Are we blind to injuries in the visually impaired?
A review of the literature

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Injury Prevention 2002;8:155–160

Objective: To review the literature on the risks and types of injuries associated with visual impairment, and to identify pertinent areas for future research.

Methods: A search of bibliographic databases was conducted in April 2000 for studies published since 1980 and selected studies that met two or more of the following criteria: formal ophthalmic assessment was used; adjustment for confounding variables; large sample size including numbers of visually impaired; and clear definitions and outcomes.

Results: Thirty one studies were selected. The majority of these studies (20) assessed falls (including eight on hip fracture and four on multiple falls), eight studies reported traffic related injuries, and three studies assessed occupational injury. The evidence on falls, which relate predominantly to older people, suggests that those with reduced visual acuity are 1.7 times more likely to have a fall and 1.9 times more likely to have multiple falls compared with fully sighted populations. The odds of a hip fracture are between 1.3 and 1.9 times greater for those with reduced visual acuity. Studies of less severe injuries and other causes of injury were either poorly designed, underpowered, or did not exist.

Conclusions: There are substantial gaps in research on both injuries to which people with visual impairment are especially susceptible and in evaluating interventions to reduce these injuries. It is recommended that in future studies the minimum data captured includes: formal ophthalmic assessment of visual fields and visual acuity, outcome measurement, control for confounders, and the costs of health care resource use and any interventions.

The risk of having an unintentional injury is higher for people who are visually impaired compared with the fully sighted population.1 It is critical that in planning and implementing measures to reduce the risk of injuries occurring in the home, workplace, and the general environment, specific consideration is given to those with visual impairment.

In England in 1999–2000, an estimated 240 000 people were blind and another 421 000 people were partially sighted (that is, 0.48% and 0.85% of the population respectively).2 Because these estimates exclude undiagnosed cases the true blind and partially sighted populations are likely to be much greater.

Intuitively, there are two main reasons why people with visual impairment are more susceptible to injury: they have fewer visual clues to alert them to potential hazards such as oncoming traffic, and home environments and workplaces have not been suitably adapted, for example, with adequate lighting. Also, the risk of falling is exacerbated in certain groups, such as older people, who tend to be more dependent on vision to maintain vertical posture.3

The aim of this study is to review the epidemiological literature on events that can lead to injury, the risk of injury, and the types of injuries sustained due to visual impairment. This study considers English language articles of unintentional injuries in those with visual impairment and excludes injuries associated with visual deficiencies, such as colour blindness or poor night vision.

Because we are interested in epidemiological studies on the incidence of injury due to visual impairment, the associated risk factors, and studies of interventions to reduce the risk of injury associated with visual impairment, we cannot strictly adhere to the guidelines for systematic reviews.5 That guideline focuses on the review and meta-analysis of randomised controlled trials, which only form a small part of this review.
reviewed in depth. For inclusion, all met two or more of the following criteria:

- Objective ophthalmic assessment.
- Adjustment for confounding variables.
- Large numbers of visually impaired.
- Clear reporting of definitions and outcomes.

Objective ophthalmic assessment includes measurement of visual acuity, visual fields, contrast sensitivity, depth perception, or diagnosis of specific eye conditions such as cataract and glaucoma. Subjective reports of visual assessment show low correlations with objective measures such as visual acuity.\(^\text{1,2}\) When comparing the risk of injuries occurring in the visually impaired with the fully sighted, there are likely to be other factors associated with visual impairment that increase the chances of injury (that is confounders). For example, as people age they are more likely to have impaired vision and they are more likely to have multiple falls as an outcome that adjusted for confounding variables.

Outcomes

The outcomes identified in the articles are measures of association between the risk of injury and visual impairment. Statistical measures of association used in the studies include relative risk (RR), odds ratios (OR), and prevalence ratios (PR).

