Health inequalities associated with post-stroke visual impairment in the United Kingdom and Ireland: a systematic review.

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Abstract

Aim: To report on the health inequalities facing stroke survivors with visual impairments as described in the current literature. **Methods**: A systemic review of the literature was conducted to investigate the potential health inequalities facing stroke survivors with subsequent visual impairments. A quality of evidence and risk of bias assessment was conducted for each of the included articles using the appropriate tool dependent on the type of article. **Results**: Only four articles discussed health inequalities affecting stroke survivors with visual impairment specifically. A further 23 articles identified health inequalities after stroke and 38 reported on health inequalities within the visually impaired UK or Irish population. Stroke survivors with visual impairment face inconsistency in eye care provision nationally, along with variability in the assessment and management of visual disorders. The subgroups identified as most at risk were: females; black ethnicity; lower socioeconomic status; older age and those with lower education attainment. **Discussion**: The issue of inconsistent service provision for this population must be addressed in future research. Further research must be conducted in order to firmly establish whether or not stroke survivors are at risk of the aforementioned sociodemographic and economic inequalities.

Background

Visual impairment is a common consequence of stroke, estimated to affect approximately 65% of stroke survivors (1). These include impairments of central vision (up to 70%); peripheral vision (up to 57%); ocular motility (up to 68%) and perceptual disorders including inattention (up to 80%) (1, 2). The resulting impact includes loss of confidence, mobility and inability to return to work or driving (1, 2).

It is estimated that there are 111,000 new strokes in the UK every year (3). In 2009, stroke mortality rate in the UK was recorded at 53,000 per year with premature death rates shown to be three times higher in the most economically deprived areas than the least deprived (3)

largely due to the association of risk factors such as smoking, obesity and poor diet (4). Preventable visual impairment is a significant public health issue and sight loss is predicted to affect four million people in the UK by 2050 due to an increasing aging population and the association of visual loss with older age (5). Further to age and social deprivation, health inequalities of stroke and visual impairment may include gender, race and educational attainment.

The reported economic cost of stroke between 2006-7 in the UK was £4.5 billion (3). In addition, visual impairment was recorded to cost the UK £4.3 billion between 2009-13 including the cost of resultant unemployment (5). Reducing health inequalities and lowering the rate of stroke and visual impairments by targeting the most affected groups could reduce this economic burden (5). The aim of this review is to report the health inequalities facing stroke survivors in the United Kingdom and Ireland with visual impairments as described in the current literature.

Methods

A systemic review of the literature was conducted to investigate the potential health inequalities facing stroke survivors with subsequent visual impairments. A quality of evidence and risk of bias assessment was conducted for each of the included articles using the appropriate tool dependant on the type of article.

Inclusion criteria for considering studies for this review

Types of studies

The following types of studies were included: randomised controlled trials, controlled trials, cohort studies, observational studies and retrospective medical note reviews. Case reports were excluded due to the high risk of bias associated with these types of reports. Review articles were excluded as the relevant articles from these review articles were extracted and discussed independently. All languages were included and translation obtained.

Types of participants

We included studies of adult participants (aged 18 years or over) diagnosed with a stroke or a visual impairment. Due to limited literature, the visual impairments discussed did not necessarily result from a stroke itself but represented the same visual symptoms one may experience following a stroke.

Types of outcome and data

The outcomes collected were clinical improvement in visual functions, functional improvement in activities of daily living and quality of life measures.

Search methods for identification of studies

We used systematic search strategies to search key electronic databases and contacted known experts in the field.

We searched the Cochrane Stroke Group Trials Register, the Cochrane Eyes and Vision Group Trials Register, and the following electronic bibliographic databases:

- The Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, latest issue);
- MEDLINE (1950 to March 2016);
- EMBASE (1980 to March 2016);
- CINAHL (1982 to March 2016);
- AMED (1985 to March 2016);
- PsycINFO (1967 to March 2016);
- Dissertations & Theses (PQDT) database (1861 to March 2016);
- British Nursing Index (1985 to March 2016);
- PsycBITE (Psychological Database for Brain Impairment Treatment Efficacy, www.psycbite.com).

In an effort to identify further published, unpublished and ongoing trials, we:

1. Searched the following registers of ongoing trials:

i) ClinicalTrials.gov (http://clinicaltrials.gov/);

ii) Current Controlled Trials (www.controlledtrials. com);

iii) Trials Central (www.trialscentral.org);

iv) Health Service Research Projects in Progress (wwwcf.nlm.nih.gov/hsr_project/home_ proj.cfm);

v) National Eye Institute Clinical Studies Database (http://clinicalstudies.info.nih.gov/cgi /protinstitute.cgi?NEI.0.html)

2. Hand-searched the *British and Irish Orthoptic Journal*, *Australian Orthoptic Journal*, and proceedings of the European Strabismological Association (ESA), International Strabismological Association (ISA), International Orthoptic Association (IOA) (http://pcwww.liv.ac.uk/~rowef/index_files/Page646.htm) and proceedings of Association for Research in Vision and Ophthalmology (www.arvo.org);

3. Performed citation tracking using Web of Science Cited Reference Search for all included studies;

4. Searched the reference lists of included trials and review articles about vision after acquired brain injury;

5. Contacted experts in the field (including authors of included trials, and excluded studies identified as possible preliminary or pilot work).

Search terms included a variety of MESH terms and alternatives in relation to stroke and visual conditions (Table 1).

Selection of studies

The titles and abstracts identified in the primary review were independently screened by both authors using the inclusion criteria discussed previously. Where it was not possible to establish if a study met these criteria from the title or abstract, the full paper was obtained. A secondary review of the full papers was then undertaken independently by the two authors to determine which studies should be included. In the case of disagreement for inclusion of studies, an

option was available to obtain a third author opinion. In practice, this was not required as no disagreements occurred for inclusion of papers.

Data Extraction

A pre-designed data extraction form was designed. Data was extracted and documented by one author (KH) and verified by another (FR).

