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Associations between vision impairment and vision-related interventions on crash risk and driving cessation: systematic review and meta-analysis

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ABSTRACT

Objectives To systematically investigate the associations between vision impairment and risk of motor vehicle crash (MVC) involvement, and evaluate vision-related interventions to reduce MVCs.

Design Medline (Ovid), EMBASE and Global Health electronic databases were systematically searched from inception to March 2022 for observational and interventional English-language studies. Screening, data extraction and appraisals using the Joanna Briggs Institute appraisal tools were completed by two reviewers independently. Where appropriate, measures of association were converted into risk ratios (RRs) or ORs for meta-analysis.

Participants Drivers of four-wheeled vehicles of all ages with no cognitive declines.

Primary and secondary outcomes MVC involvement (primary) and driving cessation (secondary).

Results 101 studies (n=778 052) were included after full-text review. 57 studies only involved older drivers (≥65 years) and 85 were in high-income settings. Heterogeneity in the data meant that most meta-analyses were underpowered as only 25 studies, further split into different groups of eye diseases and measures of vision, could be meta-analysed. The limited evidence from the meta-analyses suggests that visual field defects (four studies; RR 1.51 (95% CI 1.23, 1.85); p<0.001; I^2=46.79%), and contrast sensitivity (two studies; RR 1.40 (95% CI 1.08, 1.80); p=0.01, I^2=0.11%) and visual acuity loss (five studies; RR 1.21 (95% CI 1.02, 1.43); p=0.03, I^2=28.49%) may increase crash risk. The results are more inconclusive for available evidence for associations of glaucoma (five studies, RR 1.27 (95% CI 0.67, 2.42); p=0.47; I^2=93.48%) and cataract (two studies RR 1.15 (95% CI 0.97, 1.36); p=0.11; I^2=3.96%) with crashes. Driving cessation may also be linked with glaucoma (two studies; RR 1.62 (95% CI 1.20, 2.19); p<0.001, I^2=22.45%), age-related macular degeneration (AMD) (three studies; RR 2.21 (95% CI 1.47, 3.31); p<0.001, I^2=75.11%) and reduced contrast sensitivity (three studies; RR 1.30 (95% CI 1.05, 1.61); p=0.02; I^2=63.19%). Cataract surgery halved MVC risk (three studies; RR 0.55 (95% CI 0.34, 0.92); p=0.02; I^2=97.10). Ranibizumab injections (four randomised controlled trials) prolonged driving in persons with AMD.

Conclusion Impaired vision identified through a variety of measures is associated with both increased MVC involvement and cessation. Cataract surgery can reduce MVC risk. Despite literature being highly heterogeneous, this review shows that detection of vision problems and appropriate treatment are critical to road safety.

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STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is an up-to-date systematic review capturing literature on a variety of eye diseases and conditions, measures of vision such as visual acuity, contrast sensitivity, glare sensitivity and visual field, and vision-related interventions and their associations with motor vehicle crash involvement and driving cessation.
⇒ There were no geographical or age restrictions placed on the population of focus allowing the global impact of vision impairment on driving to be documented for all age groups.
⇒ Meta-analysis was limited due to heterogeneity in the outcome measures reported and the definitions of vision loss and or impairment used in each study. This heterogeneity also prohibited subgroup analyses by age and geographical location.
⇒ Only statistical heterogeneity was assessed and not clinical or methodological.
⇒ Publication bias was not assessed as there were less than 10 studies included in each meta-analysis.

INTRODUCTION

Globalisation and economic development have made driving one of the main modes of transport worldwide and passenger vehicle

travel is predicted to triple between 2015 and 2050.[1] Driving allows for independent mobility and enhances access to employment and education. Unfortunately, with more drivers on the roads, motor vehicle crashes (MVCs) and road traffic injuries are increasing worldwide. Approximately 1.35 million MVC-related fatalities occur each year with an additional 20–50 million people experiencing road-related injuries per annum.[2] The United Nations (UN) has therefore created targets within the Sustainable Development Goals (SDGs) which aim to halve road deaths by 2020 (target 3.6) and provide safe and sustainable transport systems for vulnerable road users (target 11.2).[3]

Driving is a common and valued activity for many adults. Driving cessation limits independent mobility and has been linked to depressive symptoms and poorer health in older adults.[4] Functional declines in vision disproportionately impact older drivers, as they have higher prevalence of poor vision and eye diseases.[5 6] Some countries have specific licensing requirements for older drivers[7]; however, variations in visual driving standards across jurisdictions have made it difficult to assess whether these standards have safety benefits.[8]

This review was completed in collaboration with the *Lancet Global Health* Commission on Global Eye Health[9] and aimed to systematically evaluate the evidence to (1) investigate the associations between vision impairment and risk of MVC involvement across the lifespan, and (2) evaluate vision-related interventions to reduce MVCs. Since risks can be mitigated by driving retirement, this review also considered driving cessation as a secondary outcome.

METHODS

This systematic review was reported using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[10] (online supplemental appendix 1) using a published protocol.[11] An electronic database search on Medline (Ovid), EMBASE and Global Health was conducted from their inception to March 2020, and then updated in March 2022, with no geographical restrictions. Online supplemental appendix 2 details the search strategy with table 1 describing the inclusion and exclusion criteria for studies.

The population of focus was drivers of four-wheeled motorised vehicles, of all ages, with no cognitive declines. Exposures of interest included eye diseases (eg, glaucoma, cataract, age-related macular degeneration (AMD), diabetic retinopathy (DR)) and conditions (eg, refractive errors), and measures of vision such as, but not limited to, visual acuity (VA) and contrast sensitivity (CS). Studies reporting on interventions focused on treatments that would improve vision. The primary outcome measure was MVC involvement identified from self-reported surveys or government/hospital administrative datasets. The secondary outcome was self-reported driving cessation. Due to the large volume of data collected, other surrogate measures of driving safety and driving performance planned in the original protocol were beyond the scope of this manuscript but will be reported in a separate systematic review.[11] Studies which used simulators or investigated self-regulatory driving behaviours (eg, night driving avoidance) through surveys were excluded.

All titles, abstracts and full texts were reviewed independently by two investigators using Covidence systematic review management software (Covidence non-profit SaaS Enterprise, Melbourne, Australia). All discrepancies were resolved via consultation with a third investigator. Similarly, data extraction was completed independently by two investigators using data extraction forms adapted from either the Joanna Briggs Institute (JBI) templates for observational and systematic review study designs, or Cochrane templates for interventional studies. Data extracted from the studies included design, participant and setting characteristics, exposure type and definition,

Table 1 Study inclusion and exclusion criteria

Inclusion	Exclusion
► Interventional (RCTs) and observational (cohort, cross-sectional, case–control and case series) studies ► Systematic reviews with meta-analyses ► Studies on drivers of four-wheeled motorised vehicles of all ages ► Studies looking at the following exposures of interest: impairment in measures of vision (visual acuity, contrast sensitivity, visual field and glare sensitivity) or specific eye conditions including but not limited to glaucoma, cataracts, age-related macular degeneration, diabetic retinopathy, stereopsis disorders and colour vision deficiencies ► Studies on interventions such as vision screening, refractive correction, cataract surgery, anti-VEGF injections and other treatments to improve vision	► Literature reviews and narrative systematic reviews ► Commentary articles, dissertations, abstracts, editorials and conference presentations ► Studies using simulators or investigated either self-regulatory driving behaviours (eg, night driving avoidance), or self-reported measures of driving safety ► To narrow the scope of the study, studies on populations with specific non-vision-related medical conditions (eg, dementia, epilepsy, stroke and history of medical events such as syncope), low vision or vision difficulties caused by other medical conditions (eg, hemianopia caused by brain damage) ► Studies which simulated vision impairment

anti-VEGF, anti-vascular endothelial growth factor; RCTs, randomised controlled trials.

intervention details (if any), outcome measures and relevant effect measures.

Overall risk of bias for all included studies was assessed by two investigators independently with conflicts resolved by a third investigator. All quality assessments were conducted using the relevant JBI critical appraisal tools.[12] Each question on the relevant tools was categorised into either selection, detection, confounding, validity, performance, attrition or allocation bias by all authors. Thus, a range of biases were considered appropriate to this research question. Each study was given an overall 'score' on each question answered where a higher score represented less bias in the study design and execution. Based on how the questions were asked, a 'yes' indicated that some sort of measure to limit bias was undertaken. The final scores were used to assign each study as low, medium or high risk of bias, with lower scores indicating higher risk of bias.

Statistical analysis

Associations between vision impairments and vision-related interventions with MVC involvement and driving cessation were summarised with appropriate HRs, risk ratios (RRs) or ORs. Narrative summaries were reported using the Synthesis Without Meta-analysis guidelines.[13] Heterogeneity across studies was assessed using I^2 statistic. Meta-analysis was conducted by converting all effect measures into RR or OR. Random-effects meta-analysis was only conducted on studies which presented data with the same outcomes, exposures and comparators, and which reported on associations adjusted for confounders to reduce bias. Data from case–control studies were not pooled for meta-analysis to minimise possible heterogeneity. No publication bias analysis was conducted as there were less than 10 studies in each meta-analysis. Reporting of the results was guided by the Meta-analysis of Observational Studies in Epidemiology guidelines.[14] All analyses were completed using STATA V.17.

Patient and public involvement

Only existing published literature was looked at in this review and therefore no patient or public involvement was present during the design or execution of the review. Public participation may be sought out for future dissemination of this review.

RESULTS

From the electronic database search, 5111 studies were identified after the removal of 2131 duplicates. After title and abstract screening, 243 studies remained for full-text review after which 142 studies were further excluded, leaving 101 studies for data extraction (figure 1).

Sixty-three studies (31 cross-sectional, 19 cohort, 12 case–control and 1 systematic review with meta-analysis) reported on MVC involvement alone, 34 (21 cross-sectional, 8 cohort, 2 case–control, 1 case series and 2 randomised controlled trials (RCTs)) on driving cessation, and 4 (1 cross-sectional, 2 cohort and 1 case–control) on both MVC and cessation. When split by geographical regions, 48 studies from high-income countries (HICs) and 15 studies from low/middle-income countries (LMICs) reported solely on MVC involvement, while all 34 studies looking at driving cessation only came from HICs. From the studies which reported on both MVC and driving cessation, only one was from an LMIC. Study breakdown according to driving outcome and vision impairment is shown in tables 2 and 3. The majority of studies (84%) were set in HICs and 57 studies (56%) focused on older adults. However, when looking at the 16 studies set in LMICs, all but 2 had an average study population age of less than 65 years. From the total 101 studies, only 13 (7 from HICs, 6 from LMICs; 12 cross-sectional,

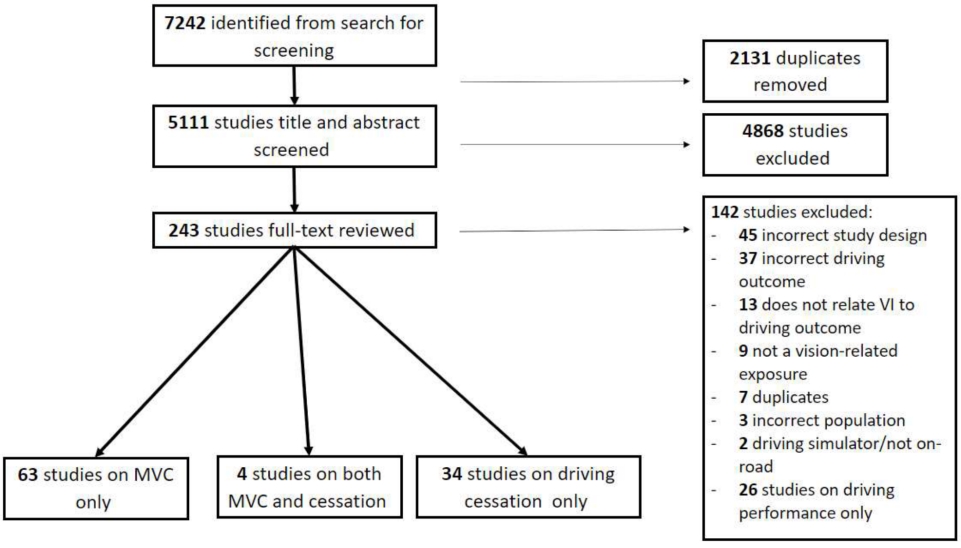

Figure 1 Flow chart of search with papers reporting on MVC and driving cessation. MVC, motor vehicle crash; VI, vision impairment.

Table 2 Breakdown of studies reporting on vision-related associations by outcome measure

Driving outcome	Vision impairment	Region (HIC/LMIC)	Total no of studies
Motor vehicle crash	Glaucoma	15 HICs; 1 LMIC	16
	Cataract	8 HICs	8
	AMD	6 HICs	6
	Diabetic retinopathy	3 HICs	3
	Stereopsis impairment	2 HICs; 3 LMICs	5
	Myopia	2 HICs; 2 LMICs	4
	Colour blindness	1 HICs; 7 LMICs	8
	Contrast sensitivity	13 HICs	13
	Visual acuity	19 HICs; 9 LMICs	28
	Glare sensitivity	3 HICs	3
	Visual field impairment	14 HICs; 6 LMICs	20
	Other*	13 HICs; 6 LMICs	19
Driving cessation	Glaucoma	12 HICs; 1 LMIC	13
	Cataract	5 HICs	5
	AMD	5 HICs	5
	Contrast sensitivity	8 HICs	8
	Visual acuity	18 HICs	18
	Glare sensitivity	3 HICs	3
	Visual field impairment	8 HICs	8
	Other†	11 HICs	11

*Unilateral vision impairment, general vision impairment, retinopathy, retinal detachment, poor visibility, refractive disorder, monocular vision impairment, hyperopia, amblyopia, diplopia, astigmatism, retinitis pigmentosa, stereoacuity.
†Dark adaptation, age-related maculopathy, detached retina, non-refractive vision impairment, self-reported vision loss, retinal haemorrhage, uncorrected refractive error.
AMD, age-related macular degeneration; HIC, high-income country; LMIC, low/middle-income country.

1 cohort) were categorised as high risk of bias with the rest rated as either low or medium (online supplemental appendix 3).

Raw data on studies reporting on MVCs[15–81] and driving cessation[70–73 82–115] can be found in online supplemental appendix 4A,B, respectively, with additional narrative summaries. Meta-analyses on associations are presented in online supplemental appendix 5A,B; only 25 studies could be meta-analysed. Studies were not included in the meta-analysis if different comparators were used, different driving outcomes were analysed (any MVC involvement, at-fault MVCs, injurious and non-injurious MVCs), or different cut-off points or definitions for vision impairment. For example, there were studies that looked at bilateral VA at 6/12 and worse, while there were others that looked at unilateral VA being 'poor' but without a formal definition of what 'poor' acuity meant. Studies rated as having a high bias were also excluded from the meta-analyses. Figure 2 synthesises the narrative summaries to show multiple associations of vision with MVCs and

Table 3 Breakdown of studies reporting on a vision-related intervention by intervention type, vision impairment and outcome measure

Intervention	Vision impairment	Driving outcome	Region (HIC/LMIC)	Studies (n)
Anti-VEGF injections	AMD	Driving cessation	1 HIC	1
	Diabetic macular oedema		1 HIC	1
Cataract surgery	Cataract	Motor vehicle crash	6 HICs	6
		Driving cessation	2 HICs	2
Corrective lenses	Refractive error	Motor vehicle crash	1 HIC	1
Anti-glaucoma therapy	Glaucoma	Driving cessation	1 HIC	1

AMD, age-related macular degeneration; anti-VEGF, anti-vascular endothelial growth factor; HIC, high-income country; LMIC, low/middle-income country.

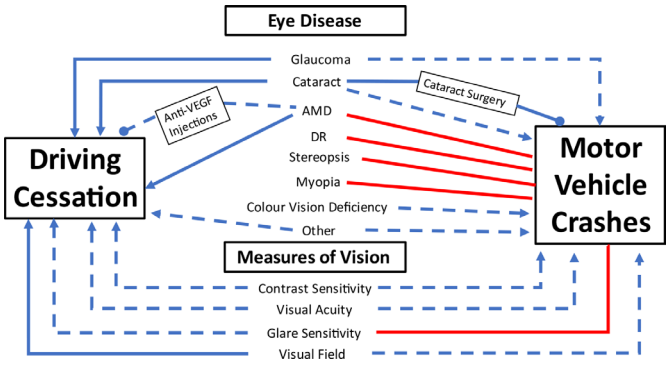

Figure 2 Network diagram illustrating strength of association of vision impairment with motor vehicle crashes and driving cessation found by narrative summaries. Consistent associations of an increased risk of the driving outcome=solid blue line with an arrowhead; inconsistent associations of either an increased risk or no risk of the driving outcome=dashed blue line with an arrowhead; consistent associations of a decreased risk of the driving outcome=solid blue line with a closed circle; inconsistent associations of a decreased risk or no change in risk of the driving outcome=dashed blue line with a closed circle; no associations found with the driving outcome=solid red line. AMD, age-related macular degeneration; anti-VEGF, anti-vascular endothelial growth factor; DR, diabetic retinopathy.

driving cessation. From figure 2, it can be seen that associations reported for eye diseases and measures of vision function were more consistent across studies looking at cessation compared with crashes. When considering vision-related interventions, only cataract surgery was shown to improve driving by minimising crash risk. The benefits of anti-vascular endothelial growth factor (VEGF) injections on prolonging driving were more inconclusive and found to only help drivers with AMD but not diabetic macular oedema (DMO). However as a whole, the evidence from the literature on associations between vision impairment and crashes and cessation is mostly inconclusive and or mixed.

Associations between eye diseases and conditions/measures of vision loss and MVCs

The results were mixed (16 studies, n=21 214 participants) for associations between glaucoma and MVCs.[24 30 38 41 43 45 46 52 54 65 67–72] As illustrated in online supplemental appendix 5A, meta-analyses found a glaucoma diagnosis to not increase the risk of any MVC involvement (OR 1.27 (95% CI 0.67 to 2.42); p=0.47); however, this estimate has a wide CI limiting the power to investigate this association.[24 30 38 43 72] Other studies were excluded from the meta-analysis as there was no similarity on the comparators used, how glaucoma was categorised (mild vs severe, unilateral vs bilateral) and the crash outcomes investigated (any MVC involvement, injurious vs non-injurious, at fault). Similarly, meta-analyses on three studies[24 30 43] looking at at-fault crashes also found no difference between drivers with and without glaucoma (RR 1.89 (95% CI 0.40 to 8.86); p=0.42). Increased risk was evident with more severe glaucoma.[30 38 43 46 52 65 69 70]

Out of the eight cataract studies (n=18 883) identified,[24 40 41 45 54 56 57 72] most found self-reported, physician-diagnosed cataracts did not impact the likelihood of any type of MVC involvement. Meta-analysis suggests that was no increased risk (online supplemental appendix 5A; OR 1.15 (95% CI 0.97 to 1.36); p=0.11)[24 40]; however, this was underpowered with only two studies used for analysis. At-fault crash involvement was investigated by two studies; however, only one reported significant associations.[24 56]

Meta-analysis could not be conducted on any studies looking at drivers with either AMD (five studies, n=4150)[24 41 44 64 66] or DR (three studies, n=4353)[24 45 54]; however, no studies found increased risk of MVC. No studies were meta-analysed as studies on AMD all had different comparators or different grades of AMD and MVC types, while studies on DR had different comparators and looked at different crash outcomes.

Impairments in stereopsis were not found to increase the risk of MVC involvement across the five studies identified (n=3253).[22 33 40 51 75] Meta-analysis on three studies showed no difference in crash involvement between those with and without stereopsis impairment (online supplemental appendix 5A; RR 1.03 (95% CI 0.86 to 1.23); p=0.74).[22 40 51]

Summary of studies on myopia (four studies, n=2039)[22 23 41 74] also found no increased risk of MVC involvement. A combination of two of these studies in meta-analysis (online supplemental appendix 5A) also did not find evidence of an association (OR 0.76 (95% CI 0.34 to 1.70); p=0.51),[22 74] noting limitation of sample size for concrete conclusions to be made. One study investigating persons with night myopia reported slightly more night-time MVCs in these drivers than those without night myopia (p=0.044).[23]

Colour vision deficiency and the risk of MVC involvement among commercial truck drivers were investigated in eight studies (n=7916)[15 21 22 34 51 53 59 77]; seven set in LMICs. Three studies found an association[15 51 59]; however, their results were not combined due to reliance on Ishihara plates which do not reliably diagnose colour vision deficiency.

VA (28 studies, n=39 129) was not found to be associated with crash involvement by 19 studies,[17 20 22 24 27–29 31 33–36 38 40 41 45 50–54 57 63 68 69 73 75 77 80] irrespective of crash scenario (at fault or not at fault) and severity (injurious or non-injurious). Bilateral VA 20/40 or worse may impact risk of MVCs (meta-analysis five studies; RR 1.21 (95% CI 1.02 to 1.43); p=0.03).[27 31 40 73 77] Combining two studies found no evidence for an association with 'not-at-fault' MVCs (RR 1.08 (95% CI 0.74 to 1.60); p=0.68) (online supplemental appendix 5A)[27 31]; however, there was limited power to explore associations.

Mixed results were reported from 13 studies (n=17 941) looking at any MVC involvement and reduced CS.[24 27 31 35 38 40 54 57 58 73] However, due to heterogeneity in outcome measures reported and definition of reduced CS, the meta-analysis in online supplemental appendix 5A was restricted to only two studies which found CS

to increase crash risk (RR 1.40 (95% CI 1.08 to 1.80); p=0.01).[31 79] When photopic and mesopic areas under the log CS were investigated with any and at-fault crash involvement, only lower mesopic peaks were found to be predictive.[58]

From the 20 studies (n=13 533) looking at visual field (VF) loss and crashes, heterogeneity in the definition of VF loss and the crash outcomes investigated meant that only four were meta-analysed. The results suggest an increased risk of MVC with bilateral field loss (RR 1.51 (95% CI 1.23 to 1.85); p<0.001) (online supplemental appendix 5A).[32 51 77 79] There were mixed results with 9 of 20 studies finding an increased risk,[31 32 38 42 54 73 77–79] 1 of 20 an association for a collinear dependent variable[19] and 10 of 20 a null finding.[16 17 33 34 37 51 53 59 68 69] The increased risks were found in association with severe, bilateral VF loss and field loss affecting both central and peripheral vision.

Most studies on glare sensitivity impairments (three studies, n=3191) found weak to no associations with crash risk[54 57 73]; they were unable to be meta-analysed.

Nineteen studies (n=1 00 167) reported on other impairments including: unilateral vision impairment,[18] general vision impairment,[21 25 28 39 41 59 61 74 76 80 81] non-DR,[41] retinal detachment,[72] other retinal disorders,[41] refractive disorder,[41] monocular vision impairment,[41 50] presbyopia,[41 74] hyperopia,[22 74] amblyopia,[18 60] diplopia,[41] astigmatism,[22 41] retinitis pigmentosa[26] and stereoacuity.[54 73] Most did not find associations with MVCs; however, one study from the USA reported increased injurious MVC involvement with impaired stereoacuity.[54] Another study in the UK reported increased MVC involvement with moderate/severe amblyopia,[41] while two other studies, one in Ethiopia[21] and the other in Bangladesh,[74] reported increased MVC involvement with self-reported bilateral visual impairment.

Impact of vision-related interventions on MVCs

Most of the six studies (n=592 897) on cataract surgery found the risk of MVC to decrease following cataract surgery,[41 47–49 55 62] and the three studies suitable for meta-analysis estimated the risk to halve (RR 0.55 (95% CI 0.34 to 0.92); p=0.02) (online supplemental appendix 5A).[47 48 55] Greater reductions to crash risk are seen after first eye surgery compared with second eye.[47] Similarly, the risk of crashing in males post-surgery is lower than females.[49]

Corrective lenses for far and near vision refractive disorders were only investigated by one study which found no associations with crash risk.[41]

Associations between eye diseases and conditions/measures of vision loss and driving cessation

There were 13 studies (n=21 939) investigating associations between glaucoma and the likelihood of driving cessation with estimates ranging from an increased risk of 1.3 to increased odds of 4.[70–72 87 91 92 99 100 103 109–111 113] The meta-analysis in online supplemental appendix 5B suggests a diagnosis of glaucoma to increase the risk of driving cessation by 63% (95% CI 1.20% to 2.19%; p<0.01)[87 91]; however, this analysis only contained two studies.

