REVIEW ARTICLE

Can we prevent accidental injury to adolescents? A systematic review of the evidence

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Abstract

***Objectives*—As part of the Department of Health strategy *The Health of the Nation*, a systematic review of published and unpublished literature relating to the effectiveness of interventions in reducing accidental injury in the population aged 15–24 years was carried out.**

***Methods*—The literature was reviewed under the standard setting headings of *road, work, home,* and *sports and leisure*, and graded for quality of evidence and strength of recommendation using a scale published in the UK national epidemiologically based needs assessment programme.**

***Results*—The most effective measures appear to be legislative and regulatory controls in road, sport, and workplace settings. Environmental engineering measures on the road and in sports have relatively low implementation costs and result in fewer injuries at all ages. There is little evidence that purely educational measures reduced injuries in the short term. Community based approaches may be effective in all age groups, and incentives to encourage safer behaviour hold promise but require further evaluation. The potential of multifactorial approaches seems greater than narrowly based linear approaches.**

***Conclusions*—Few interventions to reduce injury in adolescents have been rigorously evaluated using good quality randomised controlled trials, and where such evidence is available, fewer have been shown to be definitely worthwhile. Many studies relied on surrogate measures rather than actual injury rates, and substantial issues relating to the efficacy or implementation of preventive measures in adolescent and young adult populations remain unresolved.**

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While injury prevention in children and the elderly has received considerable attention from both researchers and policymakers, adolescents and young adults (those aged 15–24 years) have been relatively neglected. This is surprising, given the popular perception of adolescents as uninhibited and deliberate risk takers. In fact, popular perception has much to be said for it, and the epidemiology of accidents in this age group gives no cause for complacency. For example, rates of death and serious injury among car and motorcycle users increase rapidly after the age of 14, reaching a peak in the early 20s. By contrast, rates among pedestrians and bicycle users fall gradually after the age of 14. Over 80% of accidental deaths in teenagers (aged 15–19 years) are due to road accidents.[1] Nor is the problem confined to the roads. From 1982 to 1993 approximately 190 fatal injuries occurred annually in sporting and leisure activities, and young males aged 15–24 accounted for 32% of these.[2]

As a part of the UK's *The Health of the Nation* strategy,[3] we undertook a systematic review of the evidence on the effectiveness of interventions to prevent injuries in this age group. Our objectives were to identify those interventions that have been shown to be effective in well designed studies, so that their widespread introduction might be encouraged, and to highlight those areas where evidence is weak or non-existent, so that priorities might be set for further research.

Methods

A comprehensive search of the published and unpublished English language literature since 1966 was undertaken. The search strategy included online and CD-ROM databases, as well as approaches to authors, government departments, and voluntary agencies with particular interests in accident prevention in young people.*

Studies of interventions aimed at reducing injuries in 15–24 year olds, or with particular relevance to this age group, were explicitly graded according to the scheme used in the UK epidemiologically based needs assessment programme.[4] Ultimately, the important outcomes that an intervention must achieve are a reduction in accident rates, in the severity of injuries that result from an accident, or both. Many studies in accident research are field trials, laboratory tests, or crash tests, which indicate

*Details of the search strategy are available on request.

what *ought* to happen as a result of the intervention. Evidence on *actual* outcomes can only come from population based studies of an intervention in everyday use. We therefore regarded the strength of recommendations that could be made on the basis of the former types of study as inherently weaker than those based on the latter.

Road users

BICYCLISTS AND MOTORCYCLISTS

Helmet use

A large body of evidence from America, Australia, and the UK suggests that both incidence and severity of head injury are lower in cyclists wearing helmets at the time of an accident, compared with those who are not.[5–14] This effect increases with the robustness of the helmet design.[15]

Existing evidence comes from both cohort and case-control studies that attempt to control for possible confounding factors, the most important of which is severity. Only one study found evidence suggesting that severity may be less in helmet wearers than non-wearers.[11] In that study, helmets wearers suffered both less severe head injury and less severe non-head injury than other cyclists, raising the possibility that helmet wearing is a marker of a 'safer cyclist' or an 'emergency service user' rather than (or as well as) providing protection in its own right. Studies of helmet effectiveness may suffer from a number of biases which are difficult to eliminate.[16]

Legislation making cycle helmet use mandatory has been effective in increasing the proportion of cyclist who wear a helmet, in decreasing numbers of head injured cyclists, and in decreasing the number of bicycle accidents in any kind,[17–21] although the extent to which reduced injuries are related to a fall in bicycle use is unclear. A recent review has examined the effectiveness of educational and legislative strategies to promote bicycle helmet use.[22]

Similarly, legislation on motorcycle helmet use is followed by a reduction in motorcycle fatalities by about 30%, and the experience of some US states shows that repeal is followed by an increase in fatalities of 25–40%.[23–27]

Other measures

Evidence from field trials has shown that reflective clothing may be effective in increasing bicyclist conspicuity under test conditions.[28] Both cycle spacers and reflective jackets proved effective in discouraging close overtaking in normal traffic. However, there are no studies of the effect on injury rates.

