a wide range of traffic restraint measures. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. Injury data collected from police records. No information given on perceived safety or quality of environment

GST-Esslingen 1993

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Area of the town which is a mixture of residential, industrial and commercial properties. C) Similar district in Nurtingen.
Interventions	I) Area-wide traffic calming including reconstruction of major roads and renewal of residential roads. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. Injury data collected from police records. No information given on perceived safety or quality of environment

GST-Ingolstadt 1993

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Most of the old part of the town. C) Old part of the town of Regensburg.
Interventions	I) Area-wide traffic calming including street renewal. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. Injury data collected from police records. No information given on perceived safety or quality of environment

GST-Mainz 1993

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Rural area of Mainz (Mainz-Bretzenheim). Area was 200 hectares with 11,000 inhabitants. C) Another part of Mainz (Mainz-Finthen).

GST-Mainz 1993 (*Continued*)

Interventions	I) Area-wide traffic calming including reconstruction of public spaces, road narrowing and narrowing of road entrances. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. Injury data collected from police records. No information given on perceived safety or quality of environment

GST-Moabit 1993

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Densely populated residential area near the city centre. C) A part of the district Berlin-Wedding.
Interventions	I) Area-wide traffic calming including rebuilding of major roads and increasing the level of vegetation in streets. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes.
Notes	Part of the German study on traffic calming in six towns. No information given on perceived safety or quality of environment

London 2007

Methods	CBA I) 5 yrs before data 1-5 yrs after data C) 5 yrs before data 3 yrs after data
Participants	I) 78 20 mph zones in London C) All unclassified roads in London
Interventions	I) Area-wide traffic calming including road humps, raised junctions, speed cushions, chicanes, and raised footways. C) No area-wide traffic calming.

London 2007 (*Continued*)

Outcomes	Road traffic crash related injuries, deaths and serious injuries, and injuries to pedestrians, cyclists, powered 2-wheeler riders, and car occupants All road traffic crashes and crashes involving a death or serious injury Road traffic crash related injuries to children.
Notes	Collision data collected from police records.

Madrid 2006

Methods	CBA 2 yrs before data 2 yrs after data
Participants	I) Undivided rural roads belonging to the highway network of the Autonomous Community of Madrid that received treatment between 1986 and 1989 C) Undivided rural roads belonging to the highway network of the Autonomous Community of Madrid that received treatment between 1990 and 1993. i.e. roads that during the time period of the study did not receive treatment but would later be treated
Interventions	I) Highway upgrading, traffic signing, pavement markings, pavement resurfacing C) No area-wide traffic calming
Outcomes	Number of road traffic crashes
Notes	Data could not be extracted

Mørkhøj 2001

Methods	CBA 3 yrs before data 3 yrs after data
Participants	I) Residential area with both single-family houses and flats totaling 15.5km C) The remainder of the Gladsaxe Municipality
Interventions	I) Speed humps, raised crossings, road signs and increased vegetation C) No area-wide traffic calming
Outcomes	Road traffic crashes
Notes	The intervention area had been suffering from a high accident rate before the intervention. Speed reducing measures in the intervention area were placed further apart than recommended in Danish road guidelines

Osaka 1998

Methods	CBA 6 yrs before data 6 yrs after data
Participants	Ia) 10 districts in Osaka with "road-pia" projects that started in 1987 or earlier Ib) 9 districts in Osaka with "community street" projects C) 9 districts in Osaka
Interventions	Ia) "Road-pia" project introduced area-wide traffic calming including speed humps, limited street width, coloured pavement, chicanes, and entry treatments. Ib) "Community street" projects introduces chicanes, improved pavements, street furniture, and increased vegetation. C) No area-wide traffic calming
Outcomes	Road traffic crashes Pedestrian crashes Cyclist crashes
Notes	Collision data collected from police records.