Quality Assessment

One author (KH) independently assessed the quality of the studies included in this review using the STROBE checklist. An adapted version of the STROBE statement was used to assess the quality of cross-sectional, cohort and control studies. The STROBE statement covers 22 items from introduction, methods, results and discussion (6). The adapted version of the STROBE statement used in this review included 18 items.

Results

The results of the literature search identified 189 articles reporting on worldwide health inequalities in stroke populations and populations with visual impairments (Figure 1). Only four were found which directly discussed health inequalities in stroke survivors with a visual impairment. However, a further 97 were found which discussed health inequalities in stroke populations only and 88 were identified as reporting on health inequalities in populations with visual impairments, which could further identify possible inequalities facing stroke survivors with visual impairment. Collectively, these categories included:

- Socioeconomic and income
- Race/ ethnicity
- Gender
- Age
- Education level

- Occupation
- Transport
- Access to services

The four articles directly discussing health inequalities in visually impaired stroke survivors were included in the review, two of which were UK studies and thus met the inclusion criteria. However, as both articles were co-written by one of the authors, all four articles were included in the review to address potential perceived bias. Consideration of the National Health Services in these countries (Australia and US) was given to these two additional articles. Of the remaining 189 articles, only those reporting on population samples from the UK and republic of Ireland would be included in this review due to their direct relevance to our current health care system. After exclusion, the final numbers included four articles reporting on health inequalities due to post-stroke visual impairment, along with an additional 23 articles discussing stroke related health inequalities only and a further 38 articles reporting on health inequalities in non-stroke populations with visual impairment.

Quality of the evidence

The majority of the included articles (n=48) were of population based studies (36 prospective, 10 retrospective and 2 unclear), along with two surveys, three questionnaires, 11 retrospective medical note reviews or audits and one article reporting on a series of prospective focus groups. A quality of evidence assessment was completed for each using the STROBE tool (Table 2). Evidence was deemed to be of good quality if the article reported ≥75% of the items on the relevant assessment checklist. Overall, 30 of the reported articles scored 100% in the quality of evidence assessment. The remaining 35 articles included in this review reported between 75 and 99% of the checklist items assessed and were deemed to have good quality. No article scored less than 75%.

Health inequalities affecting stroke survivors with visual impairment

The literature search identified just four articles reporting on health inequalities facing stroke survivors with visual impairment (Table 3). These discussed inequalities in service delivery and gender.

Access to services

Rowe (7) reported that only 45% of stroke units in the UK provide a vision service at the acute stage of stroke. This will result in many stroke survivors being mismanaged or even undiagnosed of their visual impairment. The health inequality was in the area of residence (hospital catchment area) and was dependent on where one had their stroke as to whether or not they received visual input with their stroke care.

In a more recent study, Rowe et al. (8) identified further inequalities in stroke care when visual screening is undertaken. There is significant variability across the UK as to who performs the visual assessment, which tests are used, how visual impairments are managed and when patients are referred to eye care services. Many orthoptists and occupational therapists (22%) reported using screening tools commonly based on patient reported signs and symptoms or observed signs alone. As many stroke survivors cannot report their visual impairment due to stroke related speech difficulties and many visual problems will not elicit obvious signs, it is possible that few would be identified via this screening method (8, 9). It has been suggested that national care pathways, such as the national institute for health and care excellence (NICE) pathways (10), to guide health care professionals would address the issue of variation in visual management and onward referral to eye services to allow all stroke survivors adequate and equitable care (8).

Gender

Gall et al. (11) reported that women were more likely to suffer visual field loss following stroke whilst similar numbers of men and women suffered neglect. Moreover, the females in this study had a greater 28-day mortality due to their increased age and stroke severity. However,

it should be noted that the data collection period for this study significantly pre-dates the year of publication and may not be a true reflection of gender differences in the current population. A more recent study reported that following stroke, men and women can present with very different symptoms (12) although, the findings were not significant between either genders presenting with visual field loss, which differs from the findings by Gall et al. (11). However, men more frequently reported traditional signs and symptoms of stroke including the following visual impairments; visual hallucinations, photophobia, blurred vision, nystagmus and diplopia. Women tended to present with non-traditional stroke symptoms such as fatigue and disorientation, which often resulted in delayed diagnosis and treatment. The authors urge healthcare professionals and women to become more aware of the presenting signs to reduce this inequality (12).

Health inequalities affecting the general stroke population

Twenty-three articles were identified which discussed health inequalities facing stroke survivors without named visual impairments (Table 4). Health inequalities were reported from the following subcategories: race/ ethnicity; gender; age; socioeconomic; education level and access to stroke services.

Socioeconomic

A number of studies (n=4) discuss the relationship between poor socioeconomic status (SES) and increased risk of stroke (13-16), with one study showing that social deprivation resulted in nearly twice the risk of stroke (13). Some studies found that certain demographics were more affected by social status than others in relation to stroke outcomes (14, 15, 17).

One study compared the effect of SES and stroke mortality across a number of countries including England, Wales and Ireland, however, estimates were only possible for males aged 45-59 (18). They concluded that SES played a significant role, with males of manual-class having a significantly higher rate of stroke-mortality than those of non-manual class. However, a more recent study found that females from lower SES were twice as likely to suffer a stroke

(13). After adjustment for stroke risk factors, there was no longer a significant association with the male population. Furthermore, Chen et al. (17) reported a significant association between lower SES and survival after stroke but only for those of black ethnicity.

Various articles revealed that those form lower socioeconomic status were less likely to receive adequate hospital care following stroke. It has been reported that persons of lower SES are less likely to receive brain imaging at the acute stage of stroke (14, 19). Additionally, stroke survivors from lower SES were less likely to attend their hospital appointments (14). A further study investigating functional recovery post-stroke revealed those from socioeconomically deprived areas had significant functional impairment at three moths post-stroke compared to those of higher SES (20).