Four studies (n=14 402) looked at cataract and driving cessation with three studies reporting an increased likelihood of driving cessation by over 1.5 times; none could be meta-analysed.[72 99 100 106]

From the five studies (n=6183) identified,[85 87 99 106 108] three found the presence of AMD to be predictive of driving cessation, with meta-analysis on three suitable studies reporting the overall risk of cessation to increase by 2.21 (95% CI 1.47 to 3.31; p<0.01) (online supplemental appendix 5B).[85 87 108]

Even though the 18 identified studies (n=23 712) were highly heterogeneous,[73 82 86–88 90 91 94–98 103–106 110 111] impaired or 'poor' VA was shown to increase the chances of driving cessation in most studies,[87 103 104 106 111] with better VA decreasing the risk of cessation by up to 70%.[90] The two studies looking at VA in persons with glaucoma had mixed conclusions on the effect of VA on driving cessation.[95 110]

Eight studies (n=9602) looked at the impact of CS on driving cessation.[73 88 94 96 97 103 106 111] From the studies which categorised CS as 'poor', meta-analysis found poor CS to increase the risk of cessation (RR 1.30 (95% CI 1.05 to 1.61); p=0.02) (online supplemental appendix 5B).[94 96 106] Another study reported participants who had a decline of six or more letters in their CS levels after 2 years, as measured by a Pelli-Robson chart, to have a 71% increased risk of driving cessation.[88]

VF loss and driving cessation were investigated by eight studies (n=7988),[88 94–97 103 105 111] and all but one found associations.[105] The likelihood of cessation was generally greater with bilateral and or more severe field loss.[88 94 111] One study looking at persons with bilateral glaucoma found VF loss to double the odds of cessation.[103]

Glare sensitivity (three studies, n=5577) was not found to be consistently associated with driving cessation.[88 91 110]

Eleven studies (n=12 897) looked at driving cessation with other types of vision impairment: dark adaptation,[110] age-related maculopathy,[86] retinal detachment,[85] non-refractive vision impairment,[112] general vision loss,[85 89 93 98 100 114 115] retinal haemorrhage[85] and uncorrected refractive error.[97 112] Only two studies, one reporting on retinal haemorrhage[85] and the other on non-refractive vision impairment and uncorrected refractive error,[112] found increased risk of driving cessation.

Impact of vision-related interventions on driving cessation

There were two studies reporting the driving status of participants after anti-VEGF therapy (0.5 mg ranibizumab) from four different RCTs: MARINA (n=716; 24 months; control=sham injections) and ANCHOR (n=423; 24 months; control=photodynamic therapy (PDT)) which targeted AMD,[83] and RIDE/RISE (n=759; 24 months; control=sham injections) and RESTORE (n=345; 12 months; control=PDT) which targeted DMO.[84] By the

end of all four trials, only drivers with AMD but not DMO treated with anti-VEGF were shown to have marked differences with the control group for the number of people who continued driving from baseline (AMD: MARINA: p=0.035, ANCHOR: p=0.002; DMO: RIDE/RISE: p=0.655, RESTORE: p=0.125).

Both studies (n=1021) looking at driving status after cataract surgery reported an increase in the proportion of participants driving after successful surgery.[101 102]

There was only one study (n=240) looking at driving after anti-glaucoma therapy (pilocarpine–epinephrine)[107]; however, this is an old study and this treatment is no longer in use.

DISCUSSION

This review synthesises diverse and complex evidence from 101 studies examining vision and its impact on MVCs and driving cessation across all ages. The majority of studies in this review focused on older adults and reported more associations between vision impairment and MVCs and or cessation compared with studies on younger populations. Research was mostly observational with few studies examining the impact of interventions to improve vision. The studies excluded from the meta-analysis tended to have mixed results regarding the associations between the vision impairment and driving outcome, whereas the studies in the meta-analyses were more consistent showing definitive associations for VA, CS and VF defects. Nonetheless, the mixed results in the narrative summaries however support the emerging idea of adding visual processing and cognitive tests alongside visual assessments to produce more predictive measures of safe driving.[116] When looking at the vision-related interventions, cataract surgery was shown to halve the risk of crashing. Others have reported that following cataract surgery, driving difficulties, such as self-reported night driving ability, reduced by 88%[117] with improvements in CS linked to these changed perceptions.[118]

Variability in the relationships between vision and MVCs may be due to several reasons. The first set of reasons surrounds how MVCs are defined and investigated in the literature. First, there are many different MVC scenarios based on the driver's role (at fault or not) and severity (injurious or non-injurious) which are not always differentiated in research studies. MVCs are also studied in a variety of ways from self-reports to analyses of large crash databases. This may cause reliability issues. For example, an American study found agreement between these two collection methods was poor when examining the total MVCs over a 3-year period.[119] Crashes can also stem from external and vehicular factors which make drawing conclusions solely based on human factors inappropriate.[120] Self-regulation, jurisdictional control on vision standards for licensing and driving cessation could all mitigate the risk of crash involvement. The second set of reasons has to do with the vision impairment themselves and the severity of the impairment. The studies which reported increased crash risk, associated with diagnosis of an eye disease, evaluated more severe forms of the disease and worse functions of vision. Studies examining impact of a diagnosis of a disease tended to report no associations. For example, the lack of association between a diagnosis of cataract and MVC could be because the cataract is mild and is not having a significant impact on CS. A parallel review from our group has found greater defects in these measures to worsen driving performance and increase errors, which can theoretically lead to more crashes.[121] It is therefore critical to capture the severity of an eye disease and/or the actual level of vision impairment when investigating the impact of disease status on crash risk. As seen in this review, even though glaucoma, cataract and AMD had mixed or no associations with crashing, their corresponding measures of vision, mainly VF, CS and VA, respectively, were definitively associated. This may be why associations found between vision impairment and driving cessation were strong and consistent. A diagnosis of glaucoma or AMD, and poor CS were all found to increase the risk of driving cessation. Anti-VEGF injections could prolong driving for people with AMD. This is of importance as older adults greatly value independent mobility and regard driving as a vital activity for daily living.[122 123] With driving cessation linked towards multiple negative health outcomes in older adults,[4] anti-VEGF injections can have wider health benefits beyond direct impact on vision.

This review also highlights the paucity of research from LMICs despite approximately 93% of all road traffic-related deaths occurring in these countries, particularly in Africa and among young road users.[2] Despite the UN's push, most LMICs still lag behind the SDG targets on halving road traffic mortality set in the Decade of Action for Road Safety (2011–2020).[124] Previous systematic reviews point towards legislation-based interventions which modify behaviour, such as seat-belt and helmet use, to be the most effective at reducing road injuries and crash rates in LMICs.[125 126] These interventions are in line with UN recommendations for improving infrastructure, vehicle safety standards and safe road user behaviours in order to reach the targets set for SDGs 3.6 and 11.2.[127] However, there is no mention of licensing standards which need to be addressed as motorisation increases worldwide. Evidence from this global review supports vision standards for licensing to be updated, enforced and given higher priority in LMICs. Even though most LMICs do have guidelines on vision, especially for commercial drivers, it is apparent from the studies in this review that many drivers unfortunately do not satisfy these conditions. This may be because many people in LMICs lack access to eye healthcare services. The evidence for a corresponding increase in MVCs in LMICs is not well established with only one systematic review identified looking at data from these regions.[77] Though data from HICs can inform research and policy development in LMICs, increasing the evidence base from LMICs will ensure that interventions to reduce MVCs and maintain

access to driving in LMICs can be reflective of the local context.

Older drivers tend to self-regulate their driving habits by reducing their driving mileage and radius and avoiding high-risk driving situations.[128] Vision impairments have been reported to increase the likelihood of self-regulation by 19%,[129] with older drivers who self-rate their vision as 'poor' 15 times more likely to modify their driving than those who regard their vision as 'excellent'.[123] Our findings are consistent with these patterns of self-regulation, and a diagnosis of AMD or glaucoma was found in this review to be associated with driving cessation. It is likely that self-regulation is an intermediate step towards driving cessation encompassing reductions in driving frequencies and distance.[130] However, self-regulation has been reported as an insufficient compensatory measure to reduce crash risk among older drivers with a vision impairment,[131 132] which would therefore explain why glaucoma, particularly more severe glaucoma, was still linked with crashes in some studies. The relationship between crash involvement and AMD, however, was inconclusive. This may be because AMD affects central vision, thus making declines in this field easily noticeable allowing individuals to appropriately adapt their driving behaviours. Laboratory studies simulating central vision impairments show negative impacts on driving performance and safety, particularly with increasing age and distraction.[133] Further research is needed on driving patterns and behaviours of individuals with eye diseases.

Few studies, all from LMICs, in this review reported associations between colour vision deficiency and crash risk. Unfortunately, based on their high risk of bias, these studies were deemed unsuitable for meta-analysis. This does not mean, however, that their results should be dismissed. Previous simulation studies found persons with colour vision deficiency performed worse in driving simulations compared with those with normal colour vision.[134–136] However, these associations have not always been evident in studies of MVC risk.[137] This might be why recommendations proposed by the Commission Internationale de l'Eclairage, the international authority on lighting and signal lights, are for commercial drivers only.[135] Associations found in LMICs highlight issues regarding poor road infrastructure and lighting standards.[138] Further research is needed, with standardised diagnosis of colour vision deficiency and consideration of improvements to lighting and signals in the road environment in LMICs.

This review summarises global data on different eye diseases, declines in vision function and vision-related interventions, which makes the findings applicable worldwide considering motorisation and ongoing issues of vision loss, particularly in older people. There are, however, limitations which should be acknowledged. This review highlights the highly heterogeneous nature of research investigating the impact of vision on driving which unfortunately presented several methodological limitations. First, only a small number of studies could be synthesised for meta-analyses due to differences in study design. The underpowered meta-analyses meant that no absolute conclusions can be made from these results alone. It is therefore imperative that the meta-analyses results be considered alongside the narrative summaries to gain a full picture of the literature in this field. Further, this review did not consider how comorbidities, alongside vision impairment, can impact the risk of crash and driving cessation. Older adults with a vision impairment have been found to be twice as likely than those without a vision impairment to have five or more physical and/or cognitive comorbidities.[139] It is possible that the association with vision is confounded by the impact of comorbidities. Unfortunately, not all the studies included in this review reported on the comorbidities of their participants, limiting our ability to explore this possible source of bias and the extent to how this might have explained the heterogeneity of the pooled estimates via meta-regression. There were great variations in the comparator group used in each study and there were inconsistent cut-off points among studies looking at continuous measures of vision function. This heterogeneity also prevented subgroup analyses comparing younger with older age groups and geographical regions. Clinical and methodological heterogeneity could not be investigated, even though details on participant characteristics, relevant interventions and study designs were collected, due to the small number of studies included in each meta-analysis. Looking at these parameters, however, might have explained the high statistical heterogeneity in select meta-analyses. The published meta-analysis, however, was summarised narratively to ensure duplicate studies were not included in this evidence synthesis. Grey literature and non-English studies were not included which may have introduced publication bias and limited the number of studies identified from LMICs. Future research incorporating these areas may provide a clearer picture on how vision impairment is affecting global road safety.

In conclusion, this review summarises the global literature on the impact of vision and vision-related interventions on driving as part of the *Lancet Global Health* Commission on Global Eye Health. Select measures of vision impairment such as VF, VA and CS loss, and eye diseases such as glaucoma and AMD, were found to be associated with either crashes or driving cessation, while interventions such as cataract surgery and anti-VEGF injections mitigated these outcomes. However, the current literature is highly heterogeneous, and more studies are needed from LMICs to ensure what is known about vision and driving in these settings. Future studies should aim to address these issues to allow for the global context of vision impairment and driving safety to be better documented, which may assist in the achievement of the UN's SDG road safety targets.

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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	pg.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Appendix 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	pg.4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	pg.4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	pg.4,5, Table 1
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	pg.4
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendix 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	pg.5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	pg.5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	pg.5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	pg.5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	pg.5,6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	pg.6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	pg.6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	pg.6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	pg.6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	pg.6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	pg.6
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	pg.6
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	pg.6, Figure 1, Table 2a and 2b
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	pg.8-11, Appendix 4a and 4b
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Appendix 3
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	pg.8-11, Appendix 4a and 4b
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	pg.8-11, Appendix 4a and 4b
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	pg.8-11, Appendix 4a and 4b
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	pg.8-11, Figure 2a-b
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	pg.11-13
	23b	Discuss any limitations of the evidence included in the review.	pg.11-13
	23c	Discuss any limitations of the review processes used.	pg.12,13
	23d	Discuss implications of the results for practice, policy, and future research.	pg.11-13
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	pg.2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	pg.4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	pg.14
Competing	26	Declare any competing interests of review authors.	pg.14

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
interests			
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	pg.13

PRISMA ABSTRACT CHECKLIST

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesise results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	Yes
Registration	12	Provide the register name and registration number.	Yes

PRISMA 2020 Checklist

Appendix 2 Complete search strategy for review. While search terms were included for driving performance, driving scores and errors, the studies with outcome measures of driving performance was outside of the scope of this current manuscript and are reported elsewhere.

MEDLINE (OVID) search strategy

1. exp Eye Diseases/
2. exp Cataract Extraction/
3. Lens Implantation, Intraocular/
4. Lenses, Intraocular/
5. cataract$.tw.
6. ((intraocular or intra ocular) adj3 lens$).tw.
7. (IOL or IOLs).tw.
8. Vision Tests/
9. Visual Acuity/
10. exp Refractive Errors/
11. Visual Fields/
12. Visual Field Tests/
13. Contrast Sensitivity/
14. Depth Perception/
15. (visual adj2 (acuit$ or field$)).tw.
16. contrast sensitivity.tw.
17. (depth perception or stereopsis).tw.
18. ((impair$ or decreas$ or declin$) adj3 (vision or visual$ or sight$)).tw.
19. (improv$ adj3 (vision or visual$ or sight$)).tw.
20. ((visual or vision) adj2 function$).tw.
21. exp Vision, Ocular/
22. Vision Screening/
23. or/1-22
24. Mass Screening/
25. ((eye$ or sight or vision or visual$) adj2 (test$ or screen$ or exam$ or diagnos$ or assess$)).tw
26. 24 and 25
27. 23 or 26
28. exp Motor Vehicles/
29. exp Automobile Driving/
30. Accidents, Traffic/
31. (driver$ or driving).tw.
32. (automobile$ or car or cars or vehicle$).tw.
33. (motoring or motorcar or "motor car" or "motor cars").tw.
34. crash$.tw.
35. ((road or traffic) adj2 injur$).tw.
36. ((road or traffic or motor) adj2 (accident$ or incident$)).tw.
37. ((road or traffic or motor) adj2 collision$).tw.
38. or/28-37
39. epidemiologic studies/ or case-control studies/ or cohort studies/ or observational study/ or follow-up studies/ or longitudinal studies/ or prospective studies/ or retrospective studies/ or controlled before-after studies/ or cross-sectional studies/ or historically controlled study/ or interrupted time series analysis/
40. epidemiologic methods/ or focus groups/ or interviews as topic/ or exp "surveys and questionnaires"/

41. epidemiologic research design/ or control groups/ or cross-over studies/ or double-blind method/ or meta-analysis as topic/ or network meta-analysis/ or random allocation/ or single-blind method/
42. epidemiologic methods/ or clinical trials as topic/ or feasibility studies/ or multicenter studies as topic/ or pilot projects/ or sampling studies/ or twin studies as topic/
43. randomized controlled trial/ or controlled clinical trials as topic/ or randomized controlled trials as topic/
44. comparative study/ or evaluation studies/ or meta-analysis/ or review/ or multicenter study/ or "systematic review"/ or validation studies/
45. health surveys/
46. outcome assessment, health care/
47. risk factors/
48. self report/
49. (population or cohort or observation$ or intervention$ or prospective or retrospective or comparative).tw.
50. (questionnaire$ or survey$).tw.
51. (randomized or randomised or randomly or RCT).tw.
52. (systematic review or meta-analysis).tw.
53. (before adj2 after).tw.
54. (case$ adj2 control$).tw.
55. (cross adj1 section$).tw.
56. or/39-55
57. 27 and 38
58. 56 and 57
59. vehicle-controlled.tw.
60. (vehicle adj3 inject$).tw.
61. 59 or 60
62. 58 not 61
63. (animal$ or mouse or mice$ or dog or canine or rat or rats or primate$).ti.
64. (dry eye or cell$ or mutation$ or genes or genome or sequencing).ti.
65. or/63-64
66. 62 not 65
67. limit 66 to english language
68. exp case reports/
69. (case adj2 report$).tw.
70. 68 or 69
71. 67 not 70
72. limit 71 to (editorial or letter)
73. 71 not 72

EMBASE Search Strategy

1. exp eye disease/
2. exp cataract extraction/
3. lens implantation/
4. lens implant/
5. cataract$.tw.
6. ((intraocular or intra ocular) adj3 lens$).tw.
7. (IOL or IOLs).tw.
8. vision test/
9. visual acuity/

10. refractive error/
11. visual field/
12. perimetry/
13. contrast sensitivity/
14. depth perception/
15. (visual adj2 (acuit$ or field$)).tw.
16. contrast sensitivity.tw.
17. (depth perception or stereopsis).tw.
18. ((impair$ or decreas$ or declin$) adj3 (vision or visual$ or sight$)).tw.
19. (improv$ adj3 (vision or visual$ or sight$)).tw.
20. ((visual or vision) adj2 function$).tw.
21. vision/
22. or/1-21
23. mass screening/
24. ((eye$ or sight or vision or visual$) adj2 (test$ or screen$ or exam$ or diagnos$ or assess$)).tw.
25. 23 and 24
26. 22 or 25
27. exp car driving/
28. exp motor vehicle/
29. traffic accident/
30. (driver$ or driving).tw.
31. (automobile$ or car or cars or vehicle$).tw.
32. (motoring or motorcar or "motor car" or "motor cars").tw.
33. crash$.tw.
34. ((road or traffic) adj2 injur$).tw.
35. ((road or traffic or motor) adj2 (accident$ or incident$)).tw.
36. ((road or traffic or motor) adj2 collision$).tw.
37. or/27-36
38. study design/
39. controlled clinical trial/
40. case control study/
41. cohort analysis/
42. observational study/
43. follow up/
44. longitudinal study/
45. prospective study/
46. retrospective study/
47. epidemiology/
48. cross-sectional study/
49. control group/
50. crossover procedure/
51. "meta analysis (topic)"/
52. network meta-analysis/
53. randomization/
54. single blind procedure/
55. double blind procedure/
56. "clinical trial (topic)"/
57. "controlled clinical trial (topic)"/
58. "randomized controlled trial (topic)"/
59. "multicenter study (topic)"/
60. feasibility study/

61. pilot study/
62. comparative study/
63. evaluation study/
64. multicenter study/
65. randomized controlled trial/
66. meta analysis/
67. "systematic review"/
68. validation study/
69. interview/
70. questionnaire/
71. outcome assessment/
72. "systematic review (topic)"/
73. health survey/
74. risk factor/
75. self report/
76. evidence based practice/
77. (population or cohort or observation$ or intervention$ or prospective or retrospective or comparative).tw.
78. (questionnaire$ or survey$).tw.
79. (randomized or randomised or randomly or RCT).tw.
80. (systematic review or meta-analysis).tw.
81. (before adj2 after).tw.
82. (case$ adj2 control$).tw.
83. (cross adj1 section$).tw.
84. or/38-83
85. 26 and 37
86. 84 and 85
87. vehicle-controlled.tw.
88. (vehicle adj3 inject$).tw.
89. or/87-88
90. 86 not 89
91. (animal$ or mouse or mice$ or dog or canine or rat or rats or primate$).ti.
92. (dry eye or cell$ or mutation$ or genes or genome or sequencing).ti.
93. or/91-92
94. 90 not 93
95. limit 94 to conference abstract status
96. 94 not 95
97. limit 96 to english language
98. exp case report/
99. (case adj2 report$).tw.
100. or/98-99
101. 97 not 100
102. limit 101 to (conference paper or "conference review" or editorial or letter or note)
103. 101 not 102

GLOBAL HEALTH Search Strategy

1. exp eye diseases/
2. exp vision disorders/
3. cataract$.tw.
4. ((intraocular or intra ocular) adj3 lens$).tw.
5. (IOL or IOLs).tw.

6. (visual adj2 (acuit$ or field$)).tw.
7. contrast sensitivity.tw.
8. (depth perception or stereopsis).tw.
9. ((impair$ or decreas$ or declin$) adj3 (vision or visual$ or sight$)).tw.
10. (improv$ adj3 (vision or visual$ or sight$)).tw.
11. ((visual or vision) adj2 function$).tw.
12. ((eye$ or sight or vision or visual$) adj2 (test$ or screen$ or exam$ or diagnos$ or assess$)).tw.
13. or/1-12
14. drivers/
15. vehicles/
16. motor cars/
17. traffic/
18. traffic accidents/
19. (driver$ or driving).tw.
20. (automobile$ or car or cars or vehicle$).tw.
21. (motoring or motorcar or "motor car" or "motor cars").tw.
22. crash$.tw.
23. ((road or traffic) adj2 injur$).tw.
24. ((road or traffic or motor) adj2 (accident$ or incident$)).tw.
25. ((road or traffic or motor) adj2 collision$).tw.
26. or/14-25
27. cohort studies/
28. case-control studies/
29. longitudinal studies/
30. retrospective studies/
31. epidemiology/
32. exp clinical trials/
33. randomized controlled trials/
34. feasibility studies/
35. pilot projects/
36. meta-analysis/
37. systematic reviews/
38. reviews/
39. questionnaires/
40. surveys/
41. epidemiological surveys/
42. risk factors/
43. (population or cohort or observation$ or intervention$ or prospective or retrospective or comparative).tw.
44. (questionnaire$ or survey$).tw.
45. (randomized or randomised or randomly or RCT).tw.
46. (systematic review or meta-analysis).tw.
47. (before adj2 after).tw.
48. (case$ adj2 control$).tw.
49. (cross adj1 section$).tw.
50. or/27-49
51. 13 and 26
52. 50 and 51
53. (animal$ or mouse or mice$ or dog or canine or rat or rats or primate$).ti.
54. (dry eye or cell$ or mutation$ or genes or genome or sequencing).ti.
55. 53 or 54

56. 52 not 55
57. limit 56 to english language
58. case reports/
59. (case adj2 report$).tw.
60. 58 or 59
61. 57 not 60
62. limit 61 to (conference or conference paper or conference proceedings or correspondence or editorial or thesis)
63. 61 not 62

Appendix 3 Risk of Bias Assessment for all Included Studies

Analytical Cross-Sectional Study

Citation	Q1 (SB)	Q2 (SB)	Q3 (DB)	Q4 (C)	Q5 (C)	Q6(C)	Q7 (DB)	Q8 (V)	Risk of Bias*
High Income Countries									
Adler G, et al. 2005.	Y	Y	N	Y	Y	Y	Y	Y	L
Alvarez-Peregrina C et al., 2021	N	N	N	N	N	N	Y	N	H
Ball K, et al. 1993.	Y	N	U	U	N	N	U	Y	H
Cohen Y, et al. 2007.	Y	Y	Y	Y	N	N	Y	Y	M
Crizzle AM et al., 2020	Y	Y	U	U	N	N	Y	Y	M
Cross JM, et al. 2009.	U	U	Y	N	N	U	Y	Y	H
DeCarlo DK, et al. 2003.	Y	Y	N	U	U	U	Y	Y	M
Edwards JD, et al. 2008.	Y	Y	Y	N	Y	Y	Y	Y	L
Garre-Olmo J, et al. 2009.	Y	Y	Y	U	Y	Y	Y	Y	M
Gilhotra JS, et al. 2001.	Y	Y	Y	Y	Y	Y	Y	Y	L
Hajek A, et al. 2019.	Y	Y	N	N	Y	Y	Y	Y	M

Huisingh C, et al. 2015.	Y	Y	Y	Y	Y	Y	Y	Y	L
Ivers RQ, et al. 1999.	N	N	Y	N	Y	Y	N	Y	M
Kaleem MA et al., 2021	Y	Y	Y	Y	N	N	Y	N	M
Keay L, et al. 2016.	Y	Y	Y	Y	Y	Y	Y	Y	L
Kwon M, et al. 2016.	Y	Y	Y	Y	Y	Y	Y	Y	L
Levecq L, et al. 2013.	Y	Y	Y	Y	N	N	Y	Y	M
MacLeod KE, et al. 2014.	Y	Y	Y	Y	Y	Y	Y	Y	L
Marottoli RA, et al. 1993.	Y	Y	N	Y	U	Y	Y	Y	M
Moon SH & Park K et al., 2020	Y	Y	N	N	N	N	Y	Y	M
Ono T, et al. 2015.	Y	Y	Y	Y	Y	Y	N	Y	L
Owsley C, et al. 2001.	Y	Y	Y	Y	Y	Y	Y	Y	L
Owsley C, et al. 2020.	Y	Y	Y	Y	Y	Y	Y	Y	L
Ramulu PY, et al. 2009.	Y	Y	Y	Y	Y	Y	Y	Y	L