Rijswijk/Eindhoven 1991

Methods	CBA 6 yrs before data. 5 yrs after data.
Participants	I) Road districts in Rijswijk and Eindhoven in the Netherlands. The project began in 1976. C) Number of residential zones bordering on main traffic arteries within the boundaries of Rijswijk and Eindhoven. They were not in the immediate vicinity of the intervention areas. The experimental areas in Rijswijk consisted mainly of old residential districts whereas the control area is made up of new housing estates. Each area was about 100 hectares.
Interventions	I) Public spaces were first reclassified, with a new distribution of traffic zones and zones for other functions. The traffic zones were then reconstructed in order to improve road safety and traffic flow. Interventions included: road humps, horizontal road shifts, road closures and restrictions, road narrowing and raised cross-roads. C) No traffic calming.
Outcomes	Road traffic crash related deaths and injuries. Environmental effect. Retail sales. Public opinion.
Notes	Project began in 1976. The control areas were larger than the intervention areas and had many more residents. However, the residential density per hector was higher in the intervention area

Swindon 1981

Methods	CBA 4 yrs before data. 2 yrs after data.
Participants	I) 2.8 KM section of an all purpose arterial road in Swindon, UK C) Three routes of similar layout, frontage development and radial function. The local council agreed to keep road works to a minimum in this area
Interventions	I) A number of traffic calming measures including roundabouts, pedestrian crossings and changes to intersections. C) No changes.
Outcomes	Road traffic crash related injuries.
Notes	Behaviour of the control routes was atypical of other types of road in Swindon during the study period. No information given on perceived safety or quality of environment

Sydney-Canterbury 1990

Methods	CBA 3 yrs before data. 2.5 yrs after data. The control area was chosen due to its closeness to the trial area and its similar characteristics
Participants	I) Predominantly residential area in Sydney, Australia. The area also contained an industrial zone. C) An area to the south of the test area. This area was different in that it did not contain an industrial zone
Interventions	I) Local area traffic management scheme (LATM) implemented in 1982, including speed humps, slow points, roundabouts and a 40km speed limit. C) No LATM scheme.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes. Residents opinions on the value of LATM.
Notes	The schemes in Canterbury and Willoughby are both reported in the same paper. Collision data collected from police records.

Sydney-Willoughby 1990

Methods	CBA 2 yrs before data. 2 yrs after data.
Participants	I) Predominantly residential area in Sydney, Australia. C) Selected because of its similar traffic problems to the interventions area. The street network of the control area, however, did not reflect the grid pattern of the study area

Sydney-Willoughby 1990 (*Continued*)

Interventions	I) A LATM scheme with dense coverage of devices including entry thresholds, slow points, speed humps, T-intersection treatments, roundabouts and road closures. C) No LATM.
Outcomes	Road traffic crash related deaths and injuries. All road traffic crashes. Pedestrian crashes. Residents opinions on the value of LATM.
Notes	The schemes in Canterbury and Willoughby are both reported in the same paper

The Netherlands 1992

Methods	CBA
Participants	I) 15 areas throughout the Netherlands C) Built-up areas (excluding arterial roads) of the municipalities where the interventions were situated
Interventions	I) 30 km/h zones including signs, road humps, limited road width, elongated humps, raised sections, traffic islands and refuges, mini roundabouts, turning bans, diagonal closures, and speed humps with special cycle lanes. C) No area-wide traffic calming
Outcomes	Traffic speeds Traffic volumes Road traffic crashes
Notes	Could not extract data

USP Bradford 1989

Methods	CBA 5 yrs before data. 2 yrs after data.
Participants	I) Area in Bradford to the South west of the city centre, with a population of 33,000 in around 12,000 households. The area was mainly residential in generally unplanned street system. C) Area of much the same size and character on the opposite side of the city
Interventions	I) General area wide scheme including: junction redesign, closures of through routes; and installation of central refuges. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. Pedestrian crashes.
Notes	One of the five cities and towns involved in the Urban Safety Project led by the Transport and Road Research Laboratory, UK. Injury data collected from police records.

USP Bradford 1989 (*Continued*)

	No information given on perceived safety or quality of environment

USP Bristol 1989

Methods	CBA 5 yrs before data. 2 yrs after data.
Participants	I) An area covering approximately 10 square km north of central Bristol. In 1981 the population was approximately 32,000 in about 12,000 households. The area is predominantly residential with roughly equal amounts of local authority housing and private housing. C) An area of similar size and character to the south of the city centre
Interventions	I) General area wide scheme including: Junction redesign, Mini-roundabout, Right turn bans, Improvement of pedestrian crossings, Improved road signs and markings, Road closures. C) No area-wide traffic calming.
Outcomes	Road traffic crash related deaths and injuries. Pedestrian crashes.
Notes	One of the five cities and towns involved in the Urban safety project led by the Transport and Road Research Laboratory, UK. Injury data collected from police records. No information given on perceived safety or quality of environment