However, a number of articles reported little or no relationship between social class and stroke-related health inequalities. McCartney et al. (21) found a 42% increased rate of stroke mortality in Scotland compared to England but reported that socioeconomic characteristics accounted for only a quarter of this difference. They identified risk factors such as smoking as the main cause for the high stroke mortality rate in Scotland. Furthermore, Busch et al. (22) found that socioeconomic status did not impact on UK individuals' chances of returning to work after stroke, whilst Redfern et al. (23) found no socioeconomic inequalities relating to access of health care follow up after stroke. Although the primary factor affecting stroke outcome is likely related to risk factors as opposed to social position or area of residence, these risk factors are more commonly found in lower socioeconomic groups (13, 14) and as such, infers a health inequality within this group

Race/ ethnicity

Twelve articles discussed race/ ethnicity inequalities in stroke populations. Stroke incidence is shown to be higher in some ethnic groups compared to others. Overall, the black population appears to be at a higher risk of stroke than white, Asian or Hispanic populations (24). From 1995-2010 there was a significant decrease in stroke incidence in the white population but not in blacks (25). Black persons are more likely to be admitted to acute stroke units (19, 26, 27),

although the reason behind this is unclear. McKevitt et al. (26) suggested one reason for this is that black minorities are more often admitted as a precaution because of their typical younger age compared to white populations, or because clinicians are now sensitised to the stroke risk profile in the black African and Caribbean populations.

Heuschmann et al. (15) noted a decrease in stoke incidence for white males and females but not for black males. This finding that black males have an increased risk of stroke compared with black females was furthered by Bhopal et al. (28). Furthermore, Busch et al. (22) found the odds of black males returning to work following stroke were significantly less. Postulated reasons for this include an increased association with risk factors such as smoking and hypertension in the black population (29). It has been recommended that improved use of medication to control risk factors could address this, although, further research into compliance and dose assessment is required (27).

Some articles reported no association of race/ ethnicity after stroke, or conversely, that whites were more at risk of health inequalities. Wolfe et al. (27) found the white population to have poorer survival outcomes following stroke, whilst the black population over the age of 65 were more likely to survive a first-time stroke (57% survival rate at 5 years post stroke compared to 36% in the white population). They suggest that the heightened risk factors in the UK white population of heart disease, transient ischaemic attacks (TIA) and atrial fibrillation outweighed the risk of hypertension and diabetes in the older UK black population. This concurs with the findings by Smeeton et al. (30), where only black Caribbean and Africans under the age of 65 had higher rates of hypertension, possibly explaining why older black persons were previously found to have better stroke outcomes (27).

Redfern et al. (23) found no association of any race in access to health care following stroke. The authors initially observed higher rates of lacunar strokes and infarcts were in the Asian population, although this finding was not significant (31). Likewise, Chen et al. (17) found an initial increase in risk of mortality after stroke within black Caribbean and Africans but this was deemed not significant after adjustment for acute stroke care provisions

Gender

Overall, there has been an equal decline in stroke incidence between both genders in the last 10 years (25). However, one study has reported a higher incidence of stroke within the female UK population (13). What is more, Chen et al. (20) has shown that females have poorer functional recovery after stroke compared to men due to an increased risk of factors associated with social deprivation (20). Consequently, females have a lower chance of returning to work following a stroke (22). Hart et al. (13) was unable to explain the finding of higher stroke risk in females from the most deprived groups but speculate alcohol consumption, poor diet and lack of physical exercise as possible reasons.

Conversely, McFadden et al. (16) found that social class played a significant role in increasing stroke incidence between both genders equally, although their smaller population size could limit the validity of their findings when compared to other studies.

Others found no significant differences between gender in respect to stroke incidence (31), access of stroke services (23) or access to secondary drug prevention for patients (32). One study has shown evidence of health inequalities within the male population in relation to stroke care provision (14). Kerr et al. (14) found that men were less likely to be offered an electrocardiogam (ECG) following stroke. However, another study reported no differences between genders in relation to hospital admission or likelihood of receiving a brain scan (26). Whereas, a more recent study reported that men were more likely than women to be selected for brain scanning after a stroke (33).

Age

Four of the fifteen articles discussing age-related health inequalities found that older persons are at higher risk of stroke (24, 25, 27, 31). Hajat et al. (29) reported that increasing age correlated significantly with increased risk of infarction but not with haemorrhagic stroke, whilst a study investigating risk of stroke in females found that age was a significant factor of stroke mortality (34).

Redfern et al. (23) found stroke survivors over the age of 65 were less likely to be offered followed-up appointments. Although they could not provide an explanation for their findings, the authors speculate that health professionals may find it difficult to discuss lifestyle issues and behavioural risk factors with patients meaning those most at risk don't receive follow-up (23). Moreover, functional recovery after stroke is shown to be significantly worse in the older population (>65 years old) (20, 26).One study showed that the chances of returning to work decreased as age increased (22).

An inequality was identified in relation to access to stroke services as older patients (≥75) were less likely to receive brain imaging following stroke (19). This concurs with the findings from Lazzarino et al. (33) that younger patients were more likely to be selected for brain imaging. Moreover, Raine et al. (32) found that increasing age was significantly associated with reduced odds of receiving secondary preventative drugs after stroke. The odds increased from 26.4% for 50-59 year olds to 15.6% in 80-89 year olds, and just 4.2% for those aged >90. However, a study by Banjeree et al. (31) found that south Asians living in London were at an increased risk of stroke if aged ≤55 years. This is due to higher risk of diabetes in this younger population. This concurs with the findings by Wang et al. (25) who noted a 40% reduction in stroke incidence from 1995-2010 in those >45 years old. However, there was no significant change in the 15-44 year olds due to an increased rate of diabetes over this period. Additionally, Smeeton et al. (30) found that the rate of hypertension in black populations <65 years old reportedly increased between 1995 and 2004, subsequently increasing the incidence of stroke.