Robinson JL et al., 2021	Y	Y	Y	Y	N	N	Y	N	M
Ross LA, et al. 2009.	Y	Y	Y	Y	N	N	Y	Y	M
Runge JW. 2000.	N	N	U	U	U	U	Y	Y	H
Segal-Gidan F, et al. 2010.	Y	Y	Y	Y	Y	Y	Y	Y	L
Sengupta S, et al. 2014.	Y	Y	Y	Y	Y	Y	Y	Y	L
Stafford WR. 1981.	N	N	Y	U	N	N	Y	Y	H
Stewart RB, et al. 1993.	Y	Y	N	N	Y	Y	Y	Y	M
Swain TA et al., 2021	Y	Y	Y	Y	Y	Y	Y	Y	L
Tam ALC, et al. 2018.	Y	Y	Y	Y	N	N/A	Y	Y	M
Tanabe S, et al. 2011.	Y	Y	Y	Y	Y	Y	N	Y	L
van Landingham SW, et al. 2013.	Y	Y	Y	Y	U	U	Y	Y	M
Wedenoja J et al., 2021	Y	Y	U	U	N	N	Y	N	H
Yuki K, et al. 2014.	Y	Y	Y	Y	N	N	N	Y	M

Zebardast N, et al. 2015.	Y	Y	Y	Y	Y	Y	Y	Y	L
Low Middle Income Countries									
Abebe Y, et al. 2002.	Y	Y	Y	N	N	N	N	Y	M
Abraham EG, et al. 2010.	Y	N	N	N	N	N	N	Y	H
Adekoya BJ, et al. 2009.	Y	Y	Y	Y	N	N	N	Y	M
Ahmed M et al., 2021	N	N	Y	Y	Y	Y	Y	Y	M
Bekibele CO, et al. 2007.	N	Y	Y	Y	N	N	N	Y	M
Biza M, et al. 2013.	Y	Y	Y	Y	N	N	N	Y	M
Boadi-Kusi SB, et al. 2016.	Y	Y	N	Y	N	N	N	U	H
Emerole CG, et al. 2013.	N	N	Y	Y	N	N	N	N	H
Humphriss D. 1987.	Y	N	N	N	N	N/A	U	U	H
Isawumi MA, et al. 2011.	Y	Y	U	Y	N	N	N	U	H
Ogbonnaya CE, et al. 2018.	Y	Y	Y	Y	N	N	N	Y	M

Oladehinde MK, et al. 2007.	N	N	Y	Y	N	N	N	Y	H
Ovenseri-Ogomo G, et al. 2011.	Y	Y	Y	Y	N	N/A	N	Y	M
Pepple G, et al. 2014.	Y	Y	Y	N	N	N	N	Y	M
Vofo BN et al., 2021	Y	Y	Y	Y	N	N	Y	N	M

*Risk of bias scores: high (1-3), medium (4-6), and low (7-8)

SB= selection bias, DB= detection bias, C= confounding, V= validity

Case Control Study

Citation	**Q1 (SB)**	**Q2 (SB)**	**Q3 (SB)**	**Q4 (DB)**	**Q5 (PB)**	**Q6 (C)**	**Q7 (C)**	**Q8 (PB)**	**Q9 (V)**	**Q10 (V)**	**Risk of Bias***
High Income Countries											
Campbell MK, et al. 1993.	Y	U	Y	N	U	Y	Y	Y	U	U	M
Gallo JJ, et al. 1999.	Y	N	Y	U	U	Y	Y	Y	N	Y	M
Gresset JA, et al. 1994.	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	L
Gresset JA, et al. 1994.	U	Y	Y	U	U	N	N	Y	Y	Y	M
McCloskey LW, et al. 1994.	Y	Y	Y	Y	Y	U	U	Y	Y	Y	M

McGwin G, et al. 2000.	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	L
McGwin G, et al. 2004.	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	L
McGwin G, et al. 2005.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L
Owsley C, et al. 1998.	Y	Y	Y	Y	Y	N	N	Y	Y	Y	M
Sims RV, et al. 1998.	Y	U	Y	Y	Y	N	N	N	Y	Y	M
Szlyk JP, et al. 1995.	Y	Y	Y	Y	Y	N	N	Y	Y	Y	M
Wood JM, et al. 2018.	Y	Y	N	Y	Y	Y	Y	Y	U	Y	M
Wood JM, et al. 2016.	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
Owsley C, et al. 1999.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L
Low Middle Income Countries											
Deshmukh AV, et al. 2019.	Y	N	Y	Y	Y	N	N	Y	U	N	M

*Risk of bias scores: high (1-4), medium (5-8), and low (9-10)

SB= selection bias, DB= detection bias, PB = performance bias, C= confounding, V= validity

Case Series

Citation	Q1 (SB)	Q2 (DB)	Q3 (DB)	Q4 (SB)	Q5 (SB)	Q6 (SB)	Q7 (SB)	Q8 (AtB)	Q9 (SB)	Q10 (V)	Risk of Bias*
High Income Countries											
Goh YW, et al. 2011	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	L

*Risk of bias scores: high (1-4), medium (5-8), and low (9-10)

SB= selection bias, DB= detection bias, AtB= attrition bias, V= validity

Cohort Study

Citation	Q1 (SB)	Q2 (PB)	Q3 (DB)	Q4 (C)	Q5 (C)	Q6 (SB)	Q7 (DB)	Q8 (V)	Q9 (AtB)	Q10 (AtB)	Q11 (V)	Risk of Bias*
High Income Countries												
Anstey KJ, et al. 2006.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L
Baker JM, et al. 2019.	N	Y	N	Y	Y	Y	Y	Y	Y	N/A	Y	M
Fishman GA et al., 1981	Y	U	Y	Y	Y	N	N	U	N	N	N	H
Freeman EE, et al. 2005.	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	L
Green KA, et al. 2013.	Y	Y	Y	Y	Y	U	Y	Y	Y	N	Y	M

Haymes SA, et al. 2007.	Y	Y	Y	Y	Y	N/A	Y	Y	Y	N/A	Y	M
Huisingh C, et al. 2017.	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
Huisingh C, et al. 2016.	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	M
Janz NK, et al. 2009.	Y	Y	Y	Y	Y	U	Y	Y	N	N	Y	M
Keay L, et al. 2009.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L
Keeffe JE, et al. 2002.	Y	Y	Y	N	N/A	Y	N	Y	Y	U	U	M
Kristalovich L, et al. 2019.	U	Y	Y	N	N	Y	U	Y	N/A	N/A	Y	M
Maag U, et al. 1997.	Y	N	U	Y	Y	N	Y	Y	Y	N/A	Y	M
Margolis KL, et al. 2002.	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
McGwin G, et al. 2015.	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
McGwin G, et al. 2013.	Y	Y	Y	N	N/A	Y	Y	Y	U	U	Y	M
Meuleners LB,et al. 2019.	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	L

Meuleners LB, et al. 2012.	Y	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y	L
Meuleners LB, et al. 2012.	Y	Y	Y	Y	Y	Y	Y	Y	U	U	Y	M
Monestam E, et al. 2005.	Y	Y	Y	N	N	Y	Y	Y	N	N	U	M
Monestam E, et al. 1997.	Y	U	Y	N	N	Y	Y	Y	Y	N	Y	M
Naredo Turrado J, et al. 2020.	Y	Y	Y	Y	Y	U	Y	Y	Y	U	Y	M
Owsley C, et al. 2002.	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
Rahi JS, et al. 2006.	Y	Y	U	Y	Y	Y	N	Y	N	N	Y	M
Rubin GS, et al. 2007.	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	L
Schlenker MB, et al. 2018.	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
Swain TA et al., 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	L
Takahashi A, et al. 2018.	U	Y	Y	Y	Y	Y	Y	Y	N	N	Y	M
Yuki K, et al. 2016.	Y	Y	Y	N	N/A	Y	N	N	Y	U	N	M

*Risk of bias scores: high (1-4), medium (5-9), and low (10-11)

SB= selection bias, PB= performance bias, DB= detection bias, C= confounding, AtB= attrition bias, V= validity

Systematic Reviews

Citation	Q1 (SB)	Q2 (SB)	Q3 (SB)	Q4 (SB)	Q5 (InB)	Q6 (InB)	Q7 (InB)	Q8 (C)	Q9 (PubB)	Q10 (V)	Q11 (V)	Risk of Bias
High Income Countries												
Piyasena P et al., 2021	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	L

Risk of bias scores: high (1-4), medium (5-9), and low (10-11)

SB= selection bias, InB= information bias, C= confounding, PubB= publication bias, V= validity

Randomised Controlled Trials

Citation	Q1 (AlB)	Q2 (PB)	Q3 (SB)	Q4 (PB)	Q5 (PB)	Q6 (AlB)	Q7 (C)	Q8 (AtB)	Q9 (V)	Q10 (DB)	Q11 (DB)	Q12 (V)	Q13 (V)	Risk of Bias
High Income Countries														
Bressler NM, et al. 2013.	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	L
Bressler NM, et al. 2016.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	L

*Risk of bias scores: high (1-6), medium (7-11), and low (12-13)

AlB = allocation bias, SB= selection bias, PB= performance bias, C= confounding, DB= detection bias, AtB= attrition bias, V= validity

Appendix 4a Raw data tables and additional narrative summaries of papers on motor vehicle crashes

Table 4a(i) All studies (n=16) on glaucoma and Motor Vehicle Crashes (MVC). Of the 16 studies, 5 studies were suitable for meta-analysis on associations with any MVC involvement and 2 studies on associations with at-fault MVC involvement

Additional Narrative Summary:
Associations between glaucoma and MVCs were mixed in the studies identified. Even though seven controlled studies found glaucoma to increase the odds of any, injurious, and at-fault MVC involvement, two studies found crash involvement to halve in drivers with glaucoma. Only one study looked at not-at-fault crashes, but found no associations (OR 1 (95% Cl 0.4-2.5)). Drivers with more severe glaucoma, irrespective of whether it was in the better or worse eye, were involved in more MVCs and also had greater odds of any crash and at-fault crash involvement compared to drivers without glaucoma and drivers with mild glaucoma.

Author and Year	**Study Design**	**Participants/ Sample Size**	**Mean Age**	**Country**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR, etc?)**	**Effect Measure (with 95% CI) + any description of results (if appropriate**
Included in Meta-analysis (any MVC involvement)								
Cross JM et al., 2009	Cross-sectional	3158 (249/2909)	71.9	USA	Self-reported physician diagnosed	Drivers without glaucoma	RR (rate ratio)	**Any MVC**: 1.18 (0.81, 1.72)
Haymes S et al., 2007	Retrospective Cohort	95 (48/47)	69	Canada	Diagnosis from glaucoma specialist, glaucomatous optic disc damage and corresponding visual field damage	Drivers without glaucoma	OR (logistic regression)	**Any MVC**: 6.62 (1.4, 31.23)
Kwon M et al., 2016	Cross-sectional	1899 (206/1693)	age, no.: 70-79 years =	USA	Physician diagnosed	Drivers without glaucoma	RR (rate ratio)	**Any MVC involvement**: 1.65 (1.2, 2.28)

			1358, 80-89 years = 502, 90-98 years = 39					
Naredo Turrado J et al., 2020	Prospective Cohort	11670 (525/11145)	62.4	France	Self-reported physician diagnosed	Drivers without glaucoma	OR	**Any MVC**: 0.93 (0.72, 1.22)
McGwin G Jr et al., 2004	Case Control	691 (576/115)	69.2	USA	ICD-9 codes 365.1 and 265.3	Drivers without glaucoma	RR (relative risk)	**Any MVC**: 0.58 (0.4, 0.83)
Included in Meta-analysis (at-fault MVC involvement)								
Cross JM et al., 2009	Cross-sectional	3158 (249/2909)	71.9	USA	Self-reported physician diagnosed	Drivers without glaucoma	RR (rate ratio)	**At-fault MVC**: 0.91 (0.48, 1.72)
Haymes S et al., 2007	Retrospective Cohort	95 (48/47)	69	Canada	Diagnosis from glaucoma specialist, glaucomatous optic disc damage and corresponding visual field damage	Drivers without glaucoma	OR (logistic regression)	**At-fault MVC**: 12.44 (1.08, 143.99)
McGwin G Jr et al., 2004	Case Control	691 (576/115)	69.2	USA	ICD-9 codes 365.1 and 265.3	Drivers without glaucoma	RR (relative risk)	**At-fault MVC**: 0.99 (0.54, 1.8)
Included in Narrative Summaries Only – High Income Countries								
Adler G et al., 2004	Cross-sectional	199 (52/147)	71.3	USA	Open-or closed-angle glaucoma	Drivers without glaucoma	Prevalence (%)	25% (13/52) of drivers with glaucoma had been in an MVC compared to

								25.9% (38/147) of drivers without glaucoma (p= 0.86).
Cross JM et al., 2009	Cross-sectional	3158 (249/2909)	71.9	USA	Self-reported physician diagnosed	Drivers without glaucoma	RR (rate ratio)	**Injurious MVC**: 0.63 (0.19, 2.06)
Haymes S et al., 2007	Retrospective Cohort	95 (48/47)	69	Canada	Diagnosis from glaucoma specialist, glaucomatous optic disc damage and corresponding visual field damage	Drivers without glaucoma	OR (logistic regression)	**Any MVC (state-reported)**: 3.21 (0.72, 14.27)
								At-fault MVC (state-reported): 7.21 (0.46, 113.4)
							Prevalence (%)	27% (11/400 of drivers with glaucoma had been involved in an MVC compared to 7% (3/44) in drivers without glaucoma. 20% (8/40) of drivers with glaucoma were at-fault in an MVC compared to 2% (1/44) in drivers without glaucoma.

Kwon M et al., 2016	Cross-sectional	1899 (206/1693)	age, no.: 70-79 years = 1358, 80-89 years = 502, 90-98 years = 39	USA	Physician diagnosed	Drivers without glaucoma	Prevalence (%)	18% (37/206) of drivers with glaucoma were at-fault in a crash compared to 13% (219/1693) of drivers without glaucoma.
McCloskey L et al., 1994	Case Control	683 (42/641)	age, no.: 65-69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 86	USA	Physician diagnosed (hospital data)	Age-matched drivers with glaucoma who have not been injured in a police-reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 1.5 (0.8, 2.9)*
							Prevalence (%)	7.7% (18/234) of all drivers who had an injurious crash also had glaucoma.
McGwin G Jr et al., 2000	Case Control	901 (447/454)	N/A	USA	Self-reported physician diagnosed	Not-at-fault drivers involved in crashes, without glaucoma	OR	**Not at-fault MVC**: 1 (0.4, 2.5)
							Prevalence (%)	5.2% (10/198) of not-at-fault crashes involved drivers with

								glaucoma. 6.9% (17/249) 0f at-fault crashes involved drivers with glaucoma.
McGwin G Jr et al., 2004	Case Control	691 (576/115)	69.2	USA	ICD-9 codes 365.1 and 265.3	Drivers without glaucoma	RR (relative risk)	**All MVC per person-time**: 0.57 (0.39, 0.83)
								At-fault MVC per person-time: 1.02 (0.56, 1.87)
							Prevalence (%)	27% (153/576) of drivers with glaucoma were involved in an MVC compared to 37% (42/115) of drivers without glaucoma. 15% (87/576) of drivers with glaucoma were at-fault in a crash compared to 12% (14/115) of drivers without glaucoma.
McGwin G Jr et al., 2005	Case Control	240 (120/120)	72.9	USA	ICD-9 codes 365.1 and 265.3, given an AGIS score	Drivers with glaucoma who have not had	OR	**At-fault MVC**: 1.7(0.7, 3.7)

					from visual fields examinations – **mild defect in better eye**	an MVC between 1994 and 2000.		
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examinations **– moderate defect in better eye**		OR	**At-fault MVC:** 2 (0.7, 5.4)
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examinations – **severe defect in better eye**		OR	**At-fault MVC:** 4.2 (0.9, 15.3)
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examinations – **mild defect in worse eye**		OR	**At-fault MVC:** 1.9 (0.6, 6.1)
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examinations – **moderate defect in worse eye**		OR	**At-fault MVC:** 4.2 (1.2, 15)

					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examinations – **severe defect in worse eye**		OR	**At-fault MVC:** 9 (2.4, 33.2)
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examination – **moderate bilateral defect**		OR	**Any MVC:** 3.6 (1.4, 9.4)
					ICD-9 codes 365.1 and 265.3, given an AGIS score from visual fields examination – **severe bilateral defect**		OR	**Any MVC:** 4.4 (1.6, 12.4)
Owsley C et al., 1998	Case Control	294 (179/155)	71	USA	Physician diagnosed	Drivers without glaucoma	OR	**Injurious MVC**: 3.6 (1.2, 10.9)*
								At-fault MVC: 1.5 (0.5, 4.8)*
							Prevalence (%)	14.1% (11/78) of all injurious crash drivers had glaucoma. 6.3% (6/101) of all non-injurious crash drivers had glaucoma.

Ono T et al., 2015	Cross-sectional	386 (199/187)	64.7	Japan	**Mild POAG in the worse eye** as a visual field defect corresponding to a mean deviation (MD) of −6 dB or better	Drivers without glaucoma	OR (logistic regression)	**Any MVC**: 1.07 (0.55, 2.1)*
					Moderate POAG in the worse eye as an MD between −6 and −12 dB		OR (logistic regression)	**Any MVC**: 1.44 (0.68, 3.08)*
					Severe POAG in the worse eye as an MD of −12 dB or worse		OR (logistic regression)	**Any MVC**: 2.28 (1.07, 4.88)*
					Mild POAG in the better eye as a visual field defect corresponding to a mean deviation (MD) of −6 dB or better		OR (logistic regression)	**Any MVC**: 1.36 (0.78, 2.37)*
					Moderate POAG in the better eye as an MD between −6 and −12 dB		OR (logistic regression)	**Any MVC**: 1.82 (0.65, 5.11)*
					Severe POAG in the better eye as an MD of −12 dB or worse		OR (logistic regression)	**Any MVC**: 1.65 (0.39, 6.87)*

					Physician diagnosis of POAG in any eye		Prevalence (%)	22.6% (45/199) pf drivers with glaucoma have been in an MVC compared to 16% (30/187) of drivers without glaucoma.
Tanabe S et al., 2011	Cross-sectional	265 (121/144)	61.6	Japan	Mild POAG as a visual field defect corresponding to a mean deviation (MD) of -5 dB or better in both eyes, moderate POAG as corresponding to an MD of -5 to -10 dB in the worse eye, severe POAG as an MD of -10 dB or worse in the worse eye	Drivers free of ocular disease	OR	**Any MVC (severe glaucoma)**: 9.9 (2.1, 47.8)
							Prevalence (%)	6% (7/121) of drivers with glaucoma have been involved in an MVC compared to 3.5% (5/144) of drivers without glaucoma. When dividing by glaucoma severity, 3.9% (2/51) or moderate and 25% (5/20) of severe glaucoma drivers have been involved in a crash.

Wood J et al., 2016	Case Control	145 (75/70)	72.9	Australia	Visual acuity better than 20/40 with one or both eyes and binocular visual fields with a horizontal extent of at least 110° within 10° above and below the horizontal midline	Age-matched controls without glaucoma	Prevalence (%)	4% (3/75) of glaucoma drivers had an MVC in the past 12 months compared to 6% (4/70) of drivers without glaucoma; difference was not significant (p= 0.64)
								19% (14/75) of drivers with glaucoma had an MVC in the past 5 years compared to 23% (16/70) of drivers without glaucoma; difference was not significant (p=0.56)
Yuki K et al., 2014	Cross-sectional	247 (147/0)	63.7	Japan	Severity categorised using Mills Glaucoma Staging system – **better eye**	Drivers without history of MVC	Prevalence (%)	Amongst drivers with a history of MVCs, 11.8% (6/51), 72.5% (37/51), 9.8% (5/51), and 5.9% (3/51) had a better eye glaucoma

								severity score of 0, 1, 2, 3 or more, respectively. Amongst drivers without a history of MVC, this glaucoma score were: 20.4% (40/196), 65.8% (129/196), 9.2% (18/196), and 4.6% (9/196). The differences between proportion of people assigned these scores in the two MVC groups was not significant (p= 0.86).
					Severity categorised using Mills Glaucoma Staging system – **worse eye**			Amongst drivers with a history of MVCs, 2% (1/51), 47.1% (24/51), 23.5% (5/51) and 5.9% (3/51) had a worse eye glaucoma severity score of 0, 1, 2, 3 or more,

								respectively. Amongst drivers without a history of MVCs, the glaucoma scores were: 2.6% (5/196), 54.6% (107/196), 24.5% (48/196), and 18.3% (36/196), respectively. The differences between proportion of people assigned these scores in the two MVC groups was not significant (p= 0.86).
Yuki K et al., 2016	Prospective Cohort	191 (191/0)	63.7	Japan	Primary open angle glaucoma (POAG)	Drivers with POAG but no history of MVCs.	Prevalence (%)	15% (28/191) of drivers with glaucoma have been involved in an MVC. Of these, 64.3% (18/28) had mild, 14.3% (4/28) has moderate, and 22.4% (6/27) had severe glaucoma.
Included in Narrative Summaries Only – Low Middle Income Countries								

Deshmukh AV et al., 2019	Case Control	150 (100/50)	64.5	India	Diagnosed glaucomatous optic nerve head changes and corresponding visual field defects, which satisfied Anderson criterion	Aged-matched (older than 40 years) non-glaucoma controls	Prevalence (%)	12.9% (11/85) of drivers with glaucoma had an MVC in the past 12 months compared to 70% (35/50) of drivers without glaucoma. This significance was significant (p<0.001).

*unadjusted results

Table 4a(ii) All studies (n=8) on cataract and Motor Vehicle Crashes (MVC) with meta-analyses suitable for 2 studies on associations with any MVC involvement

Author and Year	Study Design	Total Participants (exposed/control)	Mean Age/Age Range	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR, etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Meta-analysis (any MVC involvement)								
Cross JM et al., 2009	Cross-sectional	3158 (1165/1993)	71.9	USA	Self-reported physician diagnosed	Drivers without cataract	RR (rate ratio)	**Any MVC**: 1.21 (0.95, 1.55)
Margolis KL et al., 2002	Prospective Cohort	1416 (370/1046)	71.3	USA	Self-reported physician diagnosed	Drivers without cataracts.	HR	**Any MVC:** 1.1 (0.88, 1.38)
Included in Narrative Summaries Only – High Income Countries								
Cross JM et al., 2009	Cross-sectional	3158 (1165/1993)	71.9	USA	Self-reported physician diagnosed	Drivers without cataract	RR (rate ratio)	**Injurious MVC**: 1.5 (0.85, 2.64)
								At-fault MVC: 1.01 (0.69, 1.49)
McCloskey L et al., 1994	Case Control	683 (118/672)	age, no.: 65- 69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 86	USA	Physician diagnosed (hospital data)	Age-matched drivers with cataracts who have not been injured in a police reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 1 (0.7, 1.16)*
							Prevalence (%)	17.9% (42/234) of all injurious MVCs involved drivers with cataract.

