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

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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 field 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. 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). 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.

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. That guideline focuses on the review and meta-analysis of randomised controlled trials, which only form a small part of this review.

Abbreviations: CI, confidence interval; OR, odds ratio; PR, prevalence ratios; RR, relative risk
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.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 at increased risk of falling.3 The use of visual ability as a confounding factor for falls.4 However, this is a crude proxy for reduced visual fields or loss of peripheral vision. In future studies it would be better to objectively measure functional impairment (for example, visual fields), in both patients who are treated for glaucoma and in those who are undiagnosed/untreated.

Multiple fallers are an important subset as there are implications for resources. These are more likely to be transferred to nursing homes after falling compared with single fallers and, in addition, are likely to be hospitalised for longer periods.5

### 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 outcome that adjusted for confounding variables and used formal ophthalmic assessment or did not adjust 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 outcome that adjusted for confounding variables and used formal ophthalmic assessment or did not adjust for confounding variables.

Of the remaining 221 articles, only 31 were identified that met two or more of the selection criteria. Many articles were excluded, as although they met the selection criteria, they were review or discussion articles where no analytical study had been undertaken. The 31 studies were separated into categories according to cause and setting. Injury categories used are falls and fall related fractures (20), occupational injuries (3), and traffic injuries (8). No analytical studies were identified that assessed the risk of injury in other areas including the home, poisoning, burns, and electrical injuries.

### Falls and visual impairment

The studies on falls vary with respect to the type of fall. Some include all people who had any type of fall within a specific period. Others explore the characteristics of people who have fallen more than once within a specified time period. Finally, there are studies that assess serious fall injury, such as fracture to the wrist or hip.

#### General falls

Of the 20 studies, 14 addressed visual impairment and all falls, irrespective of injury (table 1). Of these, only one adjusted for confounding variables and measured visual impairment across a large cohort.6 It found a positive association between falling and visual impairment in people over 75 years of age, with the adjusted RR 1.7 (95% confidence interval (CI) 1.2 to 2.3).11

#### Multiple falls

The Blue Mountains Eye Study is the only large cohort study we identified with multiple falls as an outcome that adjusted for confounding variables and used formal ophthalmic assessment to measure visual impairment.7 It revealed significant associations between posterior subcapsular cataract PR 2.1 (95% CI 1.0 to 4.3), the use of non-miotic glaucoma medication PR 2.0 (95% CI 1.1 to 3.6), visual acuity worse than 20/30 PR 1.9 (95% CI 1.2 to 3.0), and poor contrast sensitivity PR 1.2 (95% CI 1.1 to 1.3) with multiple falls.

The Arfken et al study predominantly used subjective reports of visual impairment and showed no difference between those with visual impairment and those without.8 This study illustrates the need for objective measures of visual impairment as it also showed a low correlation between objectively measured visual acuity and self reported visual disabilities (for example, a correlation coefficient of 0.12 for visual acuity and difficulty watching television).

The use of glaucoma medication was identified as a significant proxy risk factor for falls.9 However, this is a crude proxy for reduced visual fields or loss of peripheral vision. In future studies it would be better to objectively measure functional impairment (for example, visual fields), in both patients who are treated for glaucoma and in those who are undiagnosed/untreated.

Multiple fallers are an important subset as there are implications for resources. These are more likely to be transferred to nursing homes after falling compared with single fallers and, in addition, are likely to be hospitalised for longer periods.10

### Fall related fracture

Seven studies were identified that assessed the risk of hip fracture and one assessed the risk of Colles fracture. Falls account for approximately 90% of hip fractures.11 Therefore, the hip fracture studies may include events other than falls.

#### Hip fracture

Studies with hip fracture as the outcome are intrinsically methodologically more sound than many of the studies described earlier. These studies do not rely on subjective recall of previous injury since hip fracture almost always requires admission to hospital.