USP Nelson 1989

Methods	CBA 5 yrs before data. 2 yrs after data.
Participants	I) An area that consists mainly of the town of Nelson (excluding the town centre), covering an area of 7 square km. In 1981 it had approximately 11,400 households with 30,000 people. Many pre-1914 houses in long terraces, some post-1945 local authority housing. Steep hills. C) An area of approximately the same size and character in the adjacent district of Burnley. The centre of Burnley lies about 3 miles to the south of Nelson
Interventions	I) General area wide scheme including: Junction redesign, Road closures, Mini-roundabouts
Outcomes	Road traffic crash related deaths and injuries. Pedestrian crashes.
Notes	One of the five cities and towns involved in the Urban safety project led by the Transport and Road Research Laboratory, UK. No information given on perceived safety or quality of environment

USP Reading 1989

Methods	CBA 5 yrs before data. Nearly 2 yrs after data. A comparable control area in the same city was chosen.
Participants	I) An area to the west of the central commercial area which covers approximately 8 square km. In 1981 area had a population of about 36,000 people occupying 15,000 households. C) An area similar in size to the southeast of the central area
Interventions	I) General area wide scheme including: Road closures, Right turn bans, Mini roundabouts.
Outcomes	Road traffic crash related deaths and injuries. Pedestrian crashes.
Notes	One of the five cities and towns involved in the Urban safety project led by the Transport and Road Research Laboratory, UK. Injury data collected from police records. Modifications to the design of the measures was made in the first 9 months in response to localised increases in the number of accidents. No information given on perceived safety or quality of environment

USP Sheffield 1989

Methods	CBA 5 yrs before data. 2 yrs after data.
Participants	I) An area to the north of the city centre covering approximately 9 square km. In 1981 the population of the area was approximately 50,000 people in about 18,000 houses. The area is mostly residential and consisting largely of local authority housing. C) An area of similar size and character to the south of the city centre
Interventions	I) General area wide scheme including: Road closures, traffic islands, central refuges, additional pedestrian crossings, and turning restrictions. C) No traffic calming measures.
Outcomes	Road traffic crash related deaths and injuries. Pedestrian crashes.
Notes	One of the five cities and towns involved in the Urban safety project led by the Transport and Road Research Laboratory, UK. Injury data collected from police records. No information given on perceived safety or quality of environment

CBA = Controlled-before-after study
I = Intervention
C = Control
LATM = local area traffic management scheme

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Amundsen 1984	Uncontrolled before/after
Brownfield 1980	Uncontrolled before/after
Chick 1994	Uncontrolled before/after
Chua 1991	Uncontrolled before/after
Cloke 1999	Uncontrolled before/after
Cole 1990	Uncontrolled before/after
Drammen Byplankontor 1980	Uncontrolled before/after
Ebbecke 1977	Uncontrolled before/after
Elmberg 1972	Uncontrolled before/after
Engel 1982	Not area-wide traffic calming
Engel 1983	Uncontrolled before/after
Engel 1989a	Not area-wide traffic calming
Engel 1989b	Not area-wide traffic calming
Engel 1990	Not area-wide traffic calming
Fager 1984	Uncontrolled before/after
Faure 1992	Uncontrolled before/after
Fisher 1989	Uncontrolled before/after
Gennaoui 1987	Uncontrolled before/after
Gunnarsson 1992	Uncontrolled before/after
Haakenaasen 1982	Uncontrolled before/after
Hagan 1988	Uncontrolled before/after
Hart 1982	Uncontrolled before/after

(*Continued*)

Heaton 1980	Uncontrolled before/after
HRC 1987	Uncontrolled before/after
HRC 1988	Uncontrolled before/after
Kraay 1984	Unable to locate full text to enable assessment for inclusion
Kuemmel 1983	Uncontrolled before/after
McDonald 1984	Uncontrolled before/after
Meyer 2000	Uncontrolled before/after
Mok 2003	Uncontrolled before/after
Mountain 1989	Uncontrolled before/after
Muskaug 1976	Uncontrolled before/after
Oslo Byplankontor 1978	Uncontrolled before/after
Pau 2001	Uncontrolled before/after
Portland 2000	Uncontrolled before/after
Rimiller 2003	Only evaluated “road diet” interventions
Scottish Exec. 1999	Uncontrolled before/after
Stolen 1988	Uncontrolled before/after
Tester 2004	Case-control
TRL 1997	Uncontrolled before/after
Vreugdenhil 1972	Uncontrolled before/after
Vreugdenhil 1976	Uncontrolled before/after