It has been further suggested that socioeconomic factors play a role in the association between age and stroke incidence. It was found that stroke survivors in lower socioeconomic groups were of younger age (14), which could indicate poorer health outcomes from a younger age for those living in more deprived areas of the UK.

Education

Only one article discussed education attainment and stroke-related health inequalities, concurring that a lower educational level is associated with poorer stroke recovery whilst in hospital (35). However, this was not significant for recovery following discharge. Additionally, a high level of education correlated with a higher Rivermead motor assessment score, which may suggest that those with a higher education will have a better functional outcome after stroke (35).

Health inequalities affecting the visually impaired population

Thirty-eight articles reported on health inequalities associated with non-stroke related visual impairments (Table 5). Visual impairments can arise form a wide range of possible diagnoses including glaucoma, age-related macular degeneration (AMD) and cataracts, the symptoms of which can be compared to those caused by stroke. Potential health inequalities facing this population include gender; age; occupation; socioeconomic; education level; and transport.

Socioeconomic

Patel et al. (36) reported that British women from lower socioeconomic groups are less likely to have an optometry eye examination. The reason for this inequality is uncertain but the authors postulate the cost of this service as the potential cause. Concurrently, Shickle & Farragher (37) found eye examinations were 71% more likely in the least deprived areas than in the most deprived areas, despite equal entitlement between groups.

A review investigating inequalities accessing eye services in the UK found an association poor SES and poor attendance of eye health services (38-56); late stage of eye disease at presentation to eye services (57-64); uncorrected refractive error (65, 66); increased waiting times for treatment (67, 68) and poor treatment compliance (64, 69). Articles meeting the inclusion criteria have been extracted and evaluated in Tables 2 and 5. There was an equal split between articles reporting no association and those reporting a significant association between poor SES and access to eye services. The authors suggest that this is due to a

number of the articles investigating access to eye services as a secondary research question (~~REF~~ knight (70)). Two further studies remarked that as eye care is the only fee paying service in the UK, the cost of using this service could explain this possible health inequality (36, 37). One study proposed free universal public provision to tackle income effects in up taking health care (54).

One article, reported an association between poor SES and reduced vision, which was not significant (71). They concluded that the true reason for this association was the higher rate of uncorrected refractive error within the manual working class groups. They recommended that targeting uncorrected refractive error within deprived areas may have the potential to reduce this inequality. An additional study concurred with these findings and reported uncorrected refractive error was associated with younger age, male sex, increased deprivation and non-white ethnicities (72).

As noted previously with age-related inequalities, some ocular conditions are more prevalent in lower socioeconomic groups; namely glaucoma and AMD (60, 73). Those from lower SES groups have been reported to present with glaucoma at significantly later stages than those of higher SES (59, 60). Although Fraser et al. (60) added that family history and time since last optometry visit also played a key role in this statistic. As mentioned previously, this places more deprived individuals at a significant disadvantage and at high risk of irreversible visual loss. Poor diet, increased rates of smoking and stress associated with lower SES are reportedly the cause of this progression of glaucoma (60). Day et al. (59) concluded that it is not acceptable to rely on high-street opticians to detect glaucoma in these areas of high deprivation and recommended the development of outreach services to tackle this concerning issue.

Furthermore, Yip et al. (73) reported higher levels of deprivation with AMD patients due to associated increased rates of smoking and lower levels of physical and academic education within this group. As smoking is a significant risk factor of AMD, they propose the potential lack of understanding regarding the risks of smoking suggested by the lower levels of education as the cause of this inequality.

Gender

Three articles discussing gender-related health inequalities and visual impairment reported that women were at a higher risk of visual impairment (71-73) potentially due to the higher prevalence of particular ocular diseases within females. Yip et al. (73) found a significant association of AMD prevalence within the female population only. The authors found that this risk was indirectly influenced by SES due to a mutual association of risk factors such as smoking and poor diet (73). Another study reported that more women were taking up eye examinations in Leeds (UK), indicating an increased prevalence of visual impairment within the female population (37), although this was not found to be statistically significant when compared to the male population utilising ophthalmic services.

Age

All of the articles reporting age-related health inequalities and visual impairment (n=6) concluded that older age was significantly associated with greater health inequalities (36, 37, 59, 72, 73). Older persons with visual impairment living in deprived areas are significantly less likely to take up eye examinations suggesting an association between inequalities of older age and low SES(37). Moreover, a study of solely female participants reported that women >65 years old and of manual social class were less likely to take up eye examinations in the UK (36). They postulate that the cost of having an eye assessment may be a determining factor for this group. Another study reported that participants of both genders in this same age group were three times more likely to be visually impaired than those under 65 years old (71).

The prevalence of various ocular diseases has shown to increase with age (59, 73). Day et al. (59) conducted a study to map the profile of glaucoma in Leeds and found that older persons are accessing glaucoma services at a later stage. This highlights a potentially significant inequality as late presentation of glaucoma can result in irreversible loss of the patients' visual acuity.

Education

Four articles reported an association between lower levels of education attainment and higher rates of visual impairment (60, 71, 73). Two articles reported a connection between lower levels of education and lower SES, which has further been associated with reduced vision in these deprived groups (71, 73). Yip et al. (73) reported that those with A-levels were significantly less likely to develop AMD than those without O-levels due to a lack of education and understanding of health risk factors.

Fraser et al. (60) found that those who left full time education by age 14 were more likely to present to an optician with glaucoma at a later stage than those who carried on in full time education, however this association was not statistically significant.

Occupation

One study found an association with increased risk of unemployment in individuals with reduced vision, even in those with mildly reduced vision in one eye (72). Those with the most severe grade of visual impairment had three times the risk of unemployment. Visually impaired individuals who can work are more likely to have a lower grade job and are associated with living in sheltered accommodation as a result of their visual impairment (72).