RESULTS

After removing duplicate records across the databases, 471 articles were identified. A manual search of the titles and abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. Exclusion at this stage included studies that investigated an abstracts identified 250 of these articles as irrelevant. 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confounding variables and used formal opthalmic assessment. The evidence from the studies that used self reported vision gave equivocal evidence about an association between occupational injuries and visual impairment (table 2). 24-25

### Risk of traffic related injuries due to visual impairment

No studies assessed the risk of pedestrian injuries, or of injuries sustained while using public transport that met our criteria. One was identified that assessed the risk of pedestrian injuries in children due to visual impairment where vision was self reported (table 3). 26 This study found children with poor vision had a fourfold greater risk of pedestrian injury than those with full vision. However, whether the child's vision was corrected or uncorrected was not reported.

Seven studies were identified that evaluated the association between visual impairment and risk of traffic injuries (table 3). 27-33 Associations were found between crash risk and visual field loss, 27-29 minimal visual acuity and lack of binocularity, 30 and glaucoma. 31 Cataract was associated with increased at-fault traffic crashes, 32-33 but diminished visual acuity alone and contrast sensitivity were not found to be associated with crash risk. 28-30, 34-35 The associations were weak largely due to the studies being underpowered to detect significant effects, 29 to selection bias, 30 or to risk compensation. 32-35

The full effect of visual impairment on driving performance may not be recognised, because many studies have reported that certain features of visually impaired individuals' driving
behaviour may compensate for risk. People who were visually impaired were reported to drive less, take fewer risks when driving, only drive in daylight and in familiar areas. Although poorer driving performance is recognised in drivers with impaired vision, this does not translate into increased crash rates or injuries compared with other drivers.

**DISCUSSION**

The most salient feature is the lack of sound epidemiological studies of injury associated with visual impairment. Even more conspicuous is the absence of intervention studies. Studies of injury associated with visual impairment, such as screening or detection of visual impairment, appropriate treatment, and environmental modifications are needed. To judge the effectiveness of an intervention study, the outcome should be injuries (or injuries averted) rather than improvement in vision. These types of studies are an obvious omission from public health research agendas—a point we return to later.

Studies that investigated the association between visual impairment and the risk of injury, which adjusted for confounding variables and formally measured visual impairment, were identified primarily in the falls literature. These varied in the types of visual impairment measured and the eye disorders investigated. Poor depth perception and reduced ability to perceive contrast are prevalent in conditions such as cataracts, glaucoma, and diabetic retinopathy. Some studies that used formal ophthalmic assessment investigated the risk of injury by specific eye condition. The prevalence of potentially reversible impaired vision in hospital inpatients admitted after a fall is high. Therefore, diagnosis and treatment of ocular disease is a prevention strategy that deserves further investigation.

Evidence on the association of diabetes with falls and hip fractures is inconclusive. The primary reason for this was poor case selection. In some studies, subjects with diabetes were included irrespective of the degree of retinopathy or visual impairment. In another study, subjects with diabetic retinopathy were compared with fully sighted controls without measuring the severity of retinopathy or visual impairment.

Where appropriate measures of severity of eye disease were used, for example visual acuity, the sample size was too small to draw conclusions. Sample size is a major problem. For example, in a study of over 2000 subjects, there were four hip fractures in 47 patients with diabetic retinopathy. This, and other similar studies are typically underpowered to detect significant effects. Unless large initial samples are obtained, subgroup analyses are insufficiently powered.