McGwin G Jr et al., 2000	Case Control	901 (447/454)	N/A	USA	Self-reported physician diagnosed	Not-at-fault drivers without cataract were involved in crashes	OR	**Not-at-fault MVC**: 1.1 (0.7, 1.8)
							Prevalence (%)	35.1% (69/198) of all not-at-fault crashes involved drives with cataract**.** 44.6% of all at-fault crashes involved drivers with cataract.
Naredo Turrado J et al., 2020	Prospective Cohort	11670 (525/11145)	62.4	France	Self-reported physician diagnosed	Drivers without cataract	OR	**Any MVC**: 1.27 (0.91, 1.76)*
Owsley C et al., 1998	Case Control	294 (179/155)	71	USA	Physician diagnosed	Drivers without cataract	OR	**Injurious MVC**: 1 (0.6, 1.8)*
								Non-injurious MVC: 1.1 (0.6, 1.8)*
							Prevalence (%)	47.4% (37/78) of injurious MVCs involved drivers with cataracts.
Owsley C et al., 1999	Case Control	384 (279/105)	69.9	USA	Cataract in one or both eyes from clinic notes with VA in one eye of 20/40 or worse and no previous	Drivers without cataract	RR (relative risk)	**At-fault MVC**: 2.46 (1, 6.16)
							X^2 (Chi Square)	The difference between the number of accidents between drivers with cataract and those

					cataract surgery in either eye			without cataract was non-significant (p= 0.19)
Owsley C et al., 2001	Cross-sectional	377 (274/103)	69.9	USA	Best-corrected VA of 20/40 or worse in worse eye eyes	Crash-free drivers	OR (logistic regression)	**Any MVC:** 1.26 (0.28, 5.59)
					Best-corrected VA of 20/40 or worse in better eyes			**Any MVC:** 1.39 (0.42, 4.62)

*unadjusted results

Table 4a(iii) All studies (n=3) on Age-Related Macular Degeneration (AMD) and Motor Vehicle Crashes (MVC) all suitable to only be summarised narratively

Author and Year	Study Design	Total Participants (exposed/ control)	Mean Age/ Age Range	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Narrative Summaries Only – High Income Countries								
Cross JM et al., 2009	Cross-sectional	3158 (88/2070)	71.9	USA	Self-reported physician diagnosed	Participants without AMD	RR (rate ratio)	**Any MVC**: 0.57 (0.23, 1.39)
								Injurious MVC: 0.9 (0.11, 7.44)
								At-fault MVC: 0.95 (0.35, 2.56)
McCloskey L et al., 1994	Case Control	683 (25/658)	age, no.: 65-69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 86	USA	Physician diagnosed (hospital data)	Age-matched drivers with AMD who had not been injured in a police-reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 0.9 (0.4, 2)*
							Prevalence (%)	3.8% (9/234) of drivers with AMD had a history of an MVC.
McGwin G Jr et al., 2013	Retrospective Cohort	205 (142/63)	72.7	USA	AREDS definition for early AMD	Participants without AMD	RR (rate ratio)	**Any MVC**: 0.48 (0.2, 1.18)* **Any MVC per 100 person-**

								years: 0.67 (0.32, 1.39)* **Any MVC per 1, 000, 000 person-miles**: 0.73 (0.36, 1.5)*
					AREDS definition for intermediate AMD			**Any MVC**: 0.22 (0.08, 0.64)* **Any MVC per 100 person-years**: 0.34 (0.13, 0.89)* **Any MVC per 1, 000, 000 person-miles**: 0.35 (0.13, 0.91)*
					AREDS definition for severe AMD			**Any MVC**: 0.46 (0.14, 1.54)* **Any MVC per 100 person-years**: 0.93 (0.31, 2.77)* **Any MVC per 1, 000, 000 person-miles**: 1.11 (0.38, 3.19)*
Szlyk et al., 1995	Case Control	21 (10/11)	73.2	USA	Physician diagnosed	Age-similar subjects with normal vision	X^2 (Chi Square)	X2= 4.68 (p<0.03); Age similar controls had more self-

								reported accidents than those with ARMD. The difference between the groups for the numbers of individuals involved in self-reported accidents was significant
						Younger control subjects with normal vision	X^2 (Chi Square)	X2= 8.06 (p=0.01); The number of self-reported accidents was significantly different between the younger control group and the ARMD group with the younger control group having more self-reported accidents.

Wood JM et al., 2018	Case Control	83 (33/50)	75.4	Australia	AREDS definition for late AMD	Aged-matched controls with no AMD	Prevalence with X^2 (Chi Square)	9% (3/33) of drivers with AMD had a crash in the past 12 months compared to 2% (1/50) of control drivers (p=0.28). 30% (10/33) of drivers with AMD had a history of 1 or more crashes in the past 5 years compared to 16% (8/50) of controls drivers (p=0.23).

*unadjusted results

Table 4a(iv) All studies (n=3) on diabetic retinopathy (DR) and Motor Vehicle Crashes (MVC) all suitable to only be summarised narratively

Author and Year	Study Design	Total Participants (Exposed/Control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR, etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate
Included in Narrative Summaries Only – High Income Countries								
Cross JM et al., 2009	Cross-sectional	3158 (98/3060)	71.9	USA	Self-reported physician diagnosed	Drivers without DR	RR (rate ratio)	**Any MVC**: 0.6 (0.26, 1.38)
								Injurious MVC: 0.95 (0.18, 4.92)
								At-fault MVC: 0.32 (0.08, 1.17)
McGwin G Jr et al., 2000	Case Control	901 (447/454)	N/A	USA	Self-reported physician diagnosed	Drivers without DR involved in not-at-fault crashes	OR	**Not at-fault MVC**: 1.9 (0.3, 10.9)
								At-fault MVC: 1.1 (0.3, 3.8)
							Prevalence (%)	1.1% (2/198) of not at-fault crash drivers had DR. 1.6% (3/249) of all at-fault crash drivers had DR.
Owsley C et al., 1998	Case Control	294 (179/155)	71	USA	Physician diagnosed	Drivers without DR	OR	**Non-injurious MVCs**:1 (0.1, 7.5)*
								Injurious MVCs: 0.7 (0.1, 8.2)*

*unadjusted results

Table 4a(v) All studies (n=5) on stereopsis impairment and Motor Vehicle Crashes (MVC) with meta-analysis suitable for 3 studies on associations with any MVC involvement

Author and Year	Study Design	Participants/ Sample Size	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Meta-analysis (any MVC involvement)								
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (80/440)	39.2	Ghana	Physician diagnosed as abnormal.	Drivers with normal stereopsis	OR	**Any MVC:** 0.89 (0.44, 1.8)*
Margolis KL et al., 2002	Prospective Cohort	1416 (N/A)	71.3	USA	Physician diagnosed - distance depth perception per standard deviation change	Drivers with normal stereopsis.	HR	**Any MVC:** 1.01 (0.92, 1.11)
Oladehinde MK et al., 2007	Cross-sectional	215 (11/204)	41.5	Nigeria	Physician diagnosed - Visual acuity of 6/6 - 6/18 was normal, < 6/18 - 6/60 was classified as visual impairment and < 6/60 - 3/60 was classified as severe visual impairment while visual acuity less than 3/60 was classified as blindness.	Drivers with normal stereopsis	RR (risk ratio)	**Any MVC:** 1.45 (0.42, 5.3)*

Included in Narrative Summaries Only – High Income Countries								
Alvarez-Peregrina C et al., 2022	Cross-sectional	736 (55/681)	46.4	Spain	Physician diagnosed	Drivers with normal stereopsis.	X^2 (Chi Square)	Stereopsis was not linked with history of MVCs (p> 0.05).
Included in Narrative Summaries Only – Low Middle Income Countries								
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (80/440)	39.2	Ghana	Physician diagnosed as abnormal.	Drivers with normal stereopsis	Prevalence (%)	25% (20/30) of drivers with abnormal stereopsis were involved in an MVC.
Humphriss D, 1987	Cross-sectional	366 (N/A)	N/A	South Africa	Visual acuity of at least 6/12 in each eye separately, or if one eye is below 6/12 then the second eye must be 616 or, wearing glasses and seeing binocularly the acuity must be 6/12. A lateral field of vision of 45 degrees is required.	Drivers with better stereopsis	Mean (SD)	Mean vision test score for stereopsis drivers without MVC involvement: 4.128 Mean vision test score for stereopsis drivers with MVC involvement: 5
Oladehinde MK et al., 2007	Cross-sectional	215 (11/204)	41.5	Nigeria	Physician diagnosed - Visual acuity of 6/6 - 6/18 was normal, < 6/18 - 6/60 was classified as visual	Drivers with normal stereopsis	Prevalence (%)	18.2% (2/11) of all drivers with abnormal stereopsis have been involved in an MVC

					impairment and < 6/60 - 3/60 was classified as severe visual impairment while visual acuity less than 3/60 was classified as blindness.			

*unadjusted results

Table 4a(vi) All studies (n=4) on myopia and Motor Vehicle Crashes (MVC), with 2 studies for meta-analysis

Author and Year	Study Design	Total Participants (exposed/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Meta-analysis (any MVC involvement)								
Ahmed M et al., 2021	Cross-sectional	700 (62/638)	42.3	Bangladesh	Physician diagnosed	Drivers without myopia but with a history of MVCs	OR	**Any MVC:** 0.5 (0.15, 1.65)*
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (10/510)	39.2	Ghana	Physician diagnosed – spherical power in the better eye of -0.50D or worse	Drivers without myopia but with a history of MVCs	OR	**Any MVC**: 0.99 (0.41, 2.4)*
Included in Narrative Summaries Only – High Income Countries								
Cohen Y et al., 2007	Cross-sectional	136 (34/102)	21	Israel	Night myopia: refraction in illumination and in total darkness in both eyes changed by 0.75 D or more	Drivers without night myopia	Fischer's Exact Test	No statistically significant difference in day time crashes between night myopia and normal subjects (p= 0.22). Night myopia drivers had higher night-time crashes than non-night myopia drivers (p=0.044).

McCloskey L et al., 1994	Case Control	683 (235/448)	age, no.: 65- 69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 86	USA	Physician diagnosed (hospital data)	Age-matched drivers with myopia who have not been injured in a police-reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 0.6 (0.1, 1)*

*unadjusted results

Table 4a(vii) All studies (n=8) on colour vision deficiency (CVD) and Motor Vehicle Crashes (MVC), all suitable to only be summarised narratively due to methodological limitations in non-standardised diagnosis of colour vision deficiencies

Additional Narrative Summary: One study looking at the different types of colour deficiency found individuals with protan colour deficiency, measured by Hardy-Rand Rittler (HRR) pseudo-isochromatic plates, to report significantly more MVCs than those with deutan colour deficiency (p= 0.034).								
Author and Year	**Study Design**	**Total Participants (exposed/control)**	**Mean Age/Age Range**	**Country**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR, etc.?)**	**Effect Measure (with 95% CI) + any description of results (if appropriate)**
Included in Narrative Summaries Only – High Income Countries								
Piyasena P et al., 2021	Systematic review	15394 (254/15140)	39.3	N/A	Physician diagnosed	Drivers without colour deficiencies.	RR	**Any MVC:** 1.36 (1.01, 1.82)*
Included in Narrative Summaries Only – Low Middle Income Countries								
Abebe Y et al., 2002	Cross-sectional	1878 (85/1794)	33.5	Ethiopia	Physician diagnosed - Ishihara plates	Drivers without colour deficiencies.	OR	**Any MVC:** 1.94 (1.18, 3.17)
							Prevalence (%)	32% (27/85) of all drivers with colour blindness were involved in an MVC.
Biza M et al., 2013	Cross-sectional	249 (4/245)	33.6	Ethiopia	Physician diagnosed - Ishihara plates	Drivers without colour deficiencies.	OR	**Any MVC:** 2.34 (0.19, 28.58)
							Prevalence (%)	25% (1/4) of all drivers with colour blindness were involved in an MVC.
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (37/483)	39.2	Ghana	Protan colour deficient – Hardy-Rand	Deutan colour deficient	Prevalence (%)	52.9% (9/17) of proton colour blindness drivers

					Rittler (HRR) pseudo-isochromatic plate			were involved in an MVC compared to 30.8% (4/13) of deutan colour blindness drivers; X2= 6.194 (p=0.034)
								35% (13/37) of all colour blind drivers were involved in an MVC.
							X^2 (Chi Square)	Protan colour blind drivers were more likely to report MVCs than deutan colour blind drivers: 6.194 (p= 0.034)
Isawumi MA et al., 2011	Cross-sectional	99 (6/93)	45.9	Nigeria	Physician diagnosed - Ishihara plates	Drivers with an MVC history without colour deficiencies.	X^2 (Chi Square)	X^2= 0.09, p=0.76 No significance between the number of MVC involvement in those with colour blindness and those without.
							Prevalence (%)	33% (2/6) of all drivers with colour blindness

								were involved in an MVC.
Oladehinde MK et al., 2007	Cross-sectional	215 (7/208)	41.5	Nigeria	Physician diagnosed - Ishihara plates	Drivers without a history of MVCs	RR (risk ratio)	**Any MVC:** 1.12 (10.3, 11.5)
							Prevalence (%)	2% (1/57) of all recorded MVCs involved colour blind drivers.
							X^2 (Chi Square)	There were no statistically significant associations between colour vision impairment and RTA: 2.3 (p= 0.1)
Ovenseri-Ogomo G et al., 2011	Cross-sectional	206 (7/199)	39.2	Ghana	VA < 6/18 in the better eye)	Drivers without a history of MVCs	X^2 (Chi Square)	No significance found for MVC involvement in drivers with colour blindness: X^2= 2.142, p=0.344
Pepple G et al., 2014	Cross-sectional	400 (262/138)	37.8	Nigeria	Physician diagnosed - Ishihara plates	Drivers without colour blindness.	RR (did not state test used)	**Any MVC**: 1.23 (p=0.4)*
							Prevalence (%)	56% (10/18) of drivers with colour blindness were involved in an MVC.

*unadjusted results

Table 4a(viii) All studies (n=28) on visual acuity (VA) impairment and Motor Vehicle Crashes (MVC) with meta-analysis suitable for 5 studies on any crash involvement and 2 on at-fault crashes

Additional Narrative Summary:
Results for injurious crashes were mixed; all non-significant. Similarly, there were no significant risks found for non-injurious and at-fault crash involvement, irrespective of worsening VA. One study looking at visual acuity in normal and low luminance also found poor acuity to not be a significant predictor of crash risk in both lighting conditions. A Japanese study, however, found the odds of crashing to increase by 20% in drivers with primary open angle glaucoma (POAG) experiencing worse eye declines of 0.01 LogMAR increments compared to those without VA changes.

Author and Year	Study Design	Total Participants (exposed/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Meta-analysis (any MVC involvement)								
Green K et al., 2013	Retrospective Cohort	2000 (N/A)	Age, no.: 70-79 years = 1432, 80-89 years = 526, 90-99 years = 40	USA	VA worse than 20/40	Drivers with VA 20/40 or better	RR (rate ratio)	**Any MVC**: 1.04 (0.74, 1.48)
Huisingh C et a., 2017	Prospective Cohort	659 (35/624)	N/A	USA	Distance VA > 0.3logMAR	Drivers with VA 20/40 or better	RR (rate ratio)	**Any MVC:** 0.98 (0.52, 1.84)
Margolis KL et al., 2002	Prospective Cohort	1416 (N/A)	N/A	USA	20/40 or worse	Drivers with VA 20/40 or better	HR	**Any MVC:** 1.14 (0.73, 1.8)
Piyasena P et al., 2021	Systematic Review	15394 (710/14684)	39.3	N/A	Physician diagnosed	Drivers without a vision impairment	RR	**Any MVC:** 1.46 (1.2, 1.78)

Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350	USA	Physician diagnosed – 15-letter loss of visual acuity (0.3 logMAR i.e. VA 20/40)	Drivers with a VA better than 20/40.	HR	**Any MVC:** 1.06 (0.77, 1.68)
Included in Meta-analysis (at-fault MVC involvement)								
Green K et al., 2013	Retrospective Cohort	2000 (N/A)	Age, no.: 70-79 years = 1432, 80-89 years = 526, 90-99 years = 40	USA	VA worse than 20/40 = impairment	Drivers with VA better than 20/40	RR (rate ratio)	**At-fault MVC**: 1.08 (0.71, 1.4)
Huisingh C et a., 2017	Prospective Cohort	659 (35/624)	N/A	USA	Distance VA > 0.3logMAR	Drivers with VA 20/40 or better	RR (rate ratio)	**At-fault MVC:** 1.09 (0.58, 2.05
Included in Narrative Summary Only – High Income Countries								
Alvarez-Peregrina C et al., 2021	Cross-sectional	736 (548/188)	46.4	Spain	Physician diagnosed - cut-off not defined in study	Drivers without a VA impairment	X^2 (Chi Square)	Poor VA was linked with increased risk of MVCs (p< 0.001).
Cross JM et al., 2009	Cross-sectional	3158 (1323/1835)	71.9	USA	VA worse 20/20 and better 20/40	Those with binocular acuity of 20/20 or better in any MVC	RR (rate ratio)	**Any MVC:** 1 (0.78, 1.29)

					VA worse 20/20 and better 20/40	Those with binocular acuity of 20/20 or better in injurious MVC		**Injurious MVC:** 0.54 (0.28, 1.01)
					VA worse 20/20 and better 20/40	Those with binocular acuity of 20/20 or better in at-fault MVC		**At-fault MVC:** 1.08 (0.72, 1.62)
					VA 20/40 or worse	Those with binocular acuity of 20/20 or better in any MVC		**Any MVC:** 1.24 (0.74, 2.09)
					VA 20/40 or worse	Those with binocular acuity of 20/20 or better in injurious MVC		**Injurious MVC:** 0.55 (0.11, 2.8)
					VA 20/40 or worse	Those with binocular acuity of 20/20 or better in at-fault MVC		**At-fault MVC:** 1.37 (0.66, 2.82)
Gresset J et al., 1994	Case Control	4036 (151/3885)	N/A	Canada	Physician diagnosed poor VA	Those with better VA	OR	**Any MVC:** 0.99 (0.71, 1.4)
							Prevalence (%)	8.4% (118/1400) of those involved in an MVC had poor VA.

Gresset J et al., 1994	Case Control	4021 (N/A)	N/A	Canada	VA equal to 6/12 or 6/15 and normal binocularity	Drivers with VA 20/40 or better	OR	**Any MVC**: 0.97 (0.68, 1.38)*
					VA equal to 6/12 or 6/15 and lack of binocular vision			**Any MVC:** 1.23 (0.88, 1.72)*
Huisingh C et a., 2017	Prospective Cohort	659 (35/624)	N/A	USA	Distance VA > 0.3logMAR	Drivers with VA 20/40 or better	RR (rate ratio)	**Major MVC:** 0.81 (0.29, 2.26)
								Any MVC: 1.29 (0.87, 1.93)
		659 (74/585)			Near VA > 0.3 logMAR			**Major MVC:** 1.54 (0.9, 2.63)
								At-fault MVC: 1.19 (0.77, 1.85)
Ivers R et al., 1999	Cross-sectional	3654 (N/A)	N/A	Australia	Best eye VA <20/40-20/60	drivers with Best eye VA >/=20/40	Prevalence ratio (PR)	**Any MVC:** 1.3 (0.6, 2.8)
					Best eye VA <20/60	drivers with Best eye VA >/=20/40		**Any MVC:** 1.2 (0.3, 5)
					Right eye VA <20/40-20/60	drivers with Right eye VA >/=20/40		**Any MVC:** 0.7 (0.3, 1.6)
					right eye VA<20/60	drivers with right eye VA >/=20/40		**Any MVC:** 2 (1.2, 3.5)
					left eye VA <20/40-20/60	drivers with left eye VA >/=20/40		**Any MVC:** 1.1 (0.5, 2)

					left eye VA<20/60	drivers with left eye VA >/=20/40		**Any MVC:** 1.1 (0.5, 24)
Keeffe JE et al., 2002	Retrospective Cohort	2594 (N/A)	62.5	Australia	Visual acuity <6/12	Drivers with better vision (>6/12)	X^2 (Chi Square)	People with impaired vision (<6/12) were no more likely to have an accident or to attribute that the accident was the result of impaired vision; X2= 0.175 (p>0.9)
							Prevalence (%)	9.5% (32/339) of participant involved in an MVC had poor VA.
Kwon M et al., 2016	Cross-sectional	1899 (145/1754)	age, no.: 70-79 years = 1358, 80-89 years = 502, 90-98 years = 39	USA	Low VA classified as <20/40 (0.3 logMAR)	Drivers with glaucoma and binocular VA ≥ 20/20	RR (rate ratio)	**Any MVC:** 1.51 (0.55, 4.16)
McCloskey L et al., 1994	Case Control	683	age, no.: 65- 69 years = 264, 70-74	USA	Uncorrected VA of 20/25 or 20/30	Drivers with VA 20/15 or 20/20	RR (relative risk)	**Injurious MVC**: 2.5 (0.8, 7.2)*

			years = 195, 75-79 years = 138, 80+ years = 86		Uncorrected VA of 20/40			**Injurious MVC:** 1.7 (0.6, 5.3)*
					Uncorrected VA 20/50 or 20/60			**Injurious MVC:** 2.4 (0.8, 7.2)*
					Uncorrected VA 20/70 of greater			**Injurious MVC:** 2.1 (0.7, 5.8)*
					Corrected VA 20/25 or 20/30			**Injurious MVC:** 0.7 (0.5, 1.1)*
					Corrected VA 20/40			**Injurious MVC:** 0.6 (0.3, 1.2)*
					Uncorrected VA 20/50 or 20/60			**Injurious MVC:** 0.3 (0.1, 0.9)*
					Uncorrected VA 20/70 of greater			**Injurious MVC:** 4.3 (0.5, 40.3)*
McGwin G Jr et al., 2000	Case Control	901 (104/797)	N/A	USA	Near vision impairment	Not-at-fault drivers involved in crashes without poor near vision	OR	**Not-at-fault MVC:** 1.6 (0.8, 3.3)
							Prevalence (%)	8% (16/198) of not-at-fault MVCs involved drivers with near vision impairment. 13.2% (33/249) of at-fault MVCs involved drivers

								with near vision impairment.
		901 (339/562)			Far vision impairment	Not-at-fault drivers involved in crashes without poor far vision	OR	**Not-at-fault MVC:** 1.1 (0.7, 1.7)
							Prevalence (%)	36% (71/198) of not-at-fault crashes involved drivers with far vision impairment. 41% (102/249) of at-fault crashes involved drivers with far vision impairment.
		901 (57/844)			Peripheral vision impairment	Not-at-fault drivers involved in crashes without poor peripheral vision	OR	**Not-at-fault MVC:** 1.6 (0.7, 3.9)
							Prevalence (%)	4.7% (9/198) of not-at-fault crashes involved drivers with peripheral vision impairment. 8.5% of at-fault crashes

								involved drivers with peripheral vision impairment.
Ono T et al., 2015	Cross-sectional	386 (N/A)	64.7	Japan	BCVA in the **better eye** LogMAR per 0.1 increment	POAG drivers with BCVA in both eyes of 0.7 or more	OR	**Any MVC:** 0.94 (0.87, 1.01)
Owsley C et al., 2001	Cross-sectional	377 (136/241)	69.9	USA	VA 20/25 - 20/30 in better eye	Drivers with VA 20/25 or better in the **better eye**	OR	**At-fault MVC:** 1.88 (0.72, 4.88)
		377 (118/259)			VA 20/35 - 20/50 in better eye			**At-fault MVC:** 2.54 (0.87, 7.47)
		377 (77/300)			worse than VA 20/50 in better eye			**At-fault MVC:** 1.75 (0.45, 6.85)
		377 (51/326)			VA 20/25 - 20/30 in worse eye	Drivers with VA 20/25 or better in the **worse eye**		**At-fault MVC:** 0.19 (0.03, 1.27)
		377 (67/310)			VA 20/35 - 20/50 in worse eye			**At-fault MVC:** 0.82 (0.19, 3.61)
		377 (110/267)			worse than VA 20/50 in worse eye			**At-fault MVC:** 0.74 (0.16, 3.52)
		377 (N/A)			VA impairment defined as worse than 20/50 in only 1 eye	Drivers with no VA impairment (better than VA 20/50)		**At-fault MVC:** 1.35 (0.58, 3.15)

		377 (N/A)			VA impairment defined as worse than 20/50 in both eyes	Drivers with no VA impairment (better than VA 20/50)		**At-fault MVC:** 1.01 (0.29, 3.45)
Owsley C et al., 1998	Case Control	294 (36/258)	71	USA	VA worse than 20/40	Drivers with VA 20/40 or better	OR	**Injurious MVC:** 1.6 (0.6, 3.8)*
								Non-injurious MVC: 1.6 (0.7, 3.6)*
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350	USA	Physician diagnosed – 15-letter loss of visual acuity (0.3 logMAR i.e. VA 20/40)	Drivers with a VA better than 20/40.	HR	**Any MVC (at low luminance):** 1.06 (0.75, 1.47)
Sims RV et al., 1998	Case Control	174 (N/A)	71.1	USA	Physician Diagnosed	Older drivers without crashes in 6 years preceding 1991	Univariate analysis using student t-tests	Mean (SD) VA of those with a history of MVCs was 0.09 (0.31), compared to 0.03 (0.19) in those without a history of MVCs (p= 0.001).
Yuki K et al., 2014	Cross-sectional	247 (N/A)	63.7	Japan	Physician diagnosed as better VA (LogMar)	Drivers with POAG but without a	Unpaired t-test with Benjamini's correction	Differences between the VA of those who had a history of

						history of MVCs		an MVC and those who did not was significant, p= 0.036
					Physician diagnosed as worse VA (logMar)			Differences between the VA of those who had a history of an MVC and those who did not was not significant, p= 0.6
Yuki K et al., 2016	Prospective Cohort	191 (N/A)	63.7	Japan	POAG with 0.01 logMAR increase in **worse eye**	Drivers with POAG but without a history of MVCs	OR	**Any MVC:** 1.2 (1.1, 1.4)*
					POAG with 0.001 increase logMAR in **the better eye**			**Any MVC:** 0.68 (0, 221)*
Included in Narrative Summaries only – Low Income Countries								
Adekoya BJ et al., 2009	Cross-sectional	399 (N/A)	44.7	Nigeria	VA 6/9 in the better eye	N/A – looked at all participants	X^2 (Chi Square)	Inadequate VA in the better eye is not associated with MVC involvement in the last 10 years; X2= 0.035 (p= 0.851)