Transport

One article was identified in the literature search which discussed transport issues for the visually impaired population (74). The authors identified a number of inequalities relating to mobility and access to transport services through focus groups. They discussed the difficulty of using buses, as wheelchairs were often not admitted on board whilst many sight impaired persons required this service (74). Furthermore, the high cost of frequent taxis when transport by bus or train was not possible posed a further inequality. Moreover, when it is possible to use public transport, many visually impaired patients found this to be very stressful due to lack of confidence as a result of their sight impairment (74).

Those living in rural areas are at a further disadvantage as night buses are less available in those areas. When transport options are restricted, this results in increased dependency on family or friends to take them to appointments, which limits the patients' access to medical, social and rehabilitative services (74).

Conclusion

Only two articles aimed to investigate health inequalities affecting stroke survivors in the UK with visual impairment. These identified significant inconsistency in eye care provision nationally, along with variability in the assessment and management of visual disorders. However, the authors recognise the potential perceived bias as these articles were co-written by one of the authors. To reduce bias, the review was opened up to include international articles outside of the UK and Ireland, which discussed health inequalities due to post-stroke visual impairment, although the findings should be interpreted cautiously as differences in ethnicity, lifestyle factors and private health care systems in these countries could yield inequalities unlikely to be experienced in the UK. These additional two articles discussed gender inequalities in visually impaired stroke survivors; women are more likely to present with visual field loss, men more likely to present with ocular motility defects and both have equal risk of neglect (11, 12).

Our review further identified the following stroke and visually impaired subgroups as most at risk of health inequalities in the UK and Ireland: lower SES, older age, females and those with lower education attainment. Black ethnic groups have poorer stroke outcomes than whites and Asians, and Asians have poorer outcomes than whites. Health inequalities facing these populations range from likelihood of having a stroke or vision problem to limited access to health care resources. These findings highlight a requirement for further research in which to develop strategies to overcome these established inequalities. Many of the subcategories named are associated with one another e.g. females' increased risk of stroke due to their association with socioeconomic deprivation, which in turn is related to the increased rates of

risk factors found in socially deprived areas (e.g. smoking). Therefore, the full trajectories of these inequalities should be considered when addressing these issues.

Stroke survivors often suffer from a wide range of visual deficits, however, there is a specific gap in the literature in relation to health inequalities facing this population. Due to this lack of research, it has often only been possible to speculate the potential inequalities and so, further research must be conducted in order to establish whether or not this population are at risk of the aforementioned sociodemographic and economic inequalities.

Declarations

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Table 1: Search terms

Cerebrovascular disorders/ Brain ischaemia/ Intracranial Arterial Disease Intracranial Arteriovenous Malformations/ “Intracranial Embolism and Thrombosis*/ Stroke/	Eye Movements/ Eye/ Eye Disease/ Visually Impaired Persons/ Vision Disorders/ Blindness/ Diplopia/ Vision, Binocular/ Vision, Monocular/ Visual Acuity/ Visual Fields/ Vision, Low/ Ocular Motility Disorders/ Blindness, Cortical/ Hemianopsia/ Abducens Nerve Diseases/ Abducens Nerve/ Oculomotor Nerve/ Trochlear Nerve/ Visual Perception/ Nystagmus/ Strabismus/ smooth pursuits/ saccades/ depth perception/ stereopsis/ gaze disorder/	Health inequality/ Health equity/ Socioeconomic/ Sociodemographic/ Gender/ Male/ Female/ Age/ Ethnicity/ Race/ Transport/ Education/ Occupation/ Access to services/ Access to care/
OR	OR	OR
AND		