A further issue is the need to control for confounders within subgroups. For example, there are many complications with diabetes other than visual, such as peripheral neuropathy. Consequently, in future subgroup analyses (for example, for

<table>
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<tr>
<th>Reference</th>
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<th>Ophthalmic assessment</th>
<th>Adjustment for confounding variables</th>
<th>Key results</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Cohort (R) using the Health and Retirement Study (HRS)</td>
<td>n=6854, aged 51–61</td>
<td>Self report</td>
<td>Yes</td>
<td>Odds of occupational injury: increased for those with poor sight OR 1.53 (95% CI 1.11 to 2.09)</td>
</tr>
<tr>
<td>24</td>
<td>Cohort (R) using the National Health Interview Survey (NHIS)</td>
<td>n=459, 827, aged 18–65</td>
<td>Self report</td>
<td>Yes</td>
<td>Odds of occupational injury: increased for the blind OR 3.21 (95% CI 1.32 to 7.85), but not for the visually impaired OR 1.37 (95% CI 0.87 to 2.17)</td>
</tr>
<tr>
<td>53</td>
<td>Cohorts (R) reanalysis Participants in the NHIS and HRS</td>
<td>Self report</td>
<td>Yes</td>
<td>Odds of occupational injury: increased in subjects with poor vision in HRS study OR 1.48 (95% CI 1.07 to 2.06), but not in NHIS study OR 2.42 (95% CI 0.77 to 7.60)</td>
<td></td>
</tr>
</tbody>
</table>

| Abbreviations: (P) prospective study, (R) retrospective study, CI, confidence interval; OR, odds ratio. |

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Table 3  Traffic injuries and visual impairment

<table>
<thead>
<tr>
<th>Reference</th>
<th>Research methods</th>
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</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Cohort (R)</td>
<td>n=294, aged 55+</td>
<td>Formal</td>
<td>Age/crash frequency only</td>
<td>Driver crash risk: drivers with substantial visual field loss were 6 times more likely to have incurred 1 or more crashes. Other vision measures were poor predictors of crash risk.</td>
</tr>
<tr>
<td>28</td>
<td>Case-control</td>
<td>n=1400, 2636, aged 70+</td>
<td>Formal</td>
<td>Yes</td>
<td>Driver crash odds: visual acuity was not a significant predictor of accident risk</td>
</tr>
<tr>
<td>29</td>
<td>Cohort (P)</td>
<td>n=2739, aged 49+</td>
<td>Formal</td>
<td>Yes</td>
<td>Driver crash risk: neither visual acuity nor ability to see contrast in the best eye were significantly associated</td>
</tr>
<tr>
<td>30</td>
<td>Case-control (review)</td>
<td>aged 55+</td>
<td>Formal</td>
<td>Yes</td>
<td>Driver crash odds: useful field of view between 41%-60%, the injurious crash risk OR 16.5 (95% CI 5.8 to 47.3), glaucoma OR 3.6 (95% CI 1.0 to 12.6). Other vision measures were not significantly associated</td>
</tr>
<tr>
<td>31</td>
<td>Case-control</td>
<td>n=279 cases, aged 55+</td>
<td>Formal</td>
<td>Yes</td>
<td>Driver crash risk: relative risk of being a crasher in the prior 5 years compared to non-crashers with cataract RR 2.48 (95% CI 1.00 to 6.14)</td>
</tr>
<tr>
<td>26</td>
<td>Case-control</td>
<td>n=177, 471, children</td>
<td>Reported abnormal vision</td>
<td>Reported</td>
<td>Pedestrian injury odds: the adjusted odds ratio for the risk of injury abnormal vision was OR 4.25 (95% CI 1.68 to 10.8)</td>
</tr>
<tr>
<td>32</td>
<td>Cohort (R)</td>
<td>n=1878, aged 65+</td>
<td>Formal</td>
<td>Yes</td>
<td>Driver crash risk: visual field was the only vision variable associated with crash involvement OR 1.33 (conference abstract only available)</td>
</tr>
<tr>
<td>33</td>
<td>Case-control</td>
<td>n=107, adults</td>
<td>Informal</td>
<td>Yes</td>
<td>Driver crash odds: did not have significantly higher on-road accident rates</td>
</tr>
</tbody>
</table>

| Abbreviations: (P) prospective study, (R) retrospective study; CI, confidence interval; OR, odds ratio; RR, relative risk. |
people with diabetes), confounding factors (such as complications), as well as levels of visual impairment, should be measured and controlled.