Similarly, evidence from field trials suggests that reflective clothing, daytime running lights, and daytime headlight use increase motorcycle conspicuity.[29 30] Unfortunately, comparative studies do not show any effect of daytime headlight use on injury rates or motorcycle fatalities in US states where such use is mandatory.[31 32]

The majority of studies examining the effectiveness of training in reducing motorcycle injury rates have found no effect.[33–38] Although a recent study did find an effect in reducing risk, the size of this effect diminished after two years.[39]

A number of studies have found that trained riders make greater use of protective clothing.[34] It is certainly possible that the results of these studies are attributable to selection bias rather than the effects of the training itself.

Given the evidence available, only two interventions emerge as being clearly effective in reducing death or injury due to bicycle or motorcycle accidents. The first is the use of cycle or motorcycle helmets. The second is almost any legislative intervention imposing new constraints on cycle or motorcycle riders. The effectiveness of individual components of legislation is often uncertain, and injury and fatality numbers may fall simply because the legislation produces a decline in bicycle or motorcycle use. Evidence on other potential interventions is either contradictory or shows small or non-existent effects on injury rates.

OTHER ROAD USERS

Education

While both experience, which cannot be 'taught', and age effects, which might be modifiable by education, affect injury rates,[40] the limited evidence on educational and training interventions indicates that enhanced driver education courses have little or no effect. Reviews in the early literature on the effectiveness of driver education courses[41–43] concur with this finding and with later reviews.[44] A review of 'methodologically sound' studies of post-licence defensive driving courses[45] and a systematic review of 19 methodologically sound studies of driver improvement programs[46] also found no benefits.

Programmes based solely on the provision of information have also been disappointing. School based programmes, rehabilitation for drink-drivers, and education on the effects of catastrophic injury have demonstrated changes in self reported behaviour, attitudes and knowledge,[47–50] but not in objective behavioural change.[48] Studies into the effects of media campaigns on seat belt use have also produced conflicting conclusions.[51 52] This does not necessarily mean that giving information is irrelevant. It may be more helpful to see knowledge as a necessary condition for behavioural change, but insufficient in itself.

Behaviour may be modifiable more directly by providing reinforcement or incentives for changes in the desired direction. Although studies exist reporting positive associations with rewards for safer behaviour in children,[53 54] there is surprisingly little evidence evaluating such inducements in adolescents. However, two studies describing the effects of reductions in bus fares may be especially relevant to young people. Travel by bus or coach is known to be associated with a far smaller risk of injury than travel by typical alternatives for young people, such as pedal cycles and mopeds.[55] Nicholl *et al* showed that gradual reductions in bus fares resulted in an increase in bus travel, rather than alteration in the mode of travel,[56] while Allsop showed that sudden changes in the relative cost of bus travel brought about a change in the mode of travel.[57]

Adolescents tend to see themselves as having a high degree of control over the consequences of their behaviour and as unlikely to suffer the consequence of risky behaviour,[58 59] including car driving at higher than legal speeds or under the influence of alcohol.[60 61] They may have unrealistic beliefs about their skills and may deliberately choose to take risks.[62-64]

In view of this, multifactorial programmes that seek to alter several aspects of adolescents' beliefs, skills, and values may be more effective than those that seek to alter only one aspect. Such programmes, which take a variety of approaches, for example role play (in which participants practice countering peer pressures), encouraging alternative behaviour (using alternative means of transport when drinking), and the development of social norms against drinking and driving, may change knowledge, attitudes, and self reported behaviour.[65 66]

However, programmes that unintentionally enable adolescents to drive at a younger age than they otherwise would may have a negative effect.[67] This suggests that raising the legal driving age may be effective.

Legislation

Studies of legislative interventions reveal numerous possibilities, such as drink-driving legislation, or imposing night time driving curfews on young drivers.

Evidence on the effect of raising the minimum legal driving age comes from cross sectional studies in the US where different states have different minimum ages,[68-71] and consistently shows that age itself, as well as experience, plays a key part in determining accident rates. The studies reviewed universally failed to assess the impact of altering the minimum licensing age on injuries to other road users. As such a change may result in an increase in young motorcyclists, pedal cyclists, and pedestrians, the net effect may be less than has been shown for drivers alone. When the minimum drinking age is raised above 18 years, all the studies identified report a decrease in young driver (and passenger) fatalities.[72-77]

By contrast, evidence for the effectiveness of stricter enforcement of drinking and driving laws, or even random breath testing, is less clear cut, and it is difficult to assess the degree of benefit such measures could provide.[78-80]

A number of states in the US prohibit young people from driving during late evening or early morning hours (curfew laws). Comparisons of rates between these and otherwise similar states suggest that these regulations are effective, and in addition, delay the age at which drivers obtain or seek to obtain driving licences.[81-84]

Engineering

Measures to protect young vehicle occupants by engineering can be subdivided into those involving the environment, such as road humps, and those involving the vehicle, such as safety inspections, or fitting airbags.