					VA 6/24 in the better eye		X^2 (Chi Square)	Inadequate VA in the second eye is not associated with involvement in RTA in the last 10 years; X2= 0.372 (p= 0.542)
Bekibele CO et al., 2007	Cross-sectional	99 (16/83)	50.1	Nigeria	Presenting vision less than 6/9 and improved with the aid of a minimum of 0.5 Diopter lenses, with VA <6/18	Drivers without refractive error	OR	**Any MVC:** 1.2 (0.4, 3.7)*
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (38/482)	39.2	Ghana	Visual acuity of less than 0.2, either monocularly or binocularly, was classified as poor vision	N/A	X^2 (Chi Square)	No statistically significantly associations between poor vision due to refractive error and MVC involvement: X2= 3.090 (p= 0.388)
Humphriss D, 1987	Cross-sectional	366 (N/A)	N/A	South Africa	Binocular	Better mean vision test scores for binocular VA	Mean (SD)	Drivers involved in accidents were more likely to have worse mean vision test

								scores (10.031) for binocular VA compared to accident-free drivers (10.847), p<0.001
					right eye monocular VA	Better mean vision test scores for right eye monocular VA	Mean (SD)	Drivers involved in accidents more likely to have worse mean vision test scores (9.219) for right eye monocular VA compared to accident-free drivers (10.100), p<0.001
					left eye monocular VA	Better mean vision test scores for left eye monocular VA	Mean (SD)	Drivers involved in accidents more likely to have worse mean vision test scores (9.031) for left eye monocular VA compared to accident-free drivers (10.024), p<0.001

					Worse eye monocular acuity	Better mean vision test scores for worse eye monocular VA	Mean (SD)	Drivers involved in accidents more likely to have worse mean vision test scores for depth perception (4.128) compared to accident-free drivers (5.000), p<0.001
Isawumi MA et al., 2011	Cross-sectional	99 (5/94)	45.9	Nigeria	Poor driving vision if VA <6/12 in either eye	Drivers with an MVC but with normal vision.	X^2 (Chi Square)	MVCs were not directly related with VA and vice versa; X2= 1.6 (p= 0.65)
Oladehinde MK et al., 2007	Cross-sectional	215	41.5	Nigeria	Visual acuity < 6/18 - 6/60 was classified as visual impairment and < 6/60 - 3/60 was classified as severe visual impairment. VA < 3/60 was classified as blindness.	Drivers with VA 20/20 - 20/40	RR (did not state test used)	**Any MVC:** 3.5 (2.38, 5.14)*
Ogbonnaya CE et al., 2018	Cross-sectional	103 (7/96)	43.2	Nigeria	Minimum VA of 6/9 in the	Drivers without vision	X^2 (Chi Square)	The relationship between visual

					better eye and 6/12 in the worse eye of commercial motor vehicle drivers. Visually unfit to drive if VA <6/12 in the poorer eye.	impairment and no MVC history.		acuity fitness for driving and self-reported history of MVC was not statistically significant; X2= 0.05 (p= 0.82).
Ovenseri-Ogomo G et al., 2011	Cross-sectional	206 (14/192)	39.2	Ghana	VA < 6/18 in the better eye	Drivers without a history of MVC	X^2 (Chi Square)	VA not associated with history of MVC involvement; X^2= 5.982 (p=0.05)
Vofo BN et al. 2021	Cross-sectional	207 (51/156)	41.8	Cameroon	VA < 0.5	Drivers with VA > 0.5	Mean (SD)	Drivers with VA < 0.5 had a higher than average number of MVCs (2.91 +/- 1.72) compared to drives with VA > 0.5 (1.01 +/- 1.33).

*unadjusted results

Table 4a(ix) All studies (n=13) on contrast sensitivity (CS) impairment and Motor Vehicle Crashes (MVC), with only two studies suitable for meta-analysis due to different CS cut-off points, type of crash outcome explored and comparators used for each study.

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR, etc. ?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Meta-analysis (any MVC involvement)								
Huisingh C et al., 2017	Prospective Cohort	659 (291/368)	N/A	USA	CS in better eye (< 1.5)	Drivers with CS ≥ 1.5 in better eye	RR (rate ratio)	**Any MVC**: 1.22 (0.82, 1.81)
Swain TA et al., 2021	Cross-sectional	159 (17/142)	79.3	USA	CS of <1.5 log sensitivity in the worse eye	Drivers with CS of >1.5 log sensitivity in the worse eye	RR	**Any MVC:** 1.5 (0.8, 3.2)
Included in Narrative Summaries Only – High Income Countries								
Cross JM et al., 2009	Cross-sectional	3158 (1323/1835)	71.9	USA	CS is >=1.575 and <1.675	Drivers without binocular CS impairments	RR (rate ratio)	**Any MVC:** 0.91 (0.68, 1.23)
								Injurious MVC: 0.94 (0.56, 1.58)
								At-fault MVC: 0.72 (0.49, 1.05)
					CS is >=1.450 and <1.575	Drivers without binocular CS	RR (cox proportional hazards)	**Any MVC:** 0.72 (0.49, 1.05)
								Injurious MVC: 0.71 (0.32, 1.56)
								At-fault MVC: 0.87 (0.49, 1.56)
					CS is <1.450	Drivers without binocular CS	RR (cox proportional hazards)	**Any MVC:** 1.01 (0.66, 1.55)
								Injurious MVC: 0.49 (0.16, 2.37)

								At-fault MVC: 1.27 (0.68, 2.37)
Green K et al., 2013	Retrospective Cohort	2000 (N/A)	Age, no.: 70-79 years = 1432, 80-89 years = 526, 90-99 years = 40	USA	Impairment defined as <1.5 on Pelli-Robson chart.	Drivers without binocular CS impairments	RR (rate ratio)	**Any MVC**; 1.42 (1, 2.02)
								At-fault MVC: 1.52 (0.93, 2.68)
Huisingh C et al., 2017	Prospective Cohort	659 (291/368)	N/A	USA	CS in worse eye (< 1.5)	Drivers with CS ≥ 1.5 in worse eye		**Any MVC:** 1.38 (1.05, 1.81)
					CS in better eye (< 1.5)	Drivers with CS ≥ 1.5 in better eye		**Major crash involvement**: 1.29 (0.77, 2.18)
					CS in worse eye (< 1.5)	Drivers with CS ≥ 1.5 in worse eye		**Major crash involvement:** 1.54 (1.07, 2.23)
					CS in better eye (< 1.5)	Drivers with CS ≥ 1.5 in better eye		**At-fault MVC:** 1.28 (0.84, 1.94)
					CS in worse eye (< 1.5)	Drivers with CS ≥ 1.5 in worse eye		**At-fault MVC: 1.44** (1.08, 1.93)
Ivers R et al., 1999	Cross-sectional	3654 (N/A)	N/A	Australia	Vectorvision CSV-1000 chart: 3 cycle per degree in best eye CS	Reference group ≤ 2 units compared with >2 on a scale of 1-8	PR (Prevalence Ratio)	**Any MVC:** 1.3 (0.7, 2.2)

					Vectorvision CSV-1000 chart: 6 cycle per degree in best eye CS eye CS			**Any MVC:** 1.2 (0.7, 2.1)
					Vectorvision CSV-1000 chart: 12 cycle per degree in best eye CS			**Any MVC:** 1.4 (0.8, 2.3)
					Vectorvision CSV-1000 chart: 18 cycle per degree in best eye CS			**Any MVC:** 1.4 (0.9, 2.3)
					Vectorvision CSV-1000 chart: 3 cycle per degree in right eye CS			**Any MVC:** 1.2 (0.8, 1.9)
					Vectorvision CSV-1000 chart: 6 cycle per degree in right eye CS eye CS			**Any MVC:** 1 (0.6, 1.5)
					Vectorvision CSV-1000 chart: 12 cycle per degree in right eye CS			**Any MVC:** 2 (1.2, 3.1)

					Vectorvision CSV-1000 chart: 18 cycle per degree in right eye CS			**Any MVC:** 1.3 (0.8, 2.2)
					Vectorvision CSV-1000 chart: 3 cycle per degree in left eye CS			**Any MVC:** 1 (0.6, 1.6)
					Vectorvision CSV-1000 chart: 6 cycle per degree in left eye CS eye CS			**Any MVC:** 1.1 (0.6, 1.7)
					Vectorvision CSV-1000 chart: 12 cycle per degree in left eye CS			**Any MVC:** 1.3 (0.8, 2.2)
					Vectorvision CSV-1000 chart: 18 cycle per degree in left eye CS			**Any MVC:** 1.3 (0.8, 2.1)
Kwon M et al., 2016	Cross-sectional	1899 (432/1467)	age, no.: 70-79 years = 1358, 80-89 years =	USA	Pelli-Robson chart measure of ≤ 1.6 log sensitivity was defined as an impairment.	Older drivers with glaucoma, without CS impairment	RR (rate ratio)	**Any MVC**: 0.72 (0.36, 1.42)

			502, 90-98 years = 39					
Margolis KL et al., 2002	Prospective Cohort	1416 (N/A)	71.3	USA	low spatial frequencies per standard deviation change	N/A – looked at MVC information from all participants from 1986-1995	HR	**Any MVC:** 0.99 (0.89, 1.1)
					high spatial frequencies per standard deviation change			**Any MVC:** 0.94 (0.85, 1.04)
Owsley C et al., 1998	Case Control	294 (56/238)	71	USA	Pelli-Robson chart measure of <= 1.5 log sensitivity was defined as an impairment.	Older drivers with log(CS) >1.5	OR	**Injurious MVC:** 0.9 (0.4, 1.8)*
								Non-injurious MVC: 0.7 (0.3, 1.3)*
Owsley C et al., 2001	Cross-sectional	377 (274/103)	69.9	USA	CS impairment defined as ≤1.25	Participants with no CS impairment (CS >=1.50)	OR	**At-fault MVC (better eye CS >1.35 – 2.50):** 1.18 (0.41, 3.36)
								At-fault MVC (better eye CS >1.25-1.35): 1.21 (0.4, 3.68)
								At-fault MVC (better eye CS ≤1.25): 3.78 (1.15, 12.48)

								At-fault MVC (worse eye CS >1.35 – 2.50): 3.28 (0.71, 14.17)
								At-fault MVC (worse eye CS >1.25-1.35): 4.36 (0.84, 22.7)
								At-fault MVC (worse eye CS ≤1.25): 7.86 (1.55, 39.79)
								At-fault MVC (unilateral CS ≤1.25): 2.7 (1.16, 6.51)
								At-fault MVC (bilateral CS ≤1.25): 5.78 (1.87, 18.86)
Owsley C et al., 2020	Cross-sectional	915 (179/155)	age, no.: 60-69 years = 310, 70-79 years = 396, 80-90 years =	USA	Low photopic area under the log CS function	Drivers with higher photopic peak log sensitivity	RR (rate ratio)	**All MVC:** 0.8 (0.61, 1.04)
								At-fault MVC: 0.77 (0.57, 1.03)
					Low photopic peak log sensitivity			**All MVC:** 0.8 (0.61, 1.04)
								At-fault MVC: 0.77 (0.58, 1.03)

			200, 90-99 years = 9		Low mesopic area under the log CS function	Drivers with higher mesopic peak log sensitivity		**All MVC:** 1.36 (1.06, 1.72)
								At-fault MVC: 1.28 (1.01, 1.63)
					Low mesopic peak log sensitivity			**All MVC**: 1.5 (1.16, 1.93)
								At-fault MVC: 1.38 (1.07, 1.78)
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350	USA	Pelli-Robson Chart: 6 letter worsening (worsening of 0.3 logCS units)	N/A – looked at driver with and without MVC in whole population.	HR	**Any MVC when CS < 1.7**: 0.75 (0.49, 1.21)
								Any MVC when CS ≥ 1.7: 1.25 (0.44, 5.65)
Swain TA et al., 2021	Prospective Cohort	154 (17/137)	79.3	USA	CS of <1.5 log sensitivity in the worse eye	Drivers with CS of >1.5 log sensitivity in the worse eye	RR	**At-fault or near crash involvement:** 2.7 (1.3, 5.5)

Table 4a(x) All studies (n=20) on visual field (VF) impairment and Motor Vehicle Crashes (MVC) with meta-analysis suitable for only four studies on associations with any MVC involvement

Additional Narrative Summary:
When comparing impairments in the upper, lower, left, right, vertical and horizontal visual fields, impairments on the left side were found to be the most significant predictor of crash involvement (data from US, driving on right side of road).

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR, etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in meta-analysis (any MVC involvement)								
Huisingh C et al., 2015	Cross-sectional	2000 (N/A)	N/A	USA	Bilateral VF impairment	Drivers without visual field impairments	RR (rate ratio)	**Any MVC:** 1.4 (1.07, 1.83)
Oladehinde MK et al., 2007	Cross-sectional	215 (22/193)	41.5	Nigeria	Bilateral VF impairment	Drivers without a MVC history	RR (risk ratio)	**Any MVC:** 1.07 (0.98, 6.73)
Piyasena P et al., 2021	Systematic Review	15394 (337/15057)	39.3	N/A	Physician Diagnosed	Drivers without VF impairment	RR	**Any MVC:** 1.36 (1.25, 1.48)
Swain TA et al., 2021	Cross-sectional	159 (40/119)	79.3	USA	Overall VF loss of ≤ 22.4dB in the worse eye	Drivers with no overall VF loss in the worse eye	RR	**Any MVC**: 1.6 (0.8, 3.1)
Included in Narrative Summaries Only – High Income Countries								
Ball K et al., 1993	Cross-sectional	294 (N/A)	71	USA	Sensitivity loss in the 30 to 60 degree region of the visual field	N/A	Spearman's Correlation (r)	VF loss was significantly related to crash frequency however the LISREL model shows that it only has indirect effects

								on crash frequency but direct effects on UFOV which is the most significantly associated variable with crash frequency; 0.26
Huisingh C et al., 2015	Cross-sectional	2000 (N/A)	N/A	USA	Upper field impairments	Drivers without visual field impairments	RR (rate ratio)	**Any MVC**: 1.1 (0.83, 1.44)
					Lower Field Impairments			**Any MVC:** 1.4 (1.07, 1.82)
					Horizontal Meridian Impairments			**Any MVC:** 1.31 (1, 1.72)
					Vertical Meridian Impairments			**Any MVC:** 1.26 (0.97, 1.65)
					Left Side impairments			**Any MVC:** 1.49 (1.15, 1.92)
					Right side impairments			**Any MVC:** 1.16 (0.88, 1.53)
Huisingh C et al., 2017	Prospective Cohort	659 (406/253)	N/A	USA	Peripheral visual field loss at 70 or 85 degrees temporally in **either eye**	Drivers with no visual field loss in either eye	RR (rate ratio)	**Any MVC:** 1.08 (0.8, 1.47)
								Major MVC: 1.53 (1.02, 2.29)
								At-fault MVC: 0.98 (0.71, 1.37)

		659 (186/473)			Peripheral visual field loss at 70 or 85 degrees temporally in **both eye**	Drivers with no visual field loss in both eyes		**Any MVC:** 1.74 (1.18, 2.56) **Major MVC:** 2.32 (1.4, 3.83) **At-fault MVC:** 0.73 (1.14, 2.61)
Kwon M et al., 2016	Cross-sectional	1899 (N/A)	age, no.: 70-79 years = 1358, 80-89 years = 502, 90-98 years = 39	USA	Overall visual field loss ≤ 22.5 dB	Drivers (with glaucoma) without severe visual field loss.	RR (rate ratio)	**Any MVC:** 2.11 (1.09, 4.09)
					Upper visual field loss ≤ 22.5 dB			**Any MVC:** 2.37 (1.19, 4.74)
					Lower visual field loss ≤ 22.5 dB			**Any MVC:** 2.32 (1.13, 4.75)
					Left visual field loss ≤ 22.5 dB			**Any MVC:** 3.16 (1.55, 6.46)
					Right visual field loss ≤ 22.5 dB			**Any MVC:** 1.63 (0.84, 3.14)
					Horizontal meridian loss ≤ 22.5 dB			**Any MVC:** 1.78 (0.92, 3.44)
					Vertical meridian loss ≤ 22.5 dB			**Any MVC:** 1.09 (0.56, 2.11)
Kristalovich L et al., 2019	Retrospective cohort	445 (286/159)	N/A	Canada	Loss of at least 120 continuous degrees along the horizontal meridian and 15 continuous	Drivers with either no VFI or with VFI but meeting licensing standards	X^2 (Chi Square)	No significant difference in rate of crash between VFI/not meet licensing

					degrees above and below fixation with both eyes open and examined together.			standards and no VFI and VFI/meet licensing standards (p=0.402)
McGwin G Jr et al., 2015	Retrospective Cohort	438 (N/A)	72.8	USA	Binocular visual field **total deviations <7.25**	Drivers (with glaucoma) without severe visual field impairments	RR (rate ratio)	**At-fault MVC:** 1.5 (0.82, 2.74)
					Binocular visual impairment severely **impaired threshold** <20.4			**At-fault MVC:** 1.49 (0.81, 2.74)
					Binocular visual impairment severely impaired **pattern deviation <3.97**			**At-fault MVC:** 2.13 (1.21, 3.75)
Owsley C et al., 1998	Case Control	294 (36/258)	71	USA	Central 30 degree VF sensitivity: >10	Older drivers with central 30 degree VF sensitivity of 0-10	OR	**Injurious MVC:** 2.6 (1.1, 6.3)*
								Non-injurious MVC: 1.8 (0.8, 4.4)*
		294 (108/186)			Peripheral 20-60 degree VF sensitivity: >10	Older drivers with peripheral 30-60 degree VF sensitivity of 0-10		**Injurious MVC:** 2.4 (1.3, 4.5)*
								Non-injurious MVC: 1.8 (1, 3.1)*
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69	USA	Binocular visual field <20 (loss of 15 points)	N/A – looked at drivers with and without MVC in	HR	**Any MVC:** 0.59 (0.34, 1)

			years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350		Binocular visual field >=20 (loss of 15 points)	whole population.		**Any MVC:** 1.31 (1.31, 4.27)
Swain TA et al., 2021	Cross-sectional	159 (41/118)			Peripheral VF loss of ≤ 19.2dB in the worse eye	Drivers with no peripheral VF loss in the worse eye		**Any MVC:** 2.4 (1.3, 4.4)
		159 (41/118)			Superior VL loss of ≤ 22.0dB in the worse eye	Drivers with no superior VF loss in the worse eye		**Any MVC:** 0.7 (0.4, 1.5)
		159 (41/118)			Inferior VL loss of ≤ 22.1dB in the worse eye	Drivers with no inferior VF loss in the worse eye		**Any MVC:** 1.7 (0.4, 1.5)
		159 (40/119)			Left VL loss of ≤ 21.6dB in the worse eye	Drivers with no left VF loss in the worse eye		**Any MVC:** 1.7 (0.9, 3.2)
		159 (41/118)			Right VF loss of ≤ 21.8dB in the worse eye	Drivers with no right VF loss in the worse eye		**Any MVC:** 1.6 (0.9, 3)
Swain TA et al., 2021	Prospective Cohort	154 (38/116)	79.3	USA	Overall VF loss of ≤ 22.4dB in the worse eye	Drivers with no overall VF loss in the worse eye	RR	**At-fault or near crash:** 1.4 (0.8, 2.8)

		154 (40/114)			Peripheral VF loss of ≤ 19.2dB in the worse eye	Drivers with no peripheral VF loss in the worse eye		**At-fault or near crash:** 1.8 (1, 3.3)
		154 (43/111)			Superior VL loss of ≤ 22.0dB in the worse eye	Drivers with no superior VF loss in the worse eye		**At-fault or near crash:** (1.3 (0.7, 2.5)
		154 (41/113)			Inferior VL loss of ≤ 22.1dB in the worse eye	Drivers with no inferior VF loss in the worse eye		**At-fault or near crash:** (1.4, 0.8, 2.5)
		154 (42/112)			Left VL loss of ≤ 21.6dB in the worse eye	Drivers with no left VF loss in the worse eye		**At-fault or near crash:** 1.3 (0.7, 2.5)
		154 (36/118)			Right VF loss of ≤ 21.8dB in the worse eye	Drivers with no right VF loss in the worse eye		**At-fault or near crash:** 0.9 (0.5, 1.8)
Yuki K et al., 2014	Cross-sectional	247 (N/A)	63.7	Japan	N/A	POAG drivers without a MVC history	Mean (SD)	The mean IVF-MD (db) of glaucoma drivers with a history of MVCS was -0.6 (3.4) compared to -0.8 (3.7) in glaucoma drivers without a history of MVCs.
Yuki K et al., 2016	Prospective Cohort	191 (N/A)	63.7	Japan	POAG with **1dB increase in visual field**	POAG drivers without a MVC history	OR	**Any MVC:** 0.95 (0.8, 1.1)*
							Mean (SD)	Mean (SD) IVF-MD (dB) of glaucoma

								drivers with a history of MVC was -2.1 (3.9) compared to -1.6 (3.7) in glaucoma drivers without a history of MVCs.
Included in Narrative Summaries Only – Low Middle Income Countries								
Abraham EG et al., 2010	Cross-sectional	291 (13/278)	41.5	Nigeria	Cup-disc ratio >0.5 cup-disc disparity between the two eyes of up to 0.2 or more, abnormal disc pallor (localised or generalised)	Drivers without visual field impairments.	RR (relative risk)	**Any MVC:** 0.628*
Adekoya BJ et al., 2009	Cross-sectional	399 (21/378)	44.7	Nigeria	Presence of 1 or more abnormal quadrants on confrontation perimetry	N/A	X^2 (Chi Square)	Abnormal visual fields was not associated with MVC involvement in the last 10 years; X2= 1.715 (p= 0.19).
Humphriss D, 1987	Cross-sectional	366 (N/A)	N/A	South Africa	N/A	Drivers with no MVC history	Mean (SD)	Data not reported
Isawumi et al., 2011	Cross-sectional	99 (N/A)	45.9	Nigeria	N/A	Drivers with a MVC but	Prevalence (%)	21.1% (8/38) of drivers with an MVC also had

						without visual field loss		horizontal visual field loss.
Ovenseri-Ogomo G et al., 2011	Cross-sectional	206 (14/192)	39.2	Ghana	VA < 6/18 in the better eye	Drivers without a history of MVC	OR	Any MVC: 0.54 (0.016, 18.45)*
Pepple G et al., 2014	Cross-sectional	400 (16/384)	37.8	Nigeria	Physician diagnosed	Drivers without visual field impairments	RR (did not state test used)	**Any MVC:** 1.25*
							Prevalence (%)	56% (9/16) of those with visual field impairment were have been involved in an MVC.

*unadjusted results

Table 4a(xi) All studies (n=3) on glare sensitivity (GS) impairment and Motor Vehicle Crashes (MVC), all suitable to only be summarised narratively due to their different GS cut-off points, type of crash outcome explored and comparators

Author and Year	Study Design	Total Participants (exposed/control)	Mean Age/ Age Range	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR, etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Narrative Summaries Only – High Income Countries								
Owsley C et al., 1998	Case Control	294 (71/179)	71	USA	Measured using MCT-8000 (Vis Tech), defined as disability glare >0	Older drivers with disability glare <= 0	OR	**Injurious MVC**: 1.4 (0.8, 2.5)*
								Non-injurious MVC: 1.3 (0.9, 2.2)*
Owsley C et al., 2001	Cross-sectional	377 (274/103)	69.9	USA	Glare impairment defined as >=0.25, measured with Pelli-robson chart with BAT:	Those with disability glare <0.25 in the better/worse eye	OR	**At-fault MVC in the better eye:** 0.68 (0.22, 2.12)
					Glare impairment defined as >=0.25 in both eyes	those with no disability glare impairment (<0.25 score)	OR (logistic regression)	**At-fault MVC in the worse eye**: 0.62 (0.29, 1.33)
								At-fault MVC in both eyes: 0.46 (0.14, 1.53)
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years =	USA	6 letter worsening (worsening of 0.3 logCS units) - measured using Pelli-Robson chart with BAT	N/A – looked at driver with and without MVC in whole population.	HR	**Any MVC (glare <3 letters)**: 0.46 (0.26, 0.89)
								Any MVC (glare ≥ 3 letters): 2.3 (1.14, 16.78)

			553, 80-85 years = 350					

Table 4a(xii) All studies (n=19) on other types of vision impairment and Motor Vehicle Crashes (MVC), all suitable to only be summarised narratively

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age/ Age Range	Country	Type of VI	VI definition	Comparator	Outcome Measure (OR, RR, HR, etc.?)	Effect Measure (with 95% CI) + any description of results (if appropriate)
Included in Narrative Summaries only – High Income Countries									
Baker JM et al., 2019	Retrospective Cohort	66253 (62/66191)	20.8	USA	Unilateral vision impairment	ICD-9 diagnostic codes (369.6-369.8)	Young adult drivers without unilateral vision impairment	HR	**Any MVC**: 1.08 (0.6, 1.95)
		66253 (352/65901)			Amblyopia	Using the ICD-9 diagnostic codes (368.00 - 368.03) in the HER with diganosis noted in medical record from age 6	Young adult drivers without amblyopia	HR	**Any MVC**: 1.08 (0.85, 1.38)
Crizzle AM et al., 2020	Cross-sectional	3346 (513/2833)	61.5	Canada	Vision impairment	Physician diagnosed	Drivers without vision impairment	Univariate log rank test	Vision impairment was not associated with history of MVCs (p=0.9178).