Figure 1: Flowchart of pathway for inclusion of articles

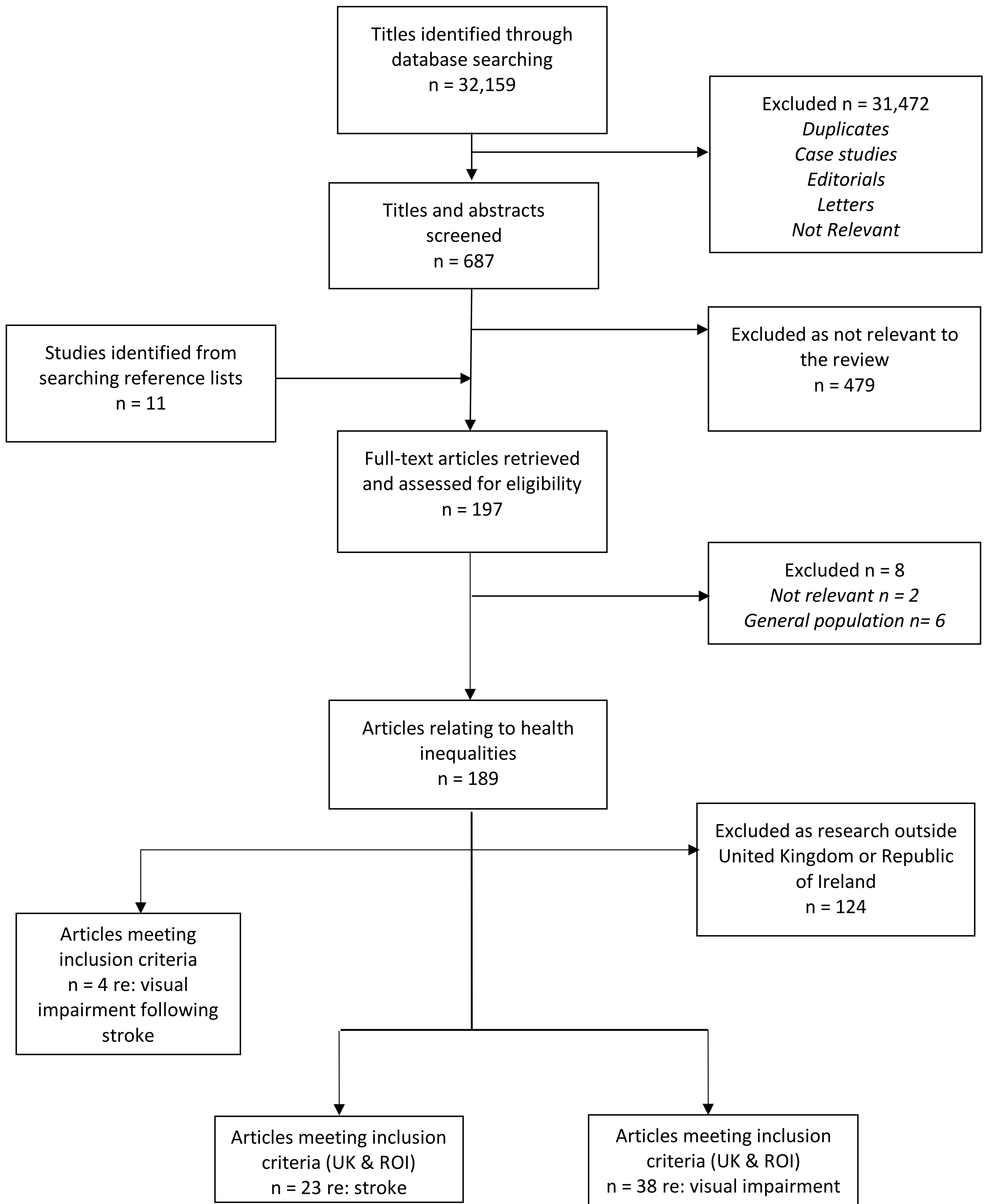

Table 2: Quality appraisal of papers using the STROBE checklist

	Methods									Results					Discussion		
	Study design	Participants	Variables	Data source	Bias	Study size	Quantitative variables	Statistical methods	Participants	Descriptive data	Outcome data	Main results	Other analyses	Key results	Limitations	Interpretation	Generalisability
	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Acharya et al. 2009 (58)	+	+	+	+	?	+	+	+	+	+	+	+	+	+	+	+	+
Addo et al. 2011 (19)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	+	+	+
Bachmann et al. 2003 (40)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Banerjee et al. 2010 (31)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	+	+	+
Bhopal et al. 2011 (28)	+	+	+	+	+	+	+	+	?	+	+	+	n/a	+	?	+	+
Buch et al. 2005 (44)	+	+	+	+	-	+	+	-	+	+	+	+	n/a	?	+	+	?
Busch et al. 2009 (22)	+	+	+	+	?	+	+	+	+	+	+	+	+	+	?	+	+
Chaturvedi & Ben-Schlomo 1995 (42)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Chen et al. 2014 (17)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chen et al. 2015 (20)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cookson et al. 2012 (43)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cooper et al. 2009 (68)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cox et al. 2004 (65)	+	+	+	+	+	+	+	+	?	+	+	-	n/a	+	-	+	+
Cumberland et al. 2016 (71)	+	+	+	+	+	+	+	+	+	?	+	+	+	+	+	+	+
Day et al 2010 (59)	+	+	+	+	?	+	+	+	?	+	+	+	+	+	+	+	+
Dickey et al. 2012 (44)	+	+	+	+	+	+	?	+	+	+	+	-	n/a	+	+	+	+
Fraser et al. 2001 (60)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Gall et al. 2010 (11)	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+
Gallagher et al. 2011 (73)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	-	+	+
Gulliford et al. 2010 (45)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Hacker & Stanistreet 2004 (67)	+	+	+	+	-	+	+	+	+	+	+	+	n/a	+	+	+	+

Hajat et al. 2001 (29)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	-	+	+
Hart et al. 2000 (13)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	-	+	+
Heuschmann et al. 2008 (15)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Jerath et al. 2011 (12)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Keenan et al. 2007 (46)	+	+	+	+	-	+	+	+	+	+	+	?	n/a	+	+	+	+
Keenan et al. 2009 (47)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Keenan et al. 2012 (48)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Kerr et al. 2010 (14)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	+	+	+
Kliner et al. 2012 (49)	+	+	+	+	-	+	+	+	-	-	+	+	n/a	+	+	+	+
Kunst et al. 1998 (18)	+	+	+	+	+	?	+	+	-	+	+	+	n/a	+	+	+	+
Lazzarino et al. 2011 (33)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Leese et al. 2008 (50)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Lockington et al. 2010 (61)	+	+	+	+	+	-	+	+	+	?	+	+	n/a	+	-	+	+
McCartney et al. 2015 (21)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
McFadden et al. 2009 (16)	+	+	+	+	+	?	+	+	+	+	+	+	n/a	+	+	+	+
McKevitt et al. 2005 (26)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Millett & Dodhia 2006 (51)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Nessim et al. 2010 (39)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Ng et al. 2010 (57)	+	+	+	+	+	+	+	+	+	+	+	-	n/a	+	-	+	?
Owen et al. 2006 (52)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	+	+	+
Owen et al. 2009 (68)	+	+	+	+	+	+	+	+	+	+	-	+	n/a	+	+	+	+
Patel et al. 2007 (36)	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Power et al. 2005 (34)	+	+	+	+	+	?	+	+	+	+	+	+	+	+	+	+	+
Putman et al. 2007 (35)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Rahi et al. 2008 (53)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Raine et al. 2009 (32)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Redfern et al. 2002 (22)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	-	+	+

Rowe 2010 (7)	+	+	+	+	-	+	+	+	+	+	+	+	n/a	+	-	+	+
Rowe at al. 2015 (8)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Sabates & Feinstein 2008 (54)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Saidkasimova et al. 2009 (62)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Scanlon et al. 2008 (55)	+	+	+	+	?	+	+	+	+	+	+	+	n/a	+	+	+	+
Sherwin et al. 2012 (66)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Shickle & Farragher 2015 (37)	+	+	+	+	+	+	+	+	+	+	+	+	n/a	+	+	+	+
Smeeton et al. 2007 (30)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sukumar et al. 2009 (63)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Van der Pols et al. 1999 (56)	+	+	?	+	?	+	+	+	+	+	+	+	n/a	+	-	+	+
Wallace et al. 2008 (64)	+	+	+	+	-	+	+	+	+	?	+	-	n/a	+	-	+	+
Wang et al. 2013 (25)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Waqar et al. 2012 (38)	+	+	+	+	+	+	+	-	+	+	+	+	n/a	+	+	+	+
Wolfe et al. 2002 (24)	+	+	+	+	?	+	+	+	+	+	+	+	+	+	?	+	+
Wolfe et al. 2005 (27)	+	+	+	+	-	+	+	+	+	+	+	+	n/a	+	+	+	+
Yip et al. 2013 (70)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Yip et al. 2015 (72)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+