There have been numerous environmental measures that have reduced rates but none are specific to the 15–24 age group.[85] The generally positive effects of area wide environmental schemes in five urban safety projects are reviewed in detail elsewhere.[16] All areas showed some reduction in casualties,[86] particularly in child cyclists and motorcyclists — a result also noted in the Netherlands.[87]

With regard to vehicle engineering, the effectiveness of vehicle inspections might be an important issue for younger drivers and passengers who often drive older cars. However, the only trial we identified showed conclusively that, when random roadside testing was present, the addition of periodic testing made no difference to the accident rate.[88]

Home and work

We identified no studies specifically relating to 15–24 year olds in domestic settings. Studies demonstrating the effectiveness of smoke detector programmes are clearly relevant to this age group, however.[89 90]

Our review identified only two examples of intervention studies aimed specifically at young people at work, although in both, unfortunately, evaluation was inconclusive.[38 91]

Community based approaches

Essential elements of a community intervention programme would include involvement in the local community's network, the inclusion of vulnerable groups, and several years for the programme to run.[92] Examples include the European Healthy Cities programmes, a Safe Block project in the USA,[93] a Safety Round project in Sweden,[94] the Corkerhill project in Glasgow,[95] and the campaign against home accidents in Norway.[96] Small scale projects include smoke detector programmes aimed at high risk populations in cities in the USA.[89 90] Compelling cases have been made for such community oriented programmes[92 95 97] mainly because of the 'lack of fit' between most other health promoting strategies and the context in which those targeted live their lives.

Our search identified two community based interventions that reported results of special relevance to the young. The first is a Swedish programme,[98] comparing injury rates in two rural areas and involving the cooperation of local authorites, organisations, and individual citizens. The interventions included changes to the physical environment as well as information, education, and supervision. While there are some methodological difficulties in this study, it is unique in specifically reporting outcomes in the 15–24 year old age group. A fall in injury rates in both home and work settings followed the intervention, although for workplace accidents the fall was not as great among the young as in older age groups.

The second is a non-randomised cohort study, the 'Safe Block' project, involving a poor urban community in Philadelphia.[93] This found that an intervention consisting of home modification, inspection, and education led to a significant improvement in instituting preventive measures and greater knowledge in the intervention group, but it failed to measure injury rates.

The encouraging results from community based approaches, with their inclusion of all age groups and a wide range of outcomes, suggests that a multiagency strategy combining a variety of interventions may be a promising approach to prevention. Evaluation is not straightforward in terms of traditional epidemiological study design, however, because these 'interventions' are often multifaceted and deliberately not restricted to a defined or randomly selected population. Thus community based interventions are not usually amenable to randomised controlled trials. The result is that, while many such projects are established, few are formally evaluated and where evaluation does occur it is likely to be only in qualitative terms. Although a qualitative study is likely to help understand why something does or does not work, even a 'less than rigorous' attempt to measure some of the quantitative outcomes is likely to be better than none at all. Accordingly, whenever community based approaches to accident prevention are being planned, the opportunity to conduct some kind of quantitative evaluation should not be missed.

Sport and leisure

Many studies of particular sports suggest measures necessary to reduce the incidence and severity of injuries.[99-101] Our search revealed relatively few studies relating specifically to young people, however, but because one half of all sports related injuries occur in the age group 16–25 years,[102] *all* the interventions yielded by the search, other than those aimed specifically at children or the elderly, were considered.

RULE CHANGES

Rule changes in some sports have been effective in reducing certain types of injury. Facial and oral injuries were reduced by more than 50% in the period after a rule change in 1962 mandating the wearing of face protectors and mouthguards in American football.[103] Similarly, the introduction of mandatory face protectors in ice hockey in Québec was followed by dramatic decreases in all facial injuries.[104]

Decreases in the number of American footballers suffering permanent quadriplegia were reported after changes were made to the rules governing tackling and spearing, and similarly in rugby union players in the wake of changes to the rules associated with the tackle, scrum, and maul.[105-109] These results may in part be due to decreases in the numbers exposed to risk.