Fishman GA et al., 1981	Retrospective Cohort	129 (42/87)	37.3	USA	Retinitis Pigmentosa	Physician diagnosed	Drivers free from ophthalmic or general defects	X^2 (Chi Square)	Statistical significant difference in accidents recorded over 5 years between retinitis pigmentosa patients (50%; 21/42)) and controls (29%; 25/62); p= 0.02
Gresset J et al., 1994	Case Control	4036 (15/4021)	N/A	Canada	Monocularity	Physician diagnosed	Male drivers who had no accident during their 70th year in 1988 and 1989	OR	**Any MVC**: 0.95 (0.32, 2.77)
		4036 (327/3709)			Visual impairment			OR	**Any MVC:** 1.07 (0.84, 1.36)
Maag U et al., 1997	Retrospective Cohort	116 (N/A)	N/A	Canada	Vision impairment	Non stereoscopic vision (> 160 seconds); an acuity of 20/40 for the better eye and zero in the other.	Drivers in good health	Mean (SD)	Average total number of crashes in people with good health with a taxi per year (SD): 0.218 (0.501) Average total number of crashes in people with binocular vision problems with

									taxi per year (SD): 0.369 (0.595); the difference was statistically significant (p= 0.01)
McCloskey L et al., 1994	Case Control	683 (10/673)	age, no.: 65-69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 86	USA	Retinopathy	Physician diagnosed (hospital data)	Age-matched drivers with retinopathy who have not been injured in a police reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 0.6 (0.1, 2.6)*
		683 (37/646)			Retinal disorders	Physician diagnosed (hospital data)	Age-matched drivers with other retinal disorders who have not been injured in a police	RR (relative risk)	**Injurious MVC**: 0.8 (0.4, 1.6)*

							reported MVC in the same calendar year as their matched case.		
		683 (394/289)			Hypermetropia	Physician diagnosed (hospital data)	Age-matched drivers with hypermetropia who have not been injured in a police reported MVC in the same calendar year as their matched case.	RR (relative risk)	**Injurious MVC**: 0.9 (0.7, 1.4)*
		683 (544/139)			Presbyopia	Physician diagnosed (hospital data)	Age-matched drivers with presbyopia who have not been injured in a police reported MVC in the same calendar year as their	RR (relative risk)	**Injurious MVC**: 1 (0.6, 1.8)*

							matched case.		
		683 (339/344)			Astigmatism	Physician diagnosed (hospital data)	Age-matched drivers with astigmatism who have not been injured in a police reported MVC in the same calendar year as their matched case	RR (relative risk)	**Injurious MVC**: 0.9 (0.7, 1.4)*
		638 (597/41)			Refractive disorder	Physician diagnosed (hospital data)	Age-matched drivers with refractive disorders who have not been injured in a police reported MVC in the same calendar year as their matched case	RR (Mantel-Haenszel)	**Injurious MV**C: 0.3 (0.1, 0.8)*
		638 (6/632)			Monocular vision	Physician diagnosed (hospital data)	Age-matched drivers with monocular vision who have not	RR (relative risk)	**Injurious MVC**: 0.7 (0.1, 4.1)*

							been injured in a police reported MVC in the same calendar year as their matched case		
		638 (10/628)			Diplopia	Physician diagnosed (hospital data)	Age-matched drivers with diplopia who have not been injured in a police reported MVC in the same calendar year as their matched case	RR (relative risk)	**Injurious MVC**: 1.2 (0.4, 4.2)*
		638 (13/625)			Vision/ophthalmic conditions	Physician diagnosed (hospital data)	Age-matched drivers with other vision and opthalmic conditions who have not been injured in a police reported MVC in the same	RR (relative risk)	**Injurious MVC**: 0.6 (0.2, 1.6)*

							calendar year as their matched case		
Naredo Turrado J et al., 2020	Prospective Cohort	11670 (11/11659)	62.4	France	Retinal detachment	Self-reported physician diagnosed	Drivers without retinal detachment	OR	**Any MVC**: 0.99 (0.37, 2.7)
Owsley C et al., 1998	Case Control	294 (N/A)	71	USA	Stereoacuity	Scores ≥ 500 arcseconds on TNO test	Older drivers with stereoacuity <500 arcseconds	OR (logistic regression)	**Injurious MVC**: 2.2 (1.1, 1.4)* **Non-injurious MVC**: 1.2 (0.7, 2.3)*
Pepple G et al., 2014	Cross-sectional	400 (32/368)	37.8	Nigeria	Vision impairment	Physician diagnosed	Drivers without a vision impairment	RR (did not state test used)	**Any MVC**: 0.62 (p= 0.46)
Rubin G et al., 2007	Prospective Cohort	2520 (545/2066)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350	USA	Stereoacuity	Stereodeficient was defined at failing the test at 457 arc seconds.	Drivers who were not sterodeficient	HR (cox proportional hazard)	**Any MVC**: 1.44 (0,88, 2.27)

Runge JW, 2000	Cross-sectional	N/A	N/A	USA	Vision Impairment	Physician diagnosed	Drivers without vision impairment s	RR (relative risk)	**At-fault MVC**: 1.51* The at-fault crash rate of those with a vision impairment was 1.14 compared to those without an impairment (0.75).
Rahi J et al., 2006	Retrospective Cohort	8661 (429/8432)	N/A	UK	Amblyopia	Mild = acuity 6/6 in one eye and 6/9 or 6/12 in the other and unilateral visual loss	People with normal vision in each eye	OR	**Any MVC**: 1.28 (0.87, 1.89)
						Moderate/severe = acuity of 6/6 in one eye and 6/18 or worse in the other and unilateral visual loss, with or without strabismus, earlier in childhood.	People with normal vision in each eye	OR (ordinal regression)	**Any MVC**: 2.33 (1.29, 4.2)
Wedenoja J et al., 2021	Cross-sectional	N/A	N/A	Finland	Vision impairment	Physician diagnosed	Drivers without	Prevalence	Only 1.3% (13/968) of all fatal MVCs were

							vision impairment.		caused by vision-related problems.
Included in Narrative Summaries Only – Low Middle Income Countries									
Ahmed M et al., 2021	Cross-sectional	700 (492/208)	42.3	Bangladesh	Near or distance visual impairment	Presenting VA ≥ 6/7.5 in the better eye and or presence of presbyopia.	Drivers without near or distance visual impairment but with a history of MVCs.	OR	**Any MVC:** 2.45 (1.09, 5.49)
		700 (125/575)	42.3	Bangladesh	Hyperopia	Physician diagnosed	Drivers without hyperopia but with a history of MVCs.	OR	**Any MVC:** 1.1 (0.56, 2.23)*
		700 (11/689)	42.3	Bangladesh	Presbyopia	Physician diagnosed	Drivers without presbyopia but with a history of MVCs.	OR	**Any MVC:** 1.7 (0.96, 3.01)*
		700 (N/A)	42.3	Bangladesh	Any distance refractive error	Physician diagnosed	Drivers without any distance refractive error but with a history of MVCs.	OR	**Any MVC:** 1.66 (0.88, 3.12)*
Biza M et al., 2013	Cross-sectional	249 (13/236)	33.6	Ethiopia	Visual impairment	VA <6/18-6/60 was classified as	Drivers with a MVC but no	OR	**Any MVC (both eyes**

						moderate visual impairment and <6/60-3/60 was classified as severe VI while VA less than 3/60 was classified as blindness.	VA impairment		**impairment)**:42.82 (2.53, 724.03) **Any MVC (right eye impairment)**: 0.03 (0.004, 0.28)* **Any MVC (left eye impairment)**: 0.09 (0.01, 0.97)*
Boadi-Kusi SB et al., 2016	Cross-sectional	520 (66/454)	39.2	Ghana	Hyperopia	Hyperopia defined as the spherical power in the better eye of +1.00D or more	Drivers with a history of MVC but no hyperopia	OR	**Any MVC**: 0 (0, 0);
		520 (30/490)			Astigmatism	Astigmatism was defined as −0.50D cylinder or worse in the better eye	Drivers with a history of MVC but no astigmatism	OR	**Any MVC**: 0.885 (0.32, 2.5)*
Emerole C et al., 2013	Cross-sectional	280 (102/178)	N/A	Nigeria	Vision impairment causing poor visibility.	Physician diagnosed with VA of 6/30 classified as abnormal.	N/A – compared with a "control" group but paper never explained what/who	Prevalence (%)	119 (79.3%) participants in the study group had an MVC history. 40.3% (448/119) participants in the study group

							the control group was.		and 70.6% (36/51) in the control group listed poor visibility as the cause of their MVC involvement ($p < 0.05$).
Ogbonnaya CE et al., 2018	Cross-sectional	103 (9/94)	43.2	Nigeria	Monocular vision impairment	Physician diagnosed	Drivers with monocular impairment but with no MVC history	X^2 (Chi Square)	The relationship between monocular visual impairment and self-reported history of RTA was not statistically significant; X2 =0.045, (p= 0.85)
		103 (7/96)			Monocular blindness	Physician diagnosed	Drivers with monocular blindness but with no MVC history	X^2 (Chi Square)	The relationship between monocular blindness and self-reported history of RTA was not statistically significant; X2 =0.358 (p= 0.55)
Vofo BN et al., 2021	Cross-sectional	207 (51/156)	41.8	Cameroon	Self-reported vision impairment.	Self-reported	Drivers without self-reported	X^2 (Chi Square)	Drivers with self-reported VI were involved in significantly

							vision impairment		higher number of MVCs (72.5%) than those with self-reported good vision (55.8%) (p< 0.05)
									Drivers with self-reported VI had higher average number of MVCs over previous 10 years (1.75 +/- 1.64) than drivers with self-reported good vision (1.03 +/- 1.40 (p< 0.05).

*unadjusted results

Table 4a(xiii) All studies (n=6) evaluating cataract surgery and Motor Vehicle Crashes (MVC) with meta-analysis suitable for 3 studies on the associations with any MVC involvement

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Meta-Analysis (any MVC involvement)								
Meuleners L et al., 2012	Retrospective Cohort	27827 (N/A)	age, no.: 60-69 years = 6609, 70-79 years = 14506, 80+ years = 6712	Australia	Physician diagnosed	Crashes before surgery	RR (risk ratio)	0.87 (0.76, 0.99)
Meuleners L et al., 2019	Retrospective Cohort	2849 (N/A)	age, no.: 60-64 years = 347, 65-69 years = 482, 70-74 years = 720, 75-79 years = 719, 80-84 years = 454, 85 +	Australia	Physician diagnosed cataract	Crashes before surgery	RR (risk ratio)	0.39 (0.37, 0.41)

			years = 127					
Owsley C et al., 2002	Prospective Cohort	277 (174/103)	71.3	USA	Cataract in 1 or both eyes with best-corrected VA of 20/40 or worse	Crashes before surgery	RR (rate ratio)	0.47 (0.23, 0.94)
Included in Narrative Summaries Only – High Income Countries								
McCloskey L et al., 1994	Case Control	683 (235/448)	age, no.: 65- 69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 88	USA	Self-reported physician diagnosed cataracts	Drivers who experienced no injuries in a crash.	RR (relative risk)	**Post-surgery with lens implant:**1 (0.5, 2.3)*
Meuleners L et al., 2012	Retrospective Cohort	Males: 1091 (513/611)	age, no.: 60-69 years = 447, 70-79 years = 823, 80 + years = 445	Australia	Physician diagnosed	No. of pre cataract surgery police reported crashes in all participants.	RR (risk ratio)	**Males:** 0.84 (0.72, 0.99)
		Females: 624 (308/330)						**Females**: 0.99 (0.75, 1.16)
Meuleners L et al., 2019	Retrospective Cohort	2849 (N/A)	age, no.: 60-64 years = 347, 65-69 years	Australia	Physician diagnosed cataract	Crashes before surgery	RR (risk ratio)	**After 2nd eye cataract surgery:** 0.77 (0.75, 0.78)

			= 482, 70-74 years = 720, 75-79 years = 719, 80-84 years = 454, 85 + years = 127					
Schlenker M et al., 2018	Prospective cohort	559546 (N/A)	76	Canada	Physician diagnosed	No. of pre cataract surgery crashes in all participants	OR	0.91 (0.84, 0.97)*

*unadjusted results

Table 4a(xiv) All studies (n=1) evaluating corrective lens wear to improve refractive error and Motor Vehicle Crashes (MVC)

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	Vision impairment	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
McCloskey L et al., 1994	Case Control	683 (235/448)	age, no.: 65- 69 years = 264, 70-74 years = 195, 75-79 years = 138, 80+ years = 94	USA	Refractive Error	Use of corrective lenses for any reason (far or near vision)	Drivers who experienced no crash-related injuries	RR (risk ratio)	0.6 (0.3, 1.1)*
								Prevalence (%)	% with condition, cases: 91% (214/235) % with condition, controls: 94.6% (424/448)

* unadjusted results

Appendix 4b Raw data tables and additional narrative summaries of papers on driving cessation

Table 4b(i) All studies (n=13) on glaucoma and driving cessation with meta-analysis suitable for 2 studies

Additional Narrative Summaries:
Persons with bilateral glaucoma (OR 2.6 (95% CI 1.4-4.8); p= 0.002) were more likely to stop driving but those with unilateral glaucoma were not (OR 1.5 (95% CI 0.7-2.9); p= 0.3) with one Japanese study reporting individuals with severe POAG in the better eye to have an approximately 11.5 times greater odds of driving cessation than persons without POAG.

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Meta-analysis								
Edwards J et al., 2008	Cross-sectional	1656 (152/1504)	72.95	USA	Self-reported physician diagnosed	Participants without glaucoma	HR	1.47 (0.98, 2.19); p=0.06
Gilhotra JS et al., 2001	Cross-sectional	3654 (61/3593)	65.9	Australia	Self-reported and physician diagnosed	Participants without glaucoma	OR	2.2 (1.3, 3.9)
Included in Narrative Summaries Only – High Income Countries								
Adler G et al., 2004	Cross-sectional	199 (52/147)	71.3	USA	Open-or closed-angle glaucoma	Participants without glaucoma	X^2 (Chi Square)	Drivers with glaucoma were no more likely than controls to have made plans for driving cessation; p=0.49
Edwards J et al., 2008	Cross-sectional	1656 (152/1504)	72.95	USA	Self-reported physician diagnosed	Participants without glaucoma	Prevalence (%)	8.6% (125/1450) of current drivers had glaucoma compared to 13.9% (28/199) of non-drivers with glaucoma.
Gilhotra JS et al., 2001	Cross-sectional	3654 (61/3593)	65.9	Australia	Open-angled	Participants without glaucoma	Prevalence (%)	2% (37/2379) of current drivers had glaucoma compared to 5% (24/451) of non-drivers with glaucoma.

Goh Y et al., 2011	Case Series	77 (77/0)	71.8	UK	Physician diagnosed	Participants with glaucoma and other ocular pathologies	OR	At clinic presentation: 4.99 (1.2, 20.6)* Glaucoma patients with other ocular pathologies were more likely to fail the driving criteria and give up driving than patients with only glaucoma.
								At last clinic visit: 4.37 (1.6, 11.8) Glaucoma patients with other ocular pathologies were more likely to fail the driving criteria and give up driving than patients with only glaucoma.
Kaleem MA et al., 2021	Cross-sectional	191 (191/0)	77	USA	Physician diagnosed	Drivers with glaucoma but with either better VA or CS.	Prevalence (%) and X^2 (Chi Square)	78% of participants reported that they had stopped driving.
								Participants with worse VA were more likely to stop driving (p< 0.05)
								Participants with worse CS were more likely to stop driving (p< 0.01).
MacLeod K et al., 2014	Cross-sectional	1279 (67/1211)	age, no.: 55-64 years = 233, 65-	USA	Self-reported physician diagnosed	Ex-drivers without glaucoma	RR (risk ratio)	1.3
							Attributable Risk	1.6

			74 years = 499, 75+ years = 547				Prevalence (%)	7.4% (6/79) of non-driving participants had glaucoma compared to 5.7% (5/79) who did not have glaucoma.
Marottoli RA et al., 1993	Cross-sectional	1331 (28/1303)	age, no.: 65-74 years = 484, 75-84 years = 105, 85+ years = 6	USA	Self-reported physician diagnosed	Participants without glaucoma	Prevalence (%)	From the 28 participants who reported glaucoma at baseline (1983), 42.9% (12/28) stopped driving by 198 compared to 22.2% (125/564) of people who did not have glaucoma and who also stopped driving.
Naredo Turrado J et al., 2020	Prospective cohort	11670 (525/11144)	62.4	France	Self-reported physician diagnosed	Participants without glaucoma	HR	1.6, p>0.05
Ramulu P et al., 2009	Cross-sectional	1135 (138/997)	79.7	USA	Bilateral or unilateral	Participants without glaucoma	OR	Bilateral: 2.6 (1.4, 4.8) Stopped driving for over 8 years (bilateral): 3 (1.4, 6.4)* Stopped driving less than 2 years ago (bilateral): 3.6 (1.5, 5.8)
								Unilateral: 1.5 (0.7, 2.9) Stopped driving less than 2 years ago (unilateral): 2.4 (1, 6)
							Prevalence (%)	40.6% (28/68) of all participants with

								bilateral glaucoma were not driving. 21.4% (15/70) of all with unilateral glaucoma were not driving. 15% (150/997) of all without glaucoma were not driving.
Takahashi A et al., 2018	Prospective cohort	359 (211/148)	54	Japan	Mild POAG at baseline	Participants without glaucoma	OR	No association found (data not shown)
					Moderate POAG in the better eye at the 3 year follow-up			37.7 (3.7, 383.8)
					Severe POAG in the better eye at baseline			11.52 (2.87, 46.35)
					Severe POAG in the better eye at 3-year follow-up			52.8 (3.5, 797)
							Prevalence (%)	5.3% (8/152) of those with mild glaucoma were no longer driving. 21% (7/33) of those with moderate/severe glaucoma were no longer driving. A total of 8.1% (15/185) of all participants with glaucoma were not driving compared to 1/3% (1/80) of drivers without glaucoma who

								were also no longer driving.
Tam A et al., 2018	Cross-sectional	99 (99/0)	71.5	Canada	Glaucoma severity was defined by the visual field mean deviation (MD) in the better eye and classified into 2 groups: mild (MD >−6 dB) and moderate/severe (MD ≤−6 dB), corrected visual acuity in the better eye ≥20/50	Mild/moderate glaucoma patients	Prevalence (%)	33% (15/46) of mild/moderate glaucoma reported driving cessation compared to 8% (4/53) of mild glaucoma patients; p= 0.002
vanLandingham et al., 2013	Cross-sectional	139 (81/58)	70.1	USA	Physician diagnosed	Glaucoma suspect controls	OR	4 (1.1, 4.7); p=0.03
							Prevalence (%)	22.5% (18/81) of participants with glaucoma were no longer driving.
Included in Narrative Summaries Only – Low Middle Income Countries								
Deshmukh AV et al., 2019	Case Control	150 (100/50)	64.5	India	Anderson criterion	Drivers without glaucoma	Prevalence (%)	16% (16/100) of those with glaucoma has stopped driving.

*unadjusted results

Table 4b(ii) All studies (n=4) on cataract and driving cessation, all suitable to be summarised narratively only

Additional Narrative Summaries: One study with sex disaggregated analysis found male drivers to be 7.01 times more likely to stop driving compared to female drivers who only had a 3.67 odds of driving cessation. Only one study examined the impact of a diagnosis of wet AMD but did not find any significant associations.								
Author and Year	**Study Design**	**Total Participants (exposure/control)**	**Mean Age**	**Country**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR?)**	**Effect Measure (with 95% CI)**
Included in Narrative Summaries Only – High Income Countries								
MacLeod K et al., 2014	Cross-sectional	1279 (278/1001)	age, no.: 55-64 years = 233, 65-74 years = 499, 75+ years = 547	USA	Self-reported physician diagnosed	Ex-drivers without cataract.	RR (risk ratio)	1.5
							Attributable risk	10.5, p<0.1
							Prevalence (%)	8% (6/79) of participants with cataracts no longer drove compared to 5.2% (4/79) with no cataracts.
Marottoli RA et al., 1993	Cross-sectional	1331 (105/1226)	age, no.: 65-74 years = 484, 75-84 years = 105, 85+ years = 6	USA	Self-reported physician diagnosed	Current Drivers	OR	2.29 (1.28, 4.1)
							Prevalence (%)	45.7% (48/105) of participant with cataracts were no longer driving compared to 18.4% (90/488) of those who were no longer driving and did not have cataracts.
Naredo Turrado J et al., 2020	Prospective cohort	11670 (291/11379)	62.4	France	Self-reported physician diagnosed	Current drivers	HR	1.79, p>0.05
Sengupta S et al., 2014	Cross-sectional	122 (N/A)	72.4	USA	Physician diagnosed	Participants without cataract/PCSO in better eye.	PR (Prevalence Ratio)	Presence of cataract/PCO in the better seeing eye did not show any significant association

								with driving cessation; p>0.5

*unadjusted results

Table 4b(iii) All studies (n=5) on AMD and driving cessation with meta-analysis suitable for 3 studies

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Meta-analysis								
Campbell MK et al., 1993	Case Control	1656 (276/1380)	N/A	USA	Self-reported physician diagnosed	Current drivers	OR	4.25 (2.6, 7); p<0.001
Edwards J et al., 2008	Cross-sectional	1656 (89/1567)	72.95	USA	Self-reported physician diagnosed	Current drivers	HR	1.46 (0.91, 2.36); p=0.12
Stewart RB et al., 1993	Cross-sectional	1470 (N/A)	78.1	USA	Self-reported physician diagnosed	Current drivers	OR	3.32 (1.91, 5.77); p=0.0001
Included in Narrative Summaries Only – High Income Countries								
Campbell MK et al., 1993	Case Control	1656 (276/1380)	N/A	USA	Self-reported physician diagnosed	Current drivers	OR	**Male**: 7.01 (3.1, 15.9); p<0.001)*
								Female: 3.67 (2.0, 6.8), p<0.001*
							Prevalence (%)	5.06% (70/1379) of participants still driving had AMD compared to 17.88% (50/277) of non-drivers with AMD.
Edwards J et al., 2008	Cross-sectional	1656 (89/1567)	72.95	USA	Self-reported physician diagnosed	Current drivers	Prevalence (%)	4.9% (71/1457) of participant still driving had AMD compared to 9.5% (19/198) of non-driving participant with AMD.

MacLeod K et al., 2014	Cross-sectional	1279 (48/1231)	age, no.: 55-64 years = 233, 65-74 years = 499, 75+ years = 547	USA	Self-reported physician diagnosed	Ex-drivers without AMD.	RR (risk ratio)	2.3
							Attributable risk	4.5, p<0.01
							Prevalence (%)	12.7% (10/79) of ex-drivers had AMD compared to 5.6% (4/79) of ex-drivers without AMD.
Sengupta S et al., 2014	Cross-sectional	122 (64/58)	72.4	USA	Physician reported wet AMD	Participants without AMD	OR	**Any eye:** 1.9 (0.5, 7.3)
								Worse eye: 0.6 (0.1, 3.3)
								Better eye: 2.7 (0.6, 11.5)
							Prevalence (%)	74.6% (48/64) of participant with AMD were still driving compared.
								More participants in the AMD group (25.4%) had stopped driving compared to those without AMD (6.9%); p= 0.006
Stewart RB et al., 1993	Cross-sectional	1470 (N/A)	78.1	USA	Self-reported physician diagnosed	Current drivers	Prevalence (%)	59.8% (35/58) of participant with AMD were still driving.