- = Not reported ? = Unclear + = Reported

Table 3: Articles reporting on health inequalities associated with stroke related visual impairments

Article	Year/ duration of research	Country of research	Study type	Population (n)	Aim
Rowe 2010 (7)	2007	UK	Survey of stroke services - non validated questionnaire	134 stroke services	To determine the extent of Orthoptic involvement in stroke services throughout the UK and what constitutes a vision assessment
Rowe et al. 2015 (8)	2013	UK	Online survey	31 professional groups, 548 individuals	To explore care provision for post stroke visual impairment and variations in the UK
Gall et al. 2010 (11)	1996-1999	Australia	Population-based study	1316 first ever stroke Women = 731 Men = 585	To examine sex differences in presentation, severity, in-hospital treatment and early mortality in a cohort of first ever stroke patients
Jerath et al. 2011 (12)	2011 (data was collected in 1984-1989)	USA	Population-based study	449 first ischaemic stroke Women = 268 Men = 181	To investigate gender differences in presenting signs and symptoms of acute ischaemic stroke

Table 4: Articles reporting on stroke related health inequalities

Article	Year/ duration of research	Country of research	Study type	Population (n)	Aim
Addo et al 2011 (19)	2007-2009	UK, England	Population based stroke register	3800 with first ever ischaemic stroke or primary intracerebral haemorrhage between 1995-2009	To investigate time trends in receipt of effective stroke care and to determine factors associated with provision of care
Banerjee et al 2010 (31)	2003-2007	UK	Prospective database	811 (stroke=736)	To analyse differences between south Asian and white risk factor profile
Bhopal et al 2012 (28)	2001-2008	UK, Scotland	Retrospective cohort study	4.65 million from census and stroke database	To show links of ethnic variations and stroke incidence
Busch et al 2009 (22)	1995-2004	UK, England (London)	Prospective, population based study	2874 first ever strokes	To investigate the frequency and determinants of return to paid work after stroke
Chen et al 2014 (17)	1995-2011	UK, England (London)	Retrospective analysis of prospectively collected data	4398 first ever stroke	Assess the associations between SES and survival after stroke
Chen et al 2015 (20)	1995-2011	UK, England (London)	Retrospective analysis of prospectively collected data	2104 alive at 3 months post stroke	To assess the association between SES and functional impairment post stroke in relation to age, sex phenotype differences
Hajat et al 2001 (29)	1995-1998	UK, England	Prospective population based study	1254 first ever stroke	To establish the frequency of cardiovascular risk factors in patients with first ever stroke – relationship with ethnicity
Hart et al 2000 (13)	Had been screened in 1972-1976	UK, Scotland	Prospective questionnaire	467 men and 535 women	Investigate stroke differentials by socioeconomic position in adulthood
Heuschmann et al 2008 (15)	1995-2004	UK, England	Prospective population based study	2874 first time stroke	Investigate trends in stroke incidence and modifiable risk factors between different ethnic groups
Kerr et al 2011 (14)	2007-2008	UK, Scotland	Prospective multi-centred observational study	467 stroke and TIA (stroke=313)	To determine whether low SES stroke/ TIA patients have reduced health care access
Kunst et al 1998 (18)	1980's	England, Wales, Ireland, Finland, Sweden, Norway, Denmark, France, Switzerland, Italy, Spain, Portugal, US	Retrospective review of national longitudinal and cross-sectional studies	Number of participants not stated Men aged 30-64 with stroke	To present an international overview of socioeconomic differences in stroke mortality

Lazzarino et al 2011 (33)	2006-2009	UK, England	Not clear if data collected retrospectively or prospectively	209,174 emergency admissions for stroke	To describe the use of brain scanning in English hospitals and identify patient groups being excluded from appropriate care
McCartney et al 2014 (21)	1995-2003	UK, England and Scotland	Retrospective review of 18 cohort studies (15 English and 3 Scottish)	193,873 Pooled data from 18 cohorts	To what extent SES, behavioural, anthropometric and biological explain high levels of mortality in Scotland compared to England
McFadden et al 2009 (16)	1993-1997 and followed up until 2007	UK, England	Prospective population study	22,488 Followed up for stroke 39-79 years old	To investigate the association between working social class and stroke incidence
McKevitt et al 2005 (26)	1995-2000	UK, England	Population based stroke register	1635 first ever stroke	Investigate the associations between SES and provision of acute and long term stroke care
Power et al 2005 (34)	Over 45 year period	UK	Prospective study (follow up of 45 years)	11,855 Women aged 14-49 (stroke = 217 participants but discussed separately)	To see if women's childhood socioeconomic position influenced their risk of mortality
Putman et al 2007 (35)	Not stated	6 stroke rehab units in Europe: UK, Germany, Switzerland, Belgium	Prospective, multicentre population based	419 first ever stroke aged 40-85	Examine the impact of education and income on recovery after stroke
Raine et al 2009 (32)	1995-2005	UK, England	Cohort study using data from primary care database	12,830 aged 50+ who suffered a stroke between 1995-2005 and survived for the first 30 days	To determine extent to which secondary drug prevention for stroke pts varies by sex age and SES
Redfern et al 2002 (22)	1995-1998	UK, England (London)	Prospective population based study	717 first ever stroke	Access to health care follow up after stroke
Smeeton et al 2007 (30)	1995-2004	UK, England (London)	Prospective population based study	566 first ever stroke	To see if race varied with incidence of intracerebral haemorrhage or subarachnoid haemorrhage
Wang et al 2013 (25)	1995-2010	UK, England (London)	Prospective population based study	4245 first ever stroke	Investigate age and ethnic disparities in stroke incidence
Wolfe et al 2002 (24)	1995-1998	UK, England (London)	Population based stroke register	1254 first ever stroke	Identify sociodemographic differences in incidence of stroke
Wolfe et al 2005 (27)	1995-2002	UK, England (London)	Population based stroke register with follow up	2321 first ever stroke	Identify ethnic differences in survival after stroke