There were four cohort studies that assessed the risk of hip fracture due to impaired vision that adjusted for confounding variables and used formal ophthalmic assessment.12,17 A significant association was found between visual acuity and risk of hip fracture in three out of the four studies (95% CI’s range 1.3 to 1.9). In a study of women aged 65 years and older, both poor depth perception and reduced ability to perceive contrast (but not poor visual acuity) were found to increase the risk of hip fracture independently.15 The relative risk of hip fracture for the low distant depth perception was 1.4 (95% CI 1.0 to 1.9) and low contrast sensitivity RR 1.2 (95% CI 1.0 to 1.5).16

In a further three case-control studies, which either did not use formal ophthalmic assessment or did not adjust for confounders, statistically significant associations between visual impairment and hip fracture were found.17–19

#### Colles fracture (fractured wrist)

No studies were identified that assessed the risk of Colles fracture due to impaired vision, that adjusted for confounding variables, and used formal ophthalmic assessment. However, one was identified that assessed the unadjusted association between having a wrist fracture for people with impaired vision.20 The authors found that the wrist fracture group had better eyesight than the control group (p=0.022). The authors suggest that individuals with better eyesight may be more likely to stretch their arm back to break a fall, and hence have an increased risk of sustaining a fractured wrist. However, not only was there no adjustment for confounding factors, the power of this study was low.

### Risk of occupational injury due to visual impairment

No studies were identified that assessed the risk of occupational injuries due to impaired vision, that adjusted for

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**Footnotes:**
1. Legood, Scuffham, Cryer
2. A significant association was found between visual acuity and risk of hip fracture in three out of the four studies (95% CI’s range 1.3 to 1.9). In a study of women aged 65 years and older, both poor depth perception and reduced ability to perceive contrast (but not poor visual acuity) were found to increase the risk of hip fracture independently. The relative risk of hip fracture for the low distant depth perception was 1.4 (95% CI 1.0 to 1.9) and low contrast sensitivity RR 1.2 (95% CI 1.0 to 1.5).
3. In a further three case-control studies, which either did not use formal ophthalmic assessment or did not adjust for confounders, statistically significant associations between visual impairment and hip fracture were found.
4. No studies were identified that assessed the risk of Colles fracture due to impaired vision, that adjusted for confounding variables, and used formal ophthalmic assessment. However, one was identified that assessed the unadjusted association between having a wrist fracture for people with impaired vision. The authors found that the wrist fracture group had better eyesight than the control group (p=0.022). The authors suggest that individuals with better eyesight may be more likely to stretch their arm back to break a fall, and hence have an increased risk of sustaining a fractured wrist. However, not only was there no adjustment for confounding factors, the power of this study was low.
confounding variables and used formal ophthalmic 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).

### 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 corrected or uncorrected was not reported.

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

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. Intervention studies, 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 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 2** Occupational injuries and visual impairment

<table>
<thead>
<tr>
<th>Reference</th>
<th>Research methods</th>
<th>Study group</th>
<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</td>
<td>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>
</tr>
</tbody>
</table>

**Table 3** Traffic injuries and visual impairment

<table>
<thead>
<tr>
<th>Reference</th>
<th>Research methods</th>
<th>Study group</th>
<th>Ophthalmic assessment</th>
<th>Adjustment for confounding variables</th>
<th>Key results</th>
</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 with crashes. Other vision measures were not significantly associated with crash risk</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 with crash risk</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 3 years compared to non-crasher 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>Yes</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.

Injuries in the visually impaired

<table>
<thead>
<tr>
<th>Key points</th>
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<tbody>
<tr>
<td>• The risk of unintentional injury, especially due to falls, is higher for those with visual impairment than the general population.</td>
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<tr>
<td>• Other than the falls literature, there are few sound epidemiological studies on visual impairment and occupational injury or traffic related injury; and there are none relating to other cause/settings categories.</td>
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<tr>
<td>• No single intervention studies were identified that developed and evaluated interventions to reduce the risk of injuries in those with visual impairment.</td>
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<tr>
<td>• The effects of vision testing and appropriate referral/treatment in multifactorial intervention studies cannot be disentangled from non-visual related interventions.</td>
</tr>
<tr>
<td>• Studies on vision interventions that use injury as the end point are needed.</td>
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</table>

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.

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