Characteristics of ongoing studies *[ordered by study ID]*

Towliat

Trial name or title	Stockholm
Methods	CBA
Participants	I) 20 areas in Stockholm and Örebro C) 18 areas in Stockholm and Örebro
Interventions	I) Road cushions, road narrowing, handrails and lampposts at pedestrian and cyclist crossings
Outcomes	traffic speeds motorists-pedestrian/cyclist conflicts motorist behaviour road user opinions
Starting date	1997
Contact information	Lund University, Department of Technology and Society
Notes	

DATA AND ANALYSES

Comparison 1. Area-wide traffic calming versus control

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Road user deaths	1		Rate Ratio (Random, 95% CI)	0.79 [0.23, 2.68]
2 Road user injuries	18		Rate Ratio (Random, 95% CI)	0.85 [0.75, 0.96]
3 Road traffic crashes	12		Rate Ratio (Random, 95% CI)	0.89 [0.76, 1.05]
4 Pedestrian-motor vehicle collisions	1		Rate Ratio (Random, 95% CI)	1.01 [0.88, 1.16]

Analysis 1.1. Comparison 1 Area-wide traffic calming versus control, Outcome 1 Road user deaths.

Review: Area-wide traffic calming for preventing traffic related injuries

Comparison: 1 Area-wide traffic calming versus control

Outcome: 1 Road user deaths

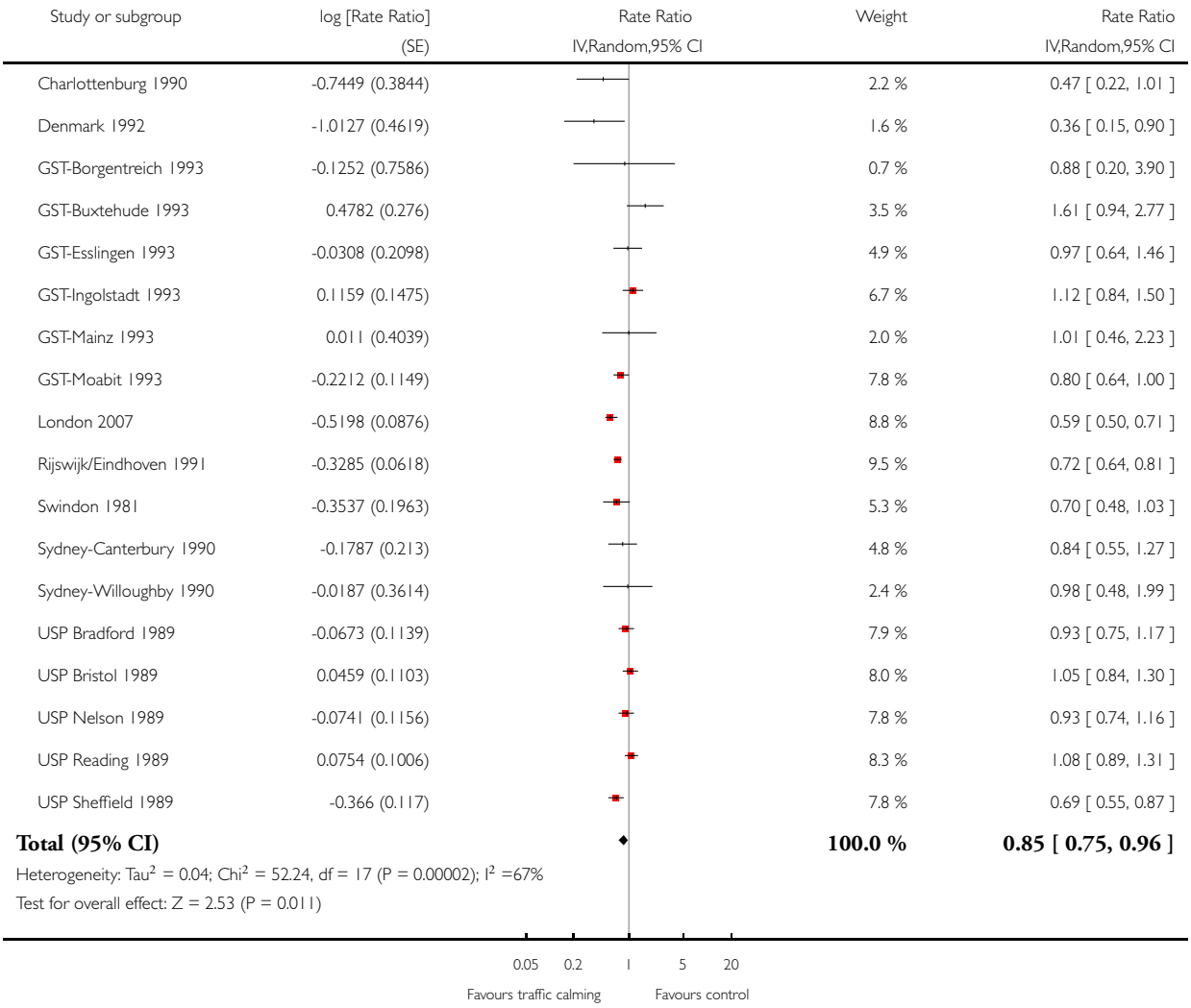
Study or subgroup	log [Rate Ratio] (SE)	Rate Ratio IV,Random,95% CI	Weight	Rate Ratio IV,Random,95% CI
Column totals	-0.2336 (0.6213)		100.0 %	0.79 [0.23, 2.68]
Total (95% CI)			**100.0 %**	**0.79 [0.23, 2.68]**
Heterogeneity: not applicable				
Test for overall effect: Z = 0.38 (P = 0.71)				