This issue of confounders is reflected in studies of occupational injuries. The studies reviewed here were inconclusive, as results from two major studies were contradictory. Although differences in the measures of self-reported poor vision may go some way to explaining the differences in results, it is more likely to be the result of differing risks in various workplaces. There was a lack of information about the environmental adaptations of workplaces to meet the need of people with visual impairment. These need to be considered in studies of occupational injuries.

Petersen et al. found a significant association between increased risk of falling and posterior subcapsular cataract PR 2.1 (95% CI 1.0 to 4.3) compared with no opacity in best eye, but no association with other types of cataract. Drivers with cataracts were four times more likely to report difficulty with challenging driving situations and were 2.5 times more likely to have a history of at-fault crash involvement. Posterior subcapsular cataract is the most common type of cataract in patients presenting for cataract surgery (60.6% of patients), and therefore, this is a treatable risk factor.

Studies of hip fracture showed differences in visual risk factors, such as visual acuity. Dargent-Molina et al. hypothesise that the discrepancy between their findings and that of Cummings et al. may be due to the difference in mean age in the two cohorts (80.5 vs 72.0). Dargent-Molina et al. suggest that in a younger cohort the decline in depth perception and contrast sensitivity may be early indicators of visual impairment—before visual acuity is affected, whereas in an older cohort the decline in visual acuity may be the factor that best shows the cumulative effect of both age related and disease related visual deficits.

There is a wide body of research that has investigated preventative interventions to reduce the risk of falling, but not specifically in relation to the population with visual impairment. There is strong evidence that visual impairment is a risk factor for falls, and the recent UK guidelines submitted to the UK Department of Health and the American and British Geriatric Societies guidelines on fall prevention advocate assessment of visual impairment. However, there is no trial evidence that reducing visual impairment reduces falls, although there does exist a multifactorial intervention trial, which was successful in reducing falls, where assessment of multiple risk factors with tailored intervention included visual impairment.

In the population aged 65 years and over, 30% are visually impaired. Visual impairment is potentially treatable in 75% of cases, but in the UK, only one quarter of those with visual impairment have contact with eye services. Therefore, many of the consequences of visual impairment, such as injurious falls, could be prevented and the economic and human impact reduced.

Effective vision screening programmes with appropriate treatment are required to adequately identify and treat the target population. A recent systematic review of randomised controlled trials of vision screening concluded that there is no evidence that community based screening of older people results in improvements in vision. The use of questions about visual problems as a screening tool, and the lack of clear plans for intervention were proposed as explanations for the lack of effectiveness. Furthermore, the cost of spectacles may deter people from attending an optometrist or from obtaining glasses. Therefore, a vision screening programme requires careful design with objective measures and appropriate treatment to be available.

There is need for further research into the epidemiology of the relative risk of injury for the visually impaired in many injury prevention areas such as pedestrians and work place injuries. Where there is evidence of increased risk to those with visual impairment there is a need to develop and assess the effectiveness of interventions. Interventions may include visual screening/assessment, treating the visual impairment where possible, and modifying the environment.

ACKNOWLEDGEMENTS

We are grateful for the funding received from the Royal National Institute for the Blind and Lilly Global Economic Affairs. One of the authors (CC) acknowledges salary support from the South East Regional Office of the Department of Health. The NHS Centre for Reviews and Dissemination provided assistance with developing search strategies and searching electronic databases. The Royal Society for the Prevention of Accidents, Linda Forsén (Norwegian Institute of Public Health), Ian Roberts (Paediatric Epidemiology and Biostatistics Unit at the Institute of Child Health London), and Robyn Norton (Institute of Child Health, University of Sydney) gave useful advice. Comments received from Tessa Martin-Kennedy and Jessamy Watkins (Lilly, Global Economic Affairs) on previous drafts were appreciated.

Lilly Global Economic Affairs and the Royal National Institute for the Blind funded the study.

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