PROTECTIVE DEVICES

Simple protective devices may also be effective. Injury risk in horseriding differs from that in other popular sports in that the risk of sustaining any injury is low but if an injury does occur it is likely to be serious. The serious nature of reported head injuries[109] suggests strongly that helmets should be worn, but horseriding helmets probably provide a lower level of protection than cycle and motorcycle helmets.[110]

Custom made mouthguards can prevent or reduce the severity of injuries to the lips, mouth, and teeth.[111 112] Evidence from laboratory trials suggests that by altering oral structures, mouthguards may provide protection against concussion in players prone to that kind of injury.[113 114] However, one study found no statistically significant differences in oral injuries between wearers and non-wearers of mouthguards.[115] Although substantial reductions in oral injuries followed the introduction of mandatory mouthguards and face protectors in American football, as both devices were introduced at the same time, it is not possible to isolate the specific contribution of each.

In contact sports, like boxing and rugby, the use of mouthguards is advocated but studies to test their effectiveness suffer from poor compliance rates.[116] Reported reasons for non-compliance include attitude, cost, physical discomfort, functional impairment of speech and breathing, difficulties with retention, and durability. Despite calls for the use of mouthguards in children's and adolescent rugby, successful implementation appears unlikely until issues of efficacy, design, and cost are resolved.

Evidence for the efficacy of knee braces in American football is modest, and there are conflicting results with the protective effects demonstrated in some studies being associated with player position.[116-121] There is also evidence to demonstrate that belts are effective in preventing injuries to the back among weightlifters.[122]

Injuries to the ankle account for approximately 16% of all new sports injuries in adults. Prophylactic taping may be effective in primary prevention of injury,[123 124] and enhanced by the use of high top shoes.[125]

Eye injuries represent 0·2% of all sports related injuries and thus do not constitute an area where major public health gains can be expected.[102] Nevertheless, serious eye injuries have been reported in squash,[126] cricket,[127] badminton,[128] and in players of other high risk activities who wear prescription lenses or streetwear spectacles.[129] Face protectors and guards can eliminate most injuries to the face, including eyes, and there is good evidence that eye protectors meeting specified standards prevent injury. Eye protectors are prohibited in two activities which carry high risk of eye injury: boxing and karate.

Collisions with 'the furniture' of the area of play are responsible for approximately 10% of all sports injuries.[102] Accordingly, modifications to the sports environment can result in dramatic reductions in the number of injuries, demonstrated clearly by US studies of modified 'breakaway' bases used in baseball and softball.[130-132]

SPORTS EDUCATION

Studies of the effectiveness of a national mass media health promotion campaign targeted at young people[133] and a controlled trial of a sports injury prevention programme specially designed for schools[134] showed improvements in knowledge and attitude to sports injuries but no effect on injury rates. Similarly, a multi-agency collaboration involving manufacturers and horseriding clubs, and health promotion publicity about the risks of head injury, was successful in raising awareness and increasing sales of horseriding helmets. Unfortunately the impact on helmet use and head injury severity was not reported.[135]

A randomised controlled trial of a standardised package of warm-up and cool down exercises in recreational runners influenced knowledge and attitudes but had no effect on injury rates.[136 137] More encouraging were results from a study of elite Swedish soccer players, which involved a programme of standardised warm-up, ankle taping, particular shoe design, leg guards, and controlled rehabilitation. When administered by medical personnel, the programme reduced injuries by 75%. This fell to 50% when supervised by the coaches.[138]

Conclusions

Few interventions to reduce injury in adolescents have been rigorously evaluated using good quality randomised controlled trials, and where such evidence is available, fewer have been shown to be definitely worthwhile. The most effective measures appear to be legislative and regulatory controls in road, sport, and workplace settings, although in some cases this may be the result of discouraging an activity, rather than making it safer. Environmental engineering measures on the road and in sports are also effective in reducing injury in all age groups and at relatively low cost. While the results reported from community based approaches are encouraging, there is little evidence that purely educational measures reduce injury rates in the short term.

Much injury research uses outcome measures that may not translate into injury rates when a measure is implemented. A good example is the available evidence on the effectiveness of daytime motorcycle headlamp use. Although car drivers colliding with motorcycles frequently report that they 'didn't see' the other road user, and *surrogate* field tests show that daytime headlamp use improved conspicuity, comparative studies of rates in US states with and without daytime motorcycle headlamp regulations offer no evidence of actual benefit.

This review has identified a small number of interventions that should be implemented on a widespread basis immediately, and that would reduce injury rates. For the most part, though, it is clear that there is still a long way to go before we can confidently say what works in preventing accidental injury to 15–24 year olds.

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Most excellent E-codes

A syndicated columnist in the US, Dave Berry, has written a whimsical piece calling attention to the Official Government Classification of Bad Medical Things That Could Happen on Your Vacation, also known as the International Classification of Diseases. He is especially intrigued by the following E-codes: E845, accident in spacecraft; E912, bean in nose; E966, beheaded by guillotine; E906.8, butted by animal; E915, hairball; E912, marble in nose; E906.8, pecked by bird; and E844, my greatest concern, sucked into jet aircraft.