*unadjusted results

Table 4b(iv) All studies (n=18) on visual acuity (VA) impairment and driving cessation, all suitable to only be summarised narratively due to their different VA cut-off points and comparators

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Narrative Summaries Only – High Income Countries								
Anstey K et al., 2006	Prospective Cohort	1466 (446/1020)	age no.: 70-74 years = 378, 75-79 years = 353, 80-84 years = 339, 85+ years = 396	Australia	Corrected distance VA at 3 metres in best eye at 6/12 or worse	Participants with VA better than 6/12 (i.e. better than 20/40)	OR	Visit 2: 1.91 (0.51, 7.13) Visit 3: 1.84 (0.68, 4.99) Visit 4: 1.15 (0.55, 2.41)
DeCarlo D et al., 2003	Cross-sectional	126 (N/A)	79	USA	Better eye	Current drivers	Mean (SD)	VA in the better eye was worse in non-drivers (1.03 +/- 0.39) than drivers (0.74 +/- 0.34).
					Worse eye			VA in the worse eye was worse in non-drivers (1.58 +/- 0.43) than drivers (1.18 +/- 0.42).

Edwards J et al., 2008	Cross-sectional	1656 (N/A)	72.95	USA	ETDRS chart with scores assigned from 0 to 90 (e.g. score of 0 = Snellen score of 20/125, score of 90 = Snellen score of 20/16)	Current drivers	HR (multivariate model)	0.91 (0.791, 1.046); p=0.184
							HR (cox regression)	0.69 (0.61, 0.78); p<0.001
Freeman E et al., 2005	Prospective cohort	1824 (263/1561)	73.4	USA	≥ 0.1 and <0.3 logMAR at baseline	<0.1 logMAR as baseline	HR	1.27 (0.96, 1.69)
		1824 (63/1498)			≥0.3 logMAR VA at baseline	<0.1 logMAR as baseline		1.23 (0.69, 2.18)
		1824 (329/1495)			1-2 lines VA loss	<1 line loss in VA		1.25 (0.96, 1.65)
		1824 (134/1690)			>2 lines VA loss	<1 line loss in VA		1.26 (0.87, 1.84)
Garre-Olmo J et al., 2009	Cross-sectional	875 (N/A)	81.7	Spain	Self-reported	Drivers without impaired VA	OR	0.379 (0.201, 0.714); p=0.003*
Gilhotra JS et al., 2001	Cross-sectional	3654 (80/3574)	65.9	Australia	BCVA worse than 6/12 in the better eye	Current drivers	OR	4 (2.5, 3.9)
		3654 (283/3371)			Presenting VA worse than 6/12 in the better eye			2.5 (1.9, 3.4)
							Prevalence (%)	11% (49/452) of participants have stopped driving have VA >20/40 compared to the 1% (21/2379) who are still driving with VA >20/40.
Huisingh C et al., 2016	Prospective Cohort	1995 (161/1834)	77.2	USA	logMar <0.3	Drivers without VA impairment	HR	0.83 (0.49, 1.42)
							Mean (SD)	VA of those who stopped driving (0.097 [0.15]) compared to those still driving (0.051 [0.13]).

							Prevalence (%)	90.9% (149/164) of those not driving had a VA of ≤20/40 compared to 9.2% (15/164) who stopped driving with a VA of >20/40.
Janz N et al., 2009	Prospective Cohort	607 (N/A)	age, no.: 25-49 years = 131, 50-64 years = 240, 65-74 years = 177	USA	Better eye at 6 months	Driving vs. non-drivers	2-sample t-test	Mean (SD) of VA in drivers (87.7 [4.9]) vs. non-drivers (85.1 [5.4]); p<0.001
							Linear regression	Mean (SD) of VA in drivers (87.7 [4.9]) vs. non-drivers (85.1 [5.4]); p=0.012
					Better eye at 54 months		2-sample t-test	Mean (SD) of VA in drivers (86.9 [5.7]) vs. Non-drivers (83.2 [6.9]); p= 0.025
							Linear regression	Mean (SD) of VA in drivers (86.9 [5.7]) vs. Non-drivers (83.2 [6.9]); p=0.458
					Mean (SD) difference in VA in better eye from 6 months to 54 months	Remained drivers vs. became non-drivers	Linear regression	Changes in Mean (SD) in VA of drivers (-0.4[0.6]) vs. became non-drivers (3.9[0.7]); p=0.001
					Worse eye at 6 months	Driving vs. non-drivers	2-sample t-test	Mean (SD) of VA in drivers (83.2 [7.5]) vs. non-drivers (79.7 [11.0]); p= 0.007
							Linear regression	Mean (SD) of VA in drivers (83.2 [7.5]) vs. non-drivers (79.7 [11.0]);

								p= 0.095
					Worse eye at 54 months		2-sample t-test	Mean (SD) of VA in drivers (81.5 [10.6]) vs. non-drivers (75.3 [14.4]); p=0.001
							Linear regression	Mean (SD) of VA in driver (81.5 [10.6]) vs. non-driver: 75.3 (14.4); p=0.003
					Mean (SD) difference in VA in worse eye from 6 months to 54 months	Remained drivers vs. became non-drivers	Linear regression	Mean (SD) of VA in drivers (1.4[1.3]) vs. became non-drivers: -5.5(2.1); p=0.054
Keay L et al., 2009	Prospective Study	1425 (N/A)	75	USA	LogMAR scale	Whole population	Mean (SD)	mean(SD) of VA statistically significant different between those who stopped driving 0.08 (0.014) and those who continued driving -0.01(0.11); p=0.0006
Keay et al., 2016	Cross-sectional	442 (N/A)	73	Australia	High contrast vision	Current drivers with cataracts NOTE: all participants had cataracts	OR	1.21 (1.07, 1.37)
					Binocular		X^2 (Chi Square)	p<0.001
					Better eye			p<0.001
					Worse Eye			p<0.001
Levecq L et al., 2013	Cross-sectional	1000 (N/A)	71.3	Belgium	Physician diagnosed binocular VA worse than 20/40	Current drivers	X^2 (Chi Square)	Right eye: Mean VA of current drivers (0.31) was significantly better than those who gave up driving due to vision (0.25); p=0.016
								Left eye: Mean VA in current drivers (0.31) was significantly

								better than those who gave up driving due to vision (0.24); p=0.004
								Both eyes: Mean VA in current drivers (0.36) Was significantly better than those who gave up driving due to vision (0.31); p=0.031
Ramulu P et al., 2009	Cross-sectional	1135 (N/A)	79.7	USA	Binocular acuity 0.1 logMAR or worse in better eye.	Drivers without 0.1 logMAR binocular.	OR	1.5, p<0.001
Ross L et al., 2009	Cross-sectional	5206 (1062/4144)	76.3	Australia	Physician diagnosed with participants categorised into having a VA LogMAR 0.3 or better, or worse than LogMar 0.3.	Participants with normal vision (logMAR of or better than 0.3).	OR	2.08 (2.56, 1.69)*
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	age, no.: 65-69 years = 780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350	USA	15 letter loss (logMAR 0.3)	Current Drivers	Prevalence (%)	Of those no longer driving: 84% (604/719) had VA ≤ 20/40 whilst 16% (115/719) had VA > 20/40.

Segal-Gidan F et al., 2010	Cross-sectional	421 (44/377)	72	USA	Mild vision impairment was defined at the BCVA in the better eye (20/40-20/63)	Current drivers	OR	5.53 (1.45, 20.98)
		421 (23/377)			Moderate/severe vision impairment was defined as BCVA in the better eye (20/80 or worse)			13.23 (1.45, 120.3)
Sengupta S et al., 2014	Cross-sectional	122 (N/A)	72.4	USA	Worse VA in the better eye (1 line loss of vision)	1 line worse in better eye acuity (logMAR) in all participants	OR	Low VA in either eye: 1.4 (1.1, 1.9); p<0.001 Low VA in better eye: 1.5 (1.2, 1.9); p<0.001
							Mean (SD)	Participants who had stopped driving (logMAR VA 0.77) had significantly worse vision in the better seeing eye than those still driving (LogMAR VA 0.08); p=0.001
Tam A et al., 2018	Cross-sectional	99 (N/A)	71.5	Canada	Physician diagnosed	N/A – looked at VA in whole population (all glaucoma patients)	X^2 (Chi Square)	Best corrected VA not associated with cessation; p=0.18
								Declines in central vision was significantly associated with driving cessation; p= 0.001
								Declines in near vision was significantly associated with driving cessation; p= 0.001
								Declines in peripheral vision was significantly associated

								with driving cessation; p= 0.001
vanLandingham S et al., 2013	Cross-sectional	139 (N/A)	70.1	USA	1 line worse in the better eye	Glaucoma suspect controls	OR	1.3 (1, 1.8); p<0.05
						Moderate VA loss in glaucoma cases		Severe VA loss: 1.5 (1.2, 1.8); p< 0.05

*unadjusted results

Table 4b(v) All studies (n=8) on contrast sensitivity (CS) impairment and driving cessation with 3 studies suitable for meta-analysis

Additional Narrative Summaries:
CS was measured either as a continuous measure, or categorised as "poor" according to normative cut-points, with one study using both measures.

Author and Year	**Study Design**	**Total Participants (exposure/control)**	**Mean Age**	**Country**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR?)**	**Effect Measure (with 95% CI)**
Included in Meta-analysis								
Huisingh C et al., 2016	Prospective cohort	1995 (130/1865)	77.2	USA	<1.5 score on Pelli-Robson chart	Drivers with no bilateral CS impairment	HR	1.73 (1.1, 2.72)
							Mean (SD)	The mean log CS of current drivers was 1.68 (0.13) compared to 1.61 (0.16) in non-drivers.
							Prevalence (%)	5.8% (106/1831) of current drivers had a log CS <1.5, compared to 14.6% (24/164) who stopped driving.
Keay L et al., 2009	Prospective cohort	1425 (N/A)	75	USA	Per letter lost	Drivers with no bilateral CS impairment	OR	1.15 (1.03, 1.28)*
					Better eye CS		Mean (SD)	CS in better eye of those who stopped driving 32.4(4.1) significantly different between those who continued driving 35.3(2.2); p<0.001
		122 (N/A)	72.4	USA			OR	1.36 (1.1, 1.7); p<0.05

Sengupta S et al., 2014	Cross-sectional				Binocular CS 1 letter worse	Drivers with no bilateral CS impairment		
							X^2 (Chi Square)	Those who stopped driving had significantly worse CS (log CS 1.8) compared to those still driving (log CS 1.2); p=0.03
Included in Narrative Summaries Only – High Income Countries								
Freeman E et al., 2005	Prospective cohort	1824 (725/1099)	73.4	USA	>=32 and <36 letters CS at baseline	Baseline CS equal to or more than 36 letters.	HR	1.26 (0.97, 1.63)
		1824 (158/1666)			<32 letters at baseline			1.46 (0.98, 2.17)
		1824 (79/1725)			5 letter CS loss in 2 years	Less than 5 letter CS loss		1.33 (0.8, 2.22)
		1824 (86/1738)			>= 6 letter CS loss in 2 years			1.71 (1.01, 2.9)
Keay L et al., 2016	Cross-sectional	442 (N/A)	73	Australia	0.12 log units drop in CS.	Cataract patients who are still driving	OR	1.29 (1.11, 1.49)
							Prevalence (%)	17% (45/263) of current drivers and 35% (37/110) of former drivers had a CS <1 log decrease by at follow-up; p< 0.001
							Mean (SD)	The worse eye CS in current drivers was 1.27 (+/- 0.36) compared to 1.11 (+/- 0.41) in former drivers; p< 0.001
Ramulu P et al., 2009	Cross-sectional	1135 (N/A)	79.7	USA	5 letters worse in better eye	Current drivers without 5 letters worse in better eye CS.	OR	3, p<0.001
Rubin G et al., 2007	Prospective Cohort	2520 (N/A)	Age, no,: 65-69 years =	USA	Log CS ≥ 1.65	Current drivers	Prevalence (%)	49.1% (884/1801) participants had stopped driving.

			780, 70-74 years = 829, 77-79 years = 553, 80-85 years = 350		Log CS 1.35-1.65			54% (973/1801) had stopped driving.
					Log CS <1.35			96.9% (1745/1801) had stopped driving.
vanLandingham S et al., 2013	Cross-sectional	139 (N/A)	70.1	USA	Binocular CS 1 letter worse	Glaucoma suspect controls	OR	1.3 (1.2, 1.4); p<0.05

*unadjusted results

Table 4b(vi) All studies (n=8) on visual field (VF) impairment and driving cessation, all suitable to only be summarised narratively due to their different VF cut-off points and comparators

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Narrative Summaries Only – High Income Countries								
Freeman E et al., 2005	Prospective Cohort	1824 (659/1165)	73.4	USA	>1 and <= 8 points of central visual field at baseline	Equal to or greater than 1 points missed at baseline central VF	HR	1.34 (1.02, 1.76)
		1824 (174/1650)			>9 points of central visual field at baseline	Equal to or greater than 1 points missed at baseline central VF		1.81 (1.23, 2.66)
		1824 (65/1759)			5-7 points of central visual field loss in 2 years	<5 central VF loss		1.01 (0.6, 1.72)

		1824 (92/1732)			>=8 points of central visual field loss in 2 years	<5 central VF loss		0.83 (0.53, 1.29)
		1824 (632/1192)			>9 and <=18 points of peripheral visual field at baseline	Less than or equal to 9 points missed at baseline peripheral VF		1.51 (1.14, 1.98)
		1824 (180/1644)			>18 points of peripheral visual field at baseline	Less than or equal to 9 points missed at baseline peripheral VF		1.73 (1.14, 1.98)
		1824 (106/1718)			6-7 points of peripheral visual field loss in 2 years	<6 points loss of peripheral VF		1.04 (0.65, 1.65)
		1824 (88/1736)			>= 8 points of peripheral visual field loss in 2 years	<6 points loss of peripheral VF		1.91 (1.23, 2.96)
Huisingh C et al., 2016	Prospective cohort	1995 (493/1502)	77.2	USA	sensitivity <=22.5 dB	Participants without VF impairment	HR	1.78 (1.29, 2.46)
Janz N et al., 2009	Prospective cohort	607 (N/A)	age, no.: 25-49 years = 131, 50-64 years = 240, 65-74 years = 187	USA	Better eye at 6 months	Drivers vs. non-drivers	2-sample t-test	Mean (SD) MD of drivers (-2.1 [2.7]), vs. non-drivers (-2.9 [3.0)]; p=0.014
							Liner regression	Mean (SD) MD of drivers (-2.1 [2.7]) vs. non-drivers (-2.9 [3.0]); p=0.966
					Better eye at 54 months		2-sample t-test	Mean (SD) MD of drivers (-1.9[3.1]) vs. non-drivers (-3.5 [3.7]); p<0.001

							Linear regression	Mean (SD) MD of drivers (-1.9[3.1]) vs. non-driver: -(3.5[3.7]); p= 0.007
					Mean (SD) difference in VA in better eye from 6 months to 54 months	Remain drivers vs. became non-drivers	Linear regression	Difference in mean (SD) MD of drivers (0.2 [2.1]) vs. became non-drivers (-0.7 [2.7]); p=0.008
					Worse eye at 6 months	Drivers vs. non-drivers	2-sample t-test	Mean (SD) MD of drivers (-5.7 [4.9]) vs. non-drivers (-5.9 [4.0]); p=0.014
							Liner regression	Mean (SD) MD of drivers (-5.7 [4.9]) vs. non-drivers (-5.9 [4.0]); p=0.429
					Worse eye at 54 months		2-sample t-test	Mean (SD) MD of drivers (-5.4 [5.2]) vs. non-drivers (-7.0 [4.9]); p=0.012
							Linear regression	Mean (SD) MD of drivers (-5.4 [5.2]) vs. non-drivers (-7.0 [4.9]); p=0.080
					Mean (SD) difference in VA in worse eye from 6 months to 54 months	Remain drivers vs. became non-drivers	Linear regression	Difference in mean (SD) MD of drivers (0.3 [0.4]), vs. became non-drivers (-1.3 [0.7]); p= 0.013
Keay L et al., 2009	Prospective Cohort	1425 (N/A)	75	USA	Bilateral VF points missing	Whole population	Mean (SD)	Mean(SD) of bilateral VF points missing was statistically

								significant different between those who stopped driving 9.8(17.1) and those who continued driving 1.98(5.1); p=0.001
Keay L et al., 2016	Cross-sectional	442 (N/A)	73	Australia	Points missed on bilateral VF.	Current drivers with cataracts NOTE: all participants in this study had cataracts.	X^2 (Chi Square)	Median (IQR) of current drivers: 3 (0-10) vs. Median (IQR) of former drivers: 8 (1-19); p= 0.02
Ramulu P et al., 2009	Cross-sectional	1135 (N/A)	79.7	USA	Bilateral VF damage in glaucoma participants	Participants without glaucoma	OR	2 (1.6, 2.5)
							Prevalence (%)	21% (14/68) of participants with bilateral VF loss in the lowest tertile (less than 3 dB of VF loss in better-eye) had stopped driving. 36% (24/68) of participants with VF loss in the middle tertile (better-eye VF mean deviation between −3 and −9 dB) had stopped driving. 52% (35/68) of participants with VF loss in the highest tertile (better eye VF mean deviation <-9 dB) had stopped driving.
Segal-Gidan F et al., 2010	Cross-sectional	421 (30/391)	72	USA	Unilateral	Current drivers	OR	1.91 (0.63, 5.76)
		421 (108/318)			Bilateral, mild			2.05 (0.74, 5.66)

		421 (93/328)			Bilateral, moderate/severe			2.84 (0.92, 8.78)
vanLandingham S et al., 2013	Cross-sectional	139 (N/A)	70.1	USA	5 dB worse in the better eye	Glaucoma suspect controls	OR	1.7 (1.1, 2.5); p= 0.008
NOTE: There are a range of different study designs as well as cut-off points and areas of VF investigated in the identified studies. Due to methodological differences between each study, meta-analysis was limited and narrative reviews have been used instead to synthesise data.								

*unadjusted results

Table 4b(vii) All studies (n=3) on glare sensitivity (GS) impairment and driving cessation, all suitable to only be summarised narratively due to their different GS cut-off points and comparators

Author and Year	**Study Design**	**Total Participants (exposure/control)**	**Mean Age**	**Country**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR?)**	**Effect Measure (with 95% CI)**
Included in Narrative Summaries Only – High Income Countries								
Freeman E et al., 2005	Prospective Cohort	1824 (702/1122)	73.4	USA	3-4 points of glare sensitivity at baseline	≤2 points difference with baseline glare GS	HR	0.78 (0.61, 0.99)
		1824 (206/1618)			≥5 points of glare sensitivity at baseline			0.9 (0.63, 1.28)
		1824 (71/1753)			4 points loss of glares sensitivity in 2 years	<4 points GS loss		1.18 (0.7, 1.99)
		1824 (52/1772)			≥5 points loss of glare sensitivity in 2 years	<4 points GS loss		1.3 (0.72, 2.37)
Gilhotra JS et al., 2001	Cross-sectional	3654 (969/2685)	65.9	Australia	Physician diagnosed	Participants still driving	OR (logistic regression)	1.5 (1.2, 1.8)
Tam A et al., 2018	Cross-sectional	99 (15/84)	71.5	Canada	Physician diagnosed	Still driving participants with cataracts	Prevalence ratio (PR)	4.79; p<0.013

*unadjusted results

Table 4b(viii) All studies (n=11) on other types of vision impairment and driving cessation, all suitable to be summarised narratively only

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	Type of VI	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Included in Narrative Summaries Only – High Income Countries									
Campbell MK et al., 1993	Case control	1656 (28/1628)	N/A	USA	Retinal detachment	Self-reported physician diagnosed	Current drivers	Prevalence (%)	Still driving = 14.25%. Not driving = 40.95% Those not driving have a higher percentage of detached retina than those still driving (p<0.05)
					Retinal haemorrhage	Self-reported physician diagnosed		OR	Both genders = 3.86 (1.4, 10.4)*
									Females: 4.70 (1.2, 17.8); p<0.5
					Vision impairment	Self-reported		Prevalence (%)	Still driving = 13.65%. Not driving = 25.34% Those not driving have a higher percentage of other visual loss than those still driving (p<0.01)
DeCarlo D et al., 2003	Cross-sectional	126 (126/0)	79	USA	Maculopathy	exudative or non-exudative	Current drivers	Prevalence (%)	The type of AMD (exudative vs nonexudative) was not significant between the non-drivers and drivers (p=0.474). Nonexudative non-drivers: 50% (48/96), nonexudative drivers : 47% (14/30), exudative non-

									drivers: 50% (48/96), exudative drivers 53% (16/30).
Hajek A et al., 2019	Cross-sectional	549 (192/357)	90.3	Germany	Vision impairment	Severe impairment	Current drivers	OR	0.06 (0.01, 0.59)*
						Mild impairment			0.56 (0.24, 1.35)*
Gallo JJ et al., 1999	Case Control	1920 (N/A)	N/A	USA	Vision impairment	Self-reported	Current drivers	OR	1.86 (0.7, 4.9)
Keay et al., 2016	Cross-sectional	442 (148/294)	73	Australia	URE	Measured with autorefraction and lensometry	Cataract patients who are still driving	X^2 (Chi Square)	No significant differences between current drivers with URE (40% [99/263]) and former drivers with URE (51% [49/110]); p= 0.07
Levecq L et al., 2013	Cross-sectional	1000 (346/654)	71.3	Belgium	Vision impairment	Physician diagnosed	N/A	Prevalence (%)	Among the 190 non-drivers, 47 (24.7%) stopped driving because of their impaired vision.
Marottoli RA et al., 1993	Cross-sectional	1331 (17/1314)	age, no.: 65-74 years = 484, 75-84 years = 105, 85+ years = 6	USA	Vision impairment	Self-reported	Current drivers	Prevalence (%)	Out of the 17 drivers who reported poor vision at baseline (1983), 58.8% (9/17) of drivers who stopped driving by 1989.
Moon SH et a., 2020	Cross-sectional	2970 (1023/1947)	71	South Korea	Vision impairment	Self-reported	Current drivers	OR	0.97 (0.83, 1.14)*
Robinson JL et a., 2021	Cross-sectional	335 (N/A)	67.4	USA	Vision impairment	Self-reported	Current drivers	X^2 (Chi Square)	Participants were less likely to be driving if they had noted vision-related concerns (p<0.001).

Tam A et al., 2018	Cross-sectional	99 (19/80)	71.5	Canada	Dark adaptation in glaucoma patients	Self-reported	Among patients with glaucoma	X^2 (Chi Square)	Dark adaptation significantly associated with driving cessation (p<0.001)
								PR (Prevalence Ratio)	1.47; p= 0.39 Individuals with self-perceived dark adaptation difficulties were not more likely to quit driving.
Zebardast N et al., 2015	Cross-sectional	2469 (132/2337)	73.5	USA	URE	Binocular presenting visual acuity of 20/30 or worse, improving to better than 20/30 with subjective refraction	Participants with normal vision.	OR	2.1 (1.3, 3.6)
					Non-refractive visual impairment	Post-refraction binocular BCVA of 20/30 or worse			3.7 (2.4, 5.7)

*unadjusted results

Table 4b(ix) All studies (n=2; reporting on 4 RCTs in total) evaluating anti-VEGF therapy and driving cessation, suitable for narrative summaries only

Author and Year	**Study Design**	**Intervention (n)**	**Control (n)**	**Mean Age**	**Country**	**Vision Impairment**	**VI Definition**	**Comparator(s)**	**Outcome Measure**	**Effect measure (with 95% where appropriate)**
Bressler N et al., 2013	RCT	478	238	77.7	USA	AMD	MARINA trial: minimally	Sham injections or 0.3 mg of Ranibizumab or 0.5 mg of	Prevalence (%) + 95% CI	Among patients who had reported driving at

							classic or occult AMD	Ranibizuman for 24 months		baseline, 74% (146/197) sham patients and 87.8% (156/178) 0.5mg patients reported still driving at 12 months. Among patients who had reported driving at baseline, 67.2% (131/195) (95% Cl 59.2-75.2) of sham patients and 78.4% (148/189) (95% Cl 71.8-85.0) of 0.5mg ranibizumab patients reported still driving 24 months later.

Bressler N et al., 2013	RCT	280	143	77.7	USA	AMD	ANCHOR: classic neovascular AMD	Verteporfin photodynamic therapy (PDT) or 0.3 mg ranibizumab injections or 0.5 mg ranibizumab injections for 24 months	Prevalence (%) + 95% CI	Among patients who reported driving at baseline, 80.5% (77/96) PDT patients and 94.2% (86/91) 0.5 mg patients reported still driving at 12 months. Among patients who reported driving at baseline, 71.6% (67/94) (95% CI 60.8-82.4) of PDT patients and 91.4% (81/89) (95% CI 85.3-97.5) of 0.5 mg ranibizumab patients reported still driving 24 months later.