Analysis 1.2. Comparison 1 Area-wide traffic calming versus control, Outcome 2 Road user injuries.

Review: Area-wide traffic calming for preventing traffic related injuries

Comparison: 1 Area-wide traffic calming versus control

Outcome: 2 Road user injuries

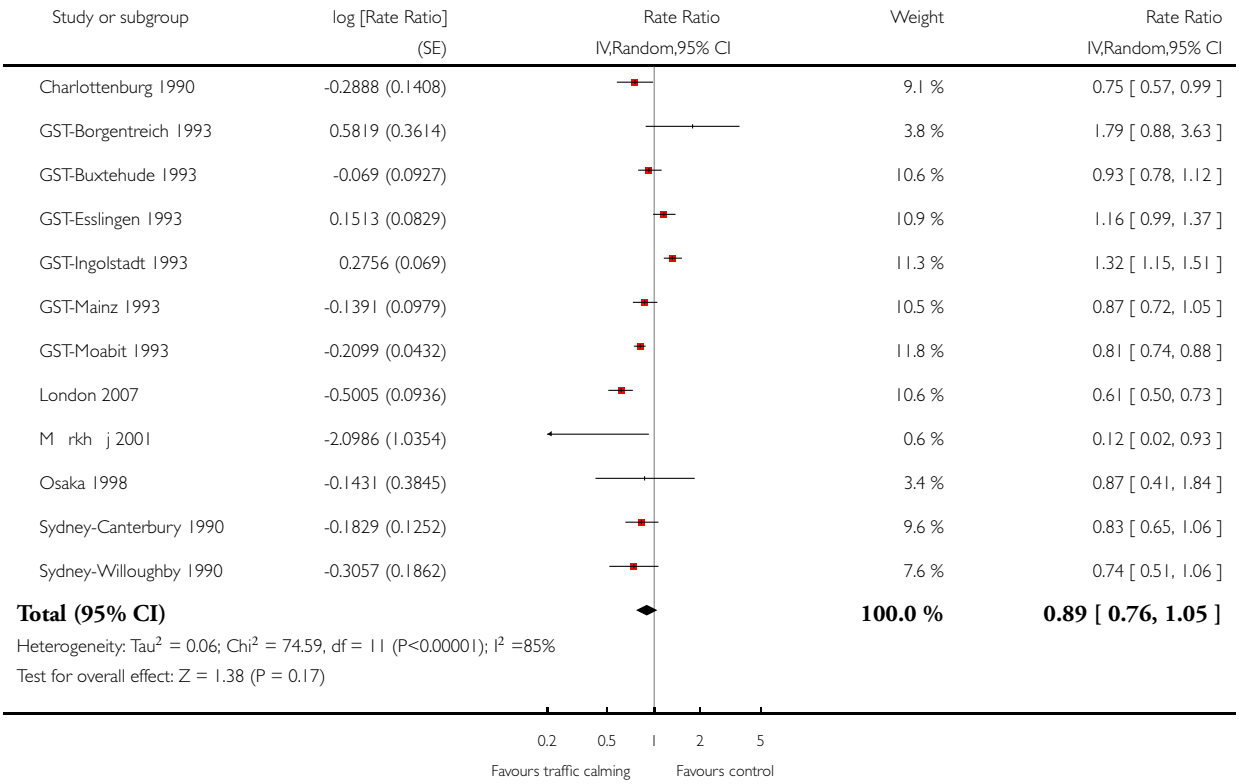


Analysis 1.3. Comparison 1 Area-wide traffic calming versus control, Outcome 3 Road traffic crashes.

Review: Area-wide traffic calming for preventing traffic related injuries

Comparison: 1 Area-wide traffic calming versus control

Outcome: 3 Road traffic crashes

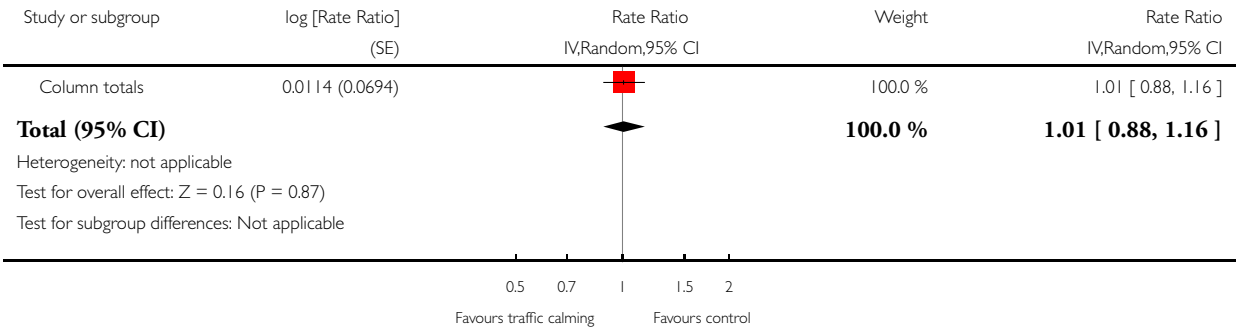


Analysis 1.4. Comparison 1 Area-wide traffic calming versus control, Outcome 4 Pedestrian-motor vehicle collisions.

Review: Area-wide traffic calming for preventing traffic related injuries

Comparison: 1 Area-wide traffic calming versus control

Outcome: 4 Pedestrian-motor vehicle collisions



ADDITIONAL TABLES

Table 1. Road user deaths

Study ID	Intervention before	Intervention after	Control before	Control after	Rate ratio (95% CI)
Denmark	0	1	1	0	Undefined
GST-Moabit	7	3	12	7	0.73 (0.14 to 3.80)
GST-Borgentreich	0	0	0	0	Undefined
GST-Buxtehude	0	0	0	1	Undefined
GST-Esslingen	3	0	3	1	Undefined
GST- Ingolstadt	0	0	0	2	Undefined
GST-Mainz	1	0	0	0	Undefined
Sydney-Canterbury	1	0	2	1	Undefined
Sydney-Willoughby	0	2	1	0	Undefined

Table 2. Road user injuries

Study	Intervention before	Intervention after	Control before	Control after	Rate Ratios (95% CI)
Charlottenburg	31	11	95	71	0.47 (0.22 to 1.01)
Denmark	40	13	19	17	0.36 (0.15 to 0.90)
GST-Borgentreich	17	10	6	4	0.88 (0.20 to 3.90)
GST-Buxtehude	40	41	96	61	1.61 (0.94 to 2,77)
GST-Esslingen	103	90	91	82	0.97 (0.64 to 1.46)
GST-Ingolstadt	185	139	272	182	1.12 (0.84 to 1.50)
GST-Mainz	27	13	63	30	1.01 (0.46 to 2.23)
GST-Moabit	275	228	379	392	0.80 (0.64 to 1.00)
London	387	208	7012	6811	0.55 (0.47 to 0.66)
Rijswijk/Eindhoven	923	458	4453	3069	0.72 (0.64 to 0.81)
Swindon	197	89	115	74	0.70 (0.48 to 1.03)
Sydney-Canterbury	76	73	101	116	0.84 (0.55 to 1.27)
Sydney-Willoughby	74	69	20	19	0.98 (0.48 to 1.99)
USP Bradford	551	190	629	232	0.93 (0.75 to 1.17)
USP Bristol	693	231	647	206	1.05 (0.84 to 1.30)
USP Nelson	539	180	634	228	0.93 (0.74 to 1.16)
USP Reading	714	303	653	257	1.08 (0.89 to 1.31)
USP Sheffield	636	181	520	214	0.69 (0.55 to 0.87)

Table 3. Road traffic crashes

Study	Intervention before	Intervention after	Control before	Control after	Rate Ratios (95% CI)
Charlottenburg	172	115	400	357	0.75 (0.57 to 0.99)
GST-Borgentreich	62	82	23	17	1.79 (0.88 to 3.63)

Table 3. Road traffic crashes (*Continued*)

GST-Buxtehude	537	629	349	438	0.93 (0.78 to 1.12)
GST-Essligen	887	982	434	413	1.16 (0.99 to 1.37)
GST-Ingolstadt	1015	876	957	627	1.32 (1.15 to 1.51)
GST-Mainz	569	473	358	342	0.87 (0.72 to 1.05)
GST-Moabit	1902	2026	2089	2745	0.81 (0.74 to 0.88)
London	322	188	6022	5800	0.61 (0.50 to 0.73)
Mørkhøj	16	1	310	158	0.12 (0.01 to 0.93)
Osaka	45	39	20	20	0.87 (0.41 to 1.84)
Sydney-Canterbury	217	201	312	347	0.83 (0.65 to 1.06)
Sydney-Willoughby	229	271	61	98	0.74 (0.51 to 1.06)

Table 4. Pedestrian-motor vehicle collisions

Study	Intervention before	Intervention after	Control before	Control after	Rate ratios (95% CI)
GST-Borgentreich	3	1	0	0	Undefined
GST-Buxtehude	26	13	24	16	0.75 (0.30 to 1.88)
GST-Esslingen	50	36	12	12	0.72 (0.29 to 1.78)
GST-Ingolstadt	56	32	105	75	0.80 (0.47 to 1.35)
GST-Mainz	13	9	18	7	1.78 (0.53 to 6.02)
GST-Moabit	179	143	179	142	1.10 (0.74 to 1.37)
Osaka	12	6	5	3	0.83 (0.15 to 4.72)
USP-Bradford	174	65	231	78	1.11 (0.75 to 1.62)
USP-Bristol	136	67	170	45	1.86 (1.20 to 2.89)
USP-Nelson	219	80	267	103	0.95 (0.67 to 1.33)
USP-Reading	173	73	116	48	1.02 (0.66 to 1.57)

Table 4. Pedestrian-motor vehicle collisions (*Continued*)

USP-Sheffield	248	68	206	83	0.68 (0.47 to 0.99)
Sydney-Canterbury	9	9	17	20	0.85 (0.28 to 2.63)
Sydney-Willoughby	8	12	1	0	Undefined

APPENDICES

Appendix 1. MEDLINE & EMBASE search strategy

1. traffic restrain$.ab,ti.
2. traffic calm$.ab,ti.
3. traffic engineering.ab,ti.
4. road design$.ab,ti.
5. road layout.ab,ti.
6. local traffic control.ab,ti.
7. traffic distribution.ab,ti.
8. speed cushion$.ab,ti.
9. speed hump$.ab,ti.
10. speed bump$.ab,ti.
11. speed table$.ab,ti.
12. vehicle speed control$.ab,ti.
13. road narrowing.ab,ti.
14. road hierarchy.ab,ti.
15. left turn lane$.ab,ti.
16. ("20" adj4 zone$).ab,ti.
17. ("30" adj4 zone$).ab,ti.
18. or/1-17
19. (Prospective adj1 (study or studies)).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
20. (Program evaluation or evaluation research).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
21. (randomi$ or randomly).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
22. (controlled adj2 (trial or trials or study or studies or experiment$)).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
23. (before adj1 after).ab,ti.
24. (control adj1 group$).ab,ti.
25. (intervention adj1 group$).ab,ti.
26. (experimental adj1 group$).ab,ti.
27. or/19-26
28. 18 and 27