Bressler N et al., 2016	RCT	502	257	62.3	USA	DME	RIDE/RISE: any DME	Sham injections or 0.3 mg ranibizumab or 0.5 mg ranibizumab	Prevalence (%) + 95% CI	For 0.3 mg ranibizumab compared to those treated with sham only, there was a 7% (-5.0 to 19) difference in the number of participants now driving (who were not driving at baseline) at 12 months. For 0.5 mg ranibizumab compared to those treated with sham only, there was a 14.4% (1.1, 27.7) difference in the number of participants now driving at 12 months. For 0.3 mg ranibizumab

										compared to those treated with sham only, there was a 12.5% (-0.9, 25.9) difference in the number of participants now driving at 24 months. For 0.5 mg ranibizumab compared to those treated with sham only, there was a 14.3% (0.7, 27.9) difference in the number of participants now driving at 24 months.

Bressler N et al., 2016	RCT	234	111	62.3	USA	DME	RESTORE: DME in a least 1 eye eligible for laser treatment and a VA letter score between 78 and 39	PDT laser only or 0.5 mg + laser or 0.5 mg only	Prevalence (%) with 95% CI	After 12 months, 12.2% (6/49) of those who were not driving at baseline and were treated with 0.5 mg ranibizumab + laser have started driving. Compared to those treated with laser only, there was a 4.2% (-7.7, 16.1) difference in the number of participants now driving at 12 months. After 12 months, 8.9% (4/45) of those who were not driving at baseline and were treated

										with 0.5 mg ranibizumab only have started driving. Compared to those treated with laser only, there was a 0.9% (-10.3, 12.1) difference in the number of participants now driving at 12 months.

Table 4b(x) All studies (n=2) evaluating cataract surgery and driving cessation, suitable for narrative summaries only

Author and Year	Study Design	Total Participants (exposure/control)	Mean Age	Country	VI Definition	Comparator	Outcome Measure (OR, RR, HR?)	Effect Measure (with 95% CI)
Monestam E et al., 2005	Prospective Cohort	810 (N/A)	74.7	Sweden	Physician diagnosed cataracts	All cataract surgery patients, comparing pre and post cataract surgery outcomes.	Prevalence (%)	Before cataract surgery, 55% (224/407) were drivers while after surgery 70% (285/407) were drivers. 5 years after surgery 63% (189/300) of patients with a driving licence were still active drivers. 37% (67/183) of patients who did not drive before surgery started to drive after. 46% (31/67) of patients who did not fulfil the visual requirements for presenting VA and the 35% (24/67) who did not fulfil the requirements for BCVA for a

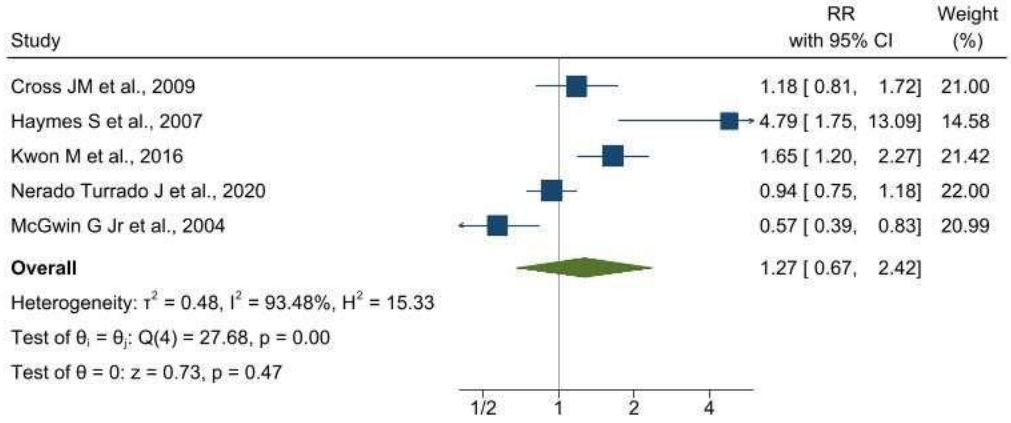
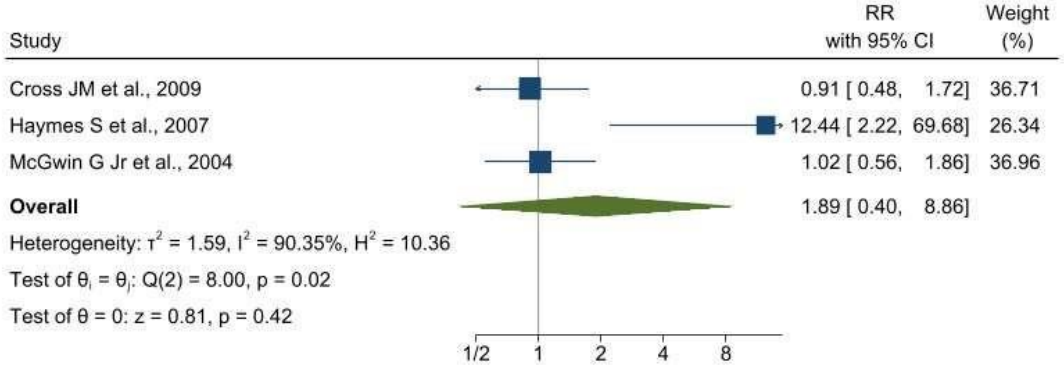
								legal licence could now legally drive. 82% (40/50) of patents who began to drive after the surgery were still driving 5 years later.
Monestam E et al., 1997	Prospective cohort	211 (N/A)	41	Sweden	Physician diagnosed cataracts	Driving status from all participants pre- and post-surgery.	Ratio (%)	The number of patients driving after surgery increased to 65% (137/211) (from 56%), but this was not significant.

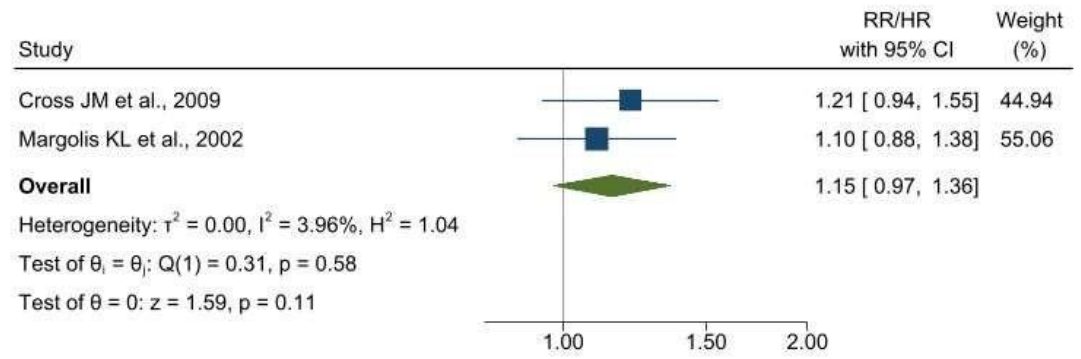
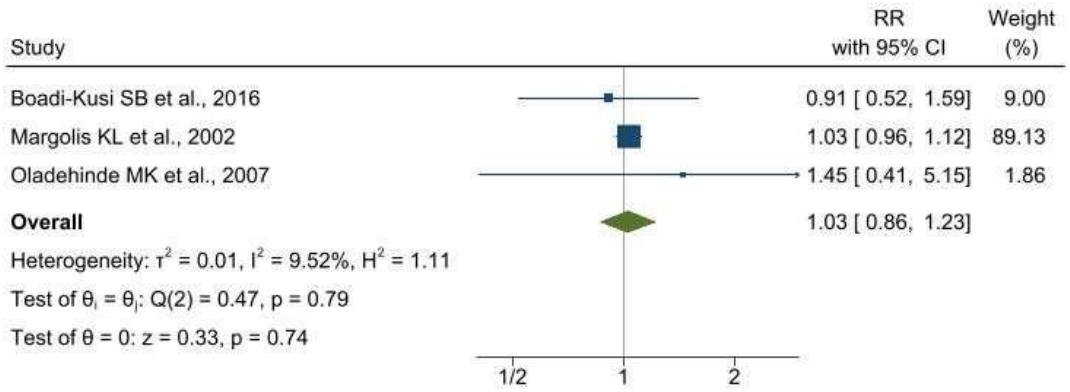
Table 4b(xi) All studies (n=1) evaluating anti-glaucoma therapy and driving cessation

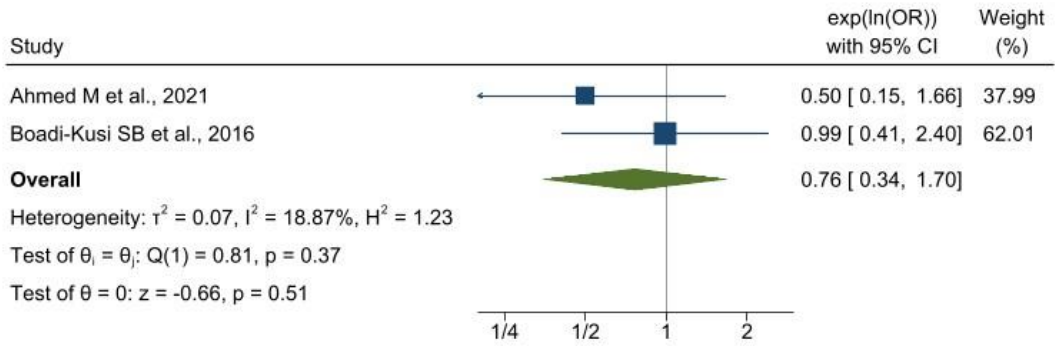
Author and Year	**Study Design**	**Total Participants (exposure/control)**	**Mean Age**	**Country**	**Vision impairment**	**VI Definition**	**Comparator**	**Outcome Measure (OR, RR, HR?)**	**Effect Measure (with 95% CI)**
Stafford WR, 1981	Cross-sectional	240 (N/A)	age, no.: 35-49 years = 11, 50-65 years = 77, >65 years = 139	USA	Glaucoma	Chronic open-angle glaucoma or ocular hypertension that has been adequately controlled for at least	Post- anti-glaucoma therapy outcomes in all participants.	Prevalence (%)	From the 229 patients who stated that the anti-glaucoma therapy side effects affected their

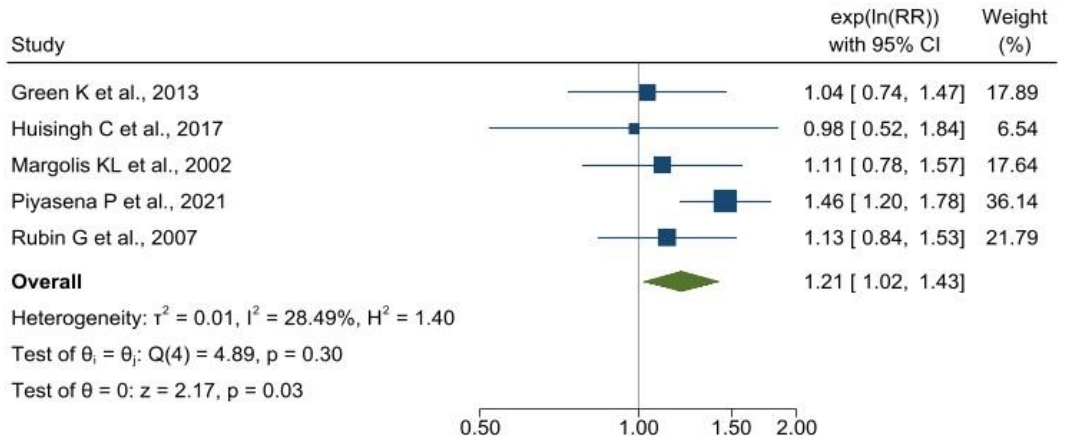
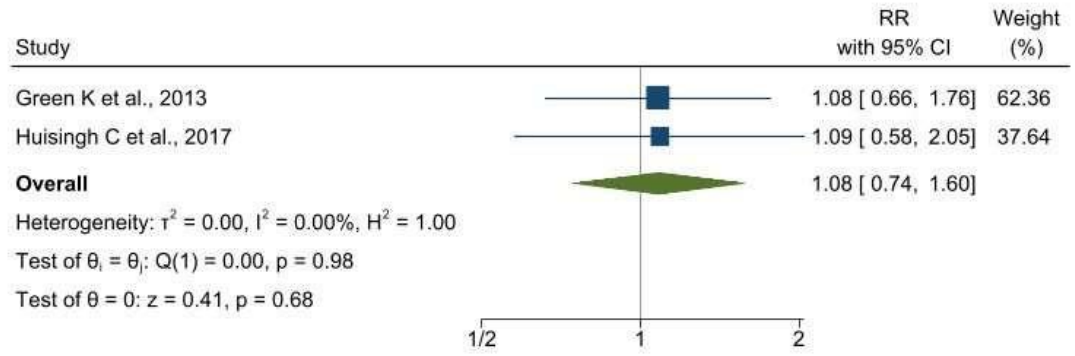
						the previous 6 months			normal activity, 12% (28/229) said that they had to give up some normal activity. Out of the 28 patients, 16 mentioned giving up driving, particularly at night.

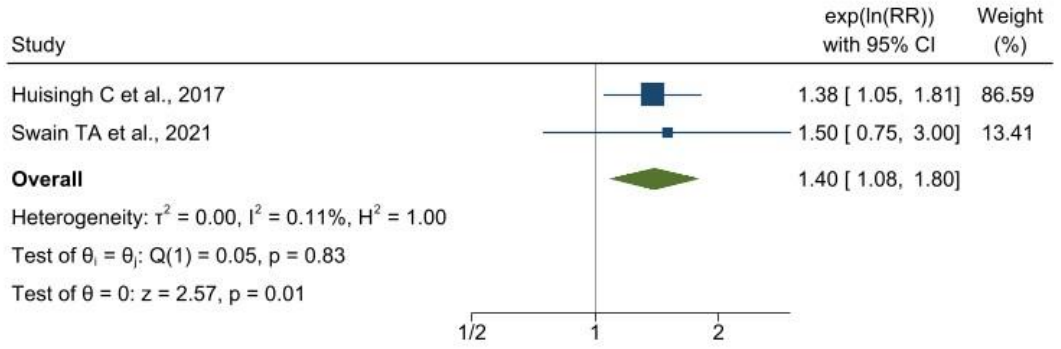
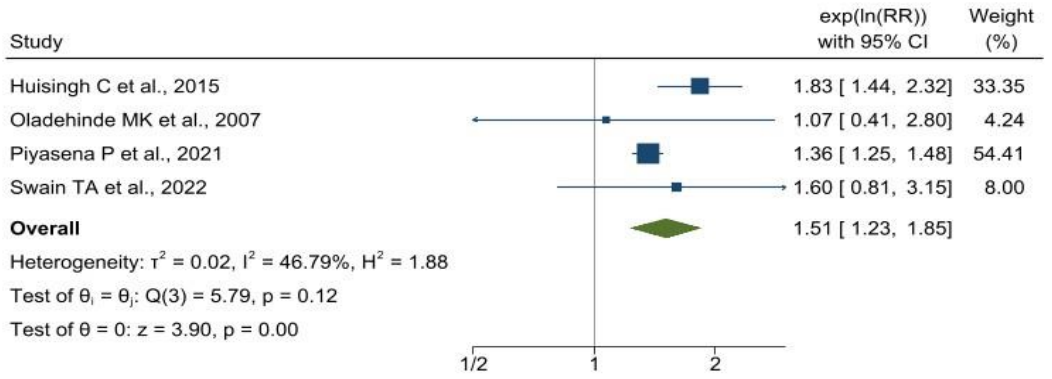
Appendix 5a Associations between MVC involvement and vision impairment and vision-related intervention

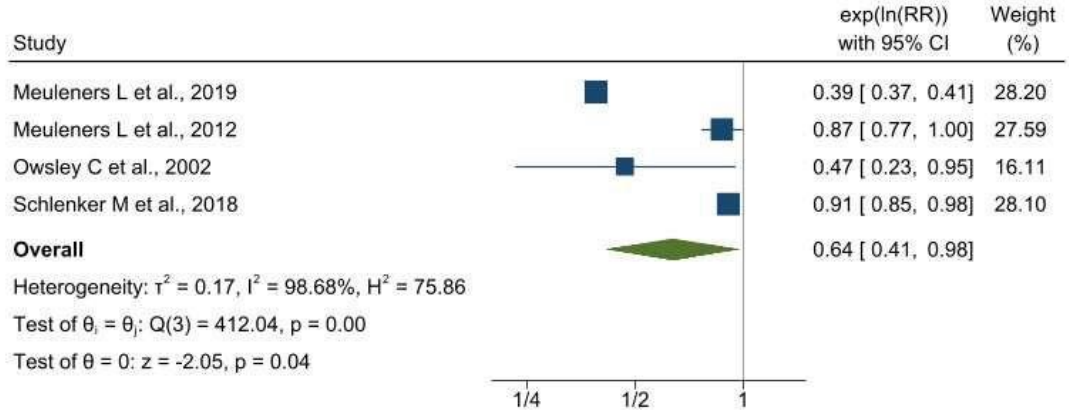
Vision impairment	Outcome	Association
Glaucoma	**Any MVC**	
	At-fault MVC	

Cataract	**Any MVC**	 NOTE: POOLED ONE STUDY WITH RR AND ANOTHER WITH HR
Stereopsis	**Any MVC**	

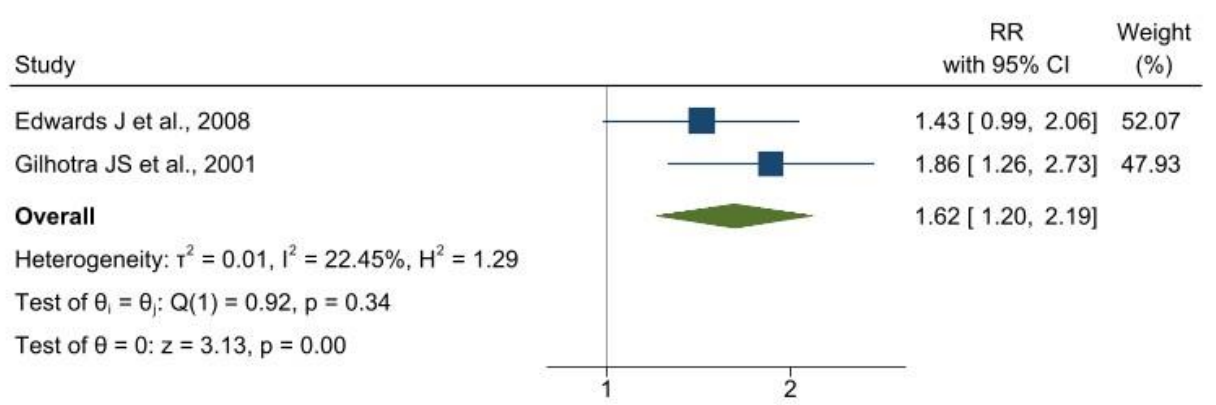
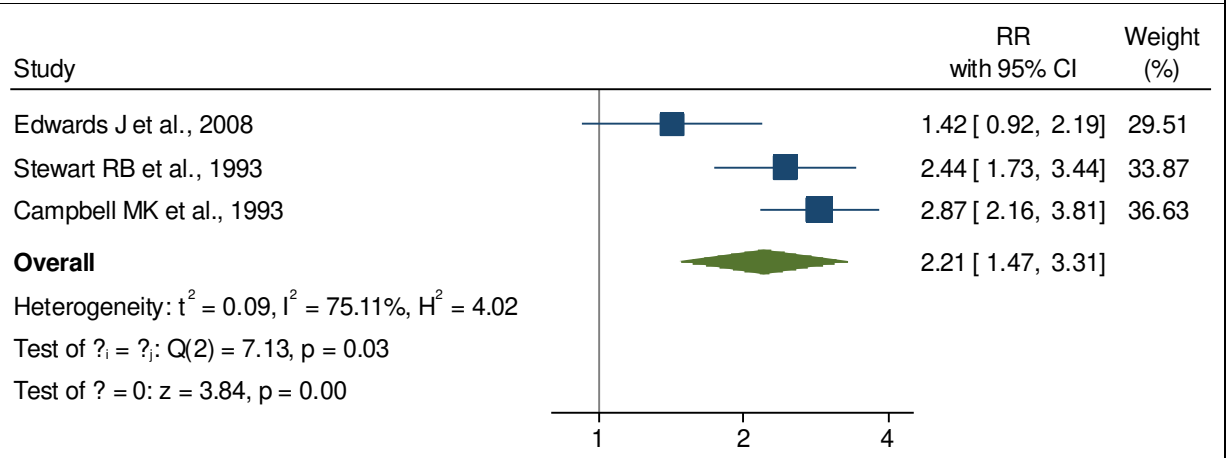
Myopia	**Any MVC**	

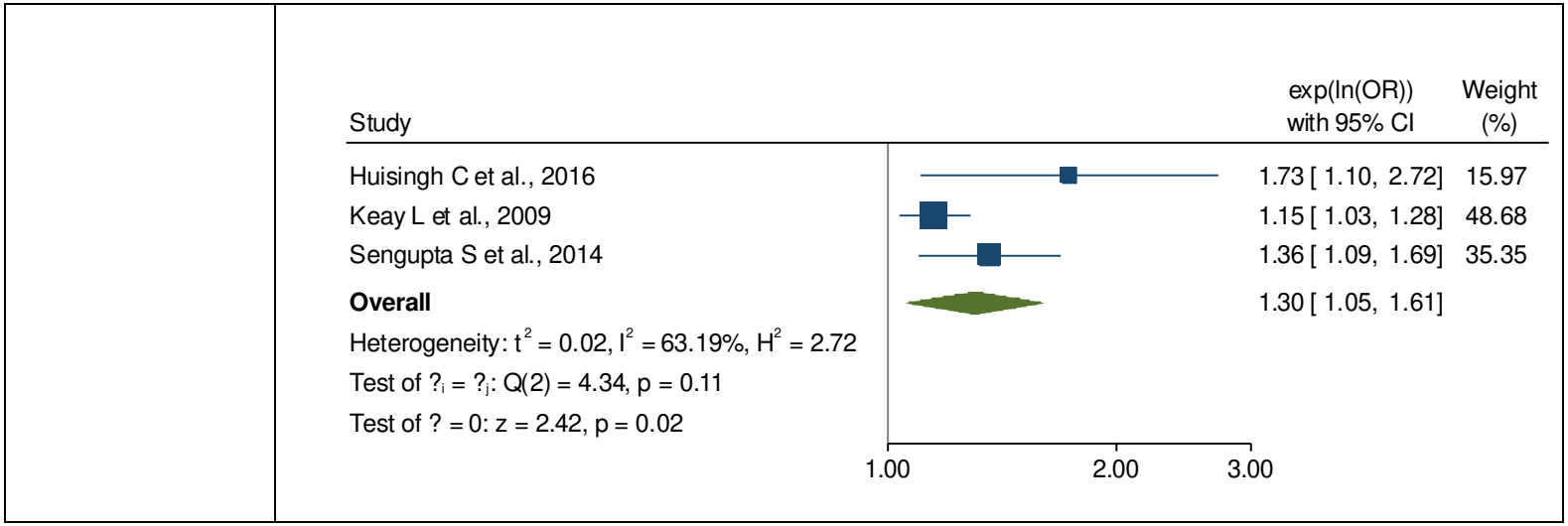
VA ≤ 20/40	**Any MVC**	
	At-fault MVC	

Vision-related Intervention	Outcome	Association
Contrast Sensitivity Loss	**Any MVC**	
Visual Field Loss	**Any MVC**	

Cataract Surgery	**Any MVC**	 HOWEVER WHEN DROPPING SCHLENKER M ET AL., 2018 (UNADJUSTED EFFECT MEASURE): **Overall** RR 0.55 [0.35, 0.92] Heterogeneity: T^2 = 0.17, I^2 = 97.10%%, H^2 = 34.52 Test of $\theta_i = \theta_j$: Q(2) = 125.66, p = 0.00 Test of θ = 0: z = -2.30, p = 0.02

Appendix 5b Associations between driving cessation and vision impairments

Vision impairment	Association
Glaucoma	
AMD	
Contrast Sensitivity	


Study
exp(ln(OR)) with 95% CI
Weight (%)
Huisingh C et al., 2016
1.73 [1.10, 2.72]
15.97
Keay L et al., 2009
1.15 [1.03, 1.28]
48.68
Sengupta S et al., 2014
1.36 [1.09, 1.69]
35.35
Overall
1.30 [1.05, 1.61]
Heterogeneity: t² = 0.02, I² = 63.19%, H² = 2.72
Test of ?i = ?j: Q(2) = 4.34, p = 0.11
Test of ? = 0: z = 2.42, p = 0.02
1.00
2.00
3.00