Appendix 2. TRANSPORT search strategy

#1 traffic restrain*
#2 traffic calm*
#3 traffic engineering
#4 road design*
#5 road layout
#6 local traffic control
#7 traffic distribution
#8 speed cushion*
#9 speed hump*
#10 speed bump*
#11 speed table*
#12 vehicle speed control*
#13 road narrowing
#14 road hierarchy
#15 left turn lane*
#16 20 zone*
#17 30 zone*
#18 OR/ #1-#17
#19 randomi* or randomly
#20 controlled near (trial or trials or study or studies or experiment*)
#21 "before and after"
#22 control group*
#23 intervention group*
#24 experimental group*
#25 OR/ #19-#24
#26 #18 AND #25

Appendix 3. CENTRAL search strategy

#1 traffic next restrain*
#2 traffic next calm*
#3 traffic next engineering
#4 road next design*
#5 road next layout
#6 "local traffic control"
#7 traffic next distribution
#8 speed next cushion*
#9 speed next hump*
#10 speed next bump*
#11 speed next table*
#12 "vehicle speed control*"
#13 road next narrowing
#14 road next hierarchy
#15 "left turn lane*"
#16 20 next zone*
#17 30 next zone*
#18 or/1-17

Appendix 4. National Research Register search strategy

(traffic next restrain*) or (traffic next calm*) or (traffic next engineering) or (road next design*) or (road next layout) or (local traffic control) or (traffic next distribution) or (speed next cushion*) or (speed next hump*) or (speed next bump*) or (speed next table*) or (vehicle speed control) or (road next narrowing) or (road next hierarchy) or (left turn lane) or (20 next zone*) or (30 next zone*)

Appendix 5. International Bibliography of the Social Sciences

#1 controlled near (trial* or study or studies or experiment*)
#2 before near after
#3 control* near group*
#4 experiment* near group*
#5 intervention near group*
#6 randomi* or randomly
#7 #1 or #2 or #3 or #4 or #5 or #6
#8 30 near zone*
#9 20 near zone*
#10 left turn lane*
#11 road near (design* or layout or narrow* or hump* or bump* or hierarchy)
#12 speed near (cushion* or bump* or hump* or table* or control* or limit*)
#13 traffic near(calm* or restrain* or engineering or distribution or control*)
#14 #8 or #9 or #10 or #11 or #12 or #13
#15 #7 and #14

WHAT'S NEW

Last assessed as up-to-date: 31 December 2007.

Date	Event	Description
29 April 2009	New search has been performed	The review has been updated with the inclusion of a further six studies, based on searches conducted to January 2008 The inclusion criteria have been amended to include reduced 'speed limit zones' as eligible types of interventions RS contributed to the update of this version of the review.

HISTORY

Protocol first published: Issue 2, 2001

Review first published: Issue 1, 2003

Date	Event	Description
23 September 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

2003 review: FB helped to design the protocol, screened search records, obtained reports, extracted data and wrote the review. IR helped to design the protocol and write the review. TC performed the analyses and commented on the review. CF advised on the analyses and commented on the review. KK extracted data and helped to obtain reports. RW designed the search strategy and helped to design the protocol.

2008 update: RS screened search records, obtained reports, extracted data, updated the analyses and updated the review text. KK extracted data, helped update the analyses and update the review text. TC advised on the data analysis. FB advised on all aspects of the update and commented on the draft updated review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- London School of Hygiene & Tropical Medicine, UK.
- University of Hertfordshire, UK.

External sources

- Medical Research Council, UK.
- Transport for London, UK.

INDEX TERMS

Medical Subject Headings (MeSH)

Accident Prevention; Accidents, Traffic [mortality; *prevention & control]; Automobile Driving; Controlled Clinical Trials as Topic; Safety; Urban Health; Wounds and Injuries [epidemiology; prevention & control]

MeSH check words

Humans