Table 5: Articles relating to vision impairment health inequalities

Article	Year/ duration of research	Country of research	Study type	Population (n)	Aim
Acharya et al 2009 (58)	2004-2005	Scotland, UK	Retrospective medical note review	240 with new exudative AMD	To evaluate the influence of socio-economic factors on visual acuity (VA) at presentation in exudative age-related macular degeneration
Bachmann et al 2003 (40)	1998-2000	England, UK	Cross-sectional questionnaire survey	770 diabetes	To investigate socio-economic inequalities in diabetes complications and to examine factors that may explain these differences.
Buch et al 2005 (44)	2000-2001	UK	Cross-sectional study	11682 Patients who underwent retinal screening between 2000-2001	To assess the coverage of a diabetes retinopathy screening service and identify characteristics associated with non-attendance
Chaturvedi & Ben-Schlomo 1995 (42)	1991-1992	UK	Cross-sectional study	140,049 patients from a GP surgery	To determine whether there are socioeconomic differences in the relationship between expressed need for possible surgical intervention and surgical provision
Cookson et al 2012 (43)	2001-2008	UK	Ecological study	32,482 English small areas all adults receiving non-emergency hospital care in the English NHS from 2001 to 2008	To investigate whether there was any change between 2001 and 2008 in small-area socio-economic equity in the utilisation of specialist care relative to need in the English NHS
Cooper et al 2009 (68)	1997-2007	England, UK	Retrospective cross-sectional study	427,277 elective knee replacement patients, 406,253 elective hip replacement patients, 2,568,318 elective cataract repair patients	To determine whether waiting times occurred for certain key elective procedures
Cox et al 2005 (65)	2000-2001	Scotland, UK	Cross-sectional study	537 fracture patients aged 65 and over	To evaluate the current visual status and ophthalmic history of a sample of

					elderly patients with fractured neck of femur
Cumberland et al 2016 (71)	2009-2010	UK	Cross-section epidemiological study	112314 Adults with low vision	To investigate the association of visual health with social determinants of general health and the association of visual health and health and social outcomes
Day et al 2010 (59)	2002-2007	UK, England (Leeds)	Equity profile mapping It is not a formal epidemiological survey	Estimate between 5963 and 6700 people with glaucoma in Leeds	Unclear. To map an equity profile for glaucoma in Leeds but can be reused for other ophthalmic conditions in other UK locations
Dickey et al 2012 (44)	1999-2008	Scotland, UK	Analysis of nationwide survey	Not stated. Covers >5000 households in the UK	To examine how the introduction of free eye examinations in Scotland affected people's use of eye care services
Gallagher et al 2011 (73)	Not stated	Ireland and Northern Ireland	14 Focus groups	121 Urban and rural dwellers with visual impairment	Explore mobility and access to transport issues of people with visual impairment (differences in urban and rural)
Gulliford et al 2010 (45)	2007-2009	England, UK	Retrospective study	31 484 subjects (59 495 appointments)	To quantify socio-economic and ethnic inequalities in diabetes retinal screening
Hacker & Stanistreet 2004 (67)	2000-2001	England, UK	Retrospective study	4306 ophthalmology or orthopaedic waiting list patients (elective, first episodes) living within Health Authority boundaries	To investigate the extent to which equitable access is achieved in one routinely administered hospital waiting list system.
Fraser et al 2001 (60)	1996-1997	UK	Prospective hospital based Case-control study	220 Glaucoma	To identify socioeconomic risk factors associated with glaucomatous visual field loss
Keenan et al 2007 (46)	1960-2003	England, UK	Retrospective audit	Hospital episodes of cataract admissions	To examine time trends and geographical variation in rates of cataract surgery

Keenan et al 2009 (47)	1976-2004	England, UK	Retrospective audit	Hospital episodes of annual trabeculectomy admissions	To examine trends over time and regional variation in rates of trabeculectomy in England.
Keenan et al 2012 (48)	1989-2009	England, UK	Retrospective audit	Hospital episodes of annual treatment rates of intravitreal injections	To report on trends over time and geographical variation in intravitreal injection rates in England
Kliner et al 2012 (49)	Unclear	England, UK	Ecological study	N=? Diabetic retinopathy	To conduct an equity profile to identify inequity in eye health across Leeds and Bradford.
Leese et al 2008 (50)	2004-2006	Scotland, UK	Population-based study	15,150 patients with diabetic retinopathy	To identify criteria that affect uptake of diabetes retinal screening in a community screening program.
Lockington et al 2010 (61)	1994-2008	Scotland, UK	Retrospective record review	536 patients with choroidal melanoma	To audit the demographic characteristics of patients with choroidal melanoma
Millett & Dodhia 2006 (51)	2003	England, UK	Cross-sectional study	Patients on a centralised disease register invited for screening N=8061	To assess uptake of the diabetes retinopathy screening programme in South East London and examine variation in attendance and screening outcomes.
Nessim et al 2010 (39)	Unclear	England, UK	Retrospective case note reviews	139 consecutive patients presenting with acute primary angle closure glaucoma	To investigate the association of social deprivation as a risk factor for acute primary angle closure in a UK urban population.
Ng et al 2012 (57)	2006	Scotland, UK	Cross-sectional study	48 patients with severe glaucoma and 74 patients with non-severe glaucoma	To evaluate the influence of socio-economic factors on severity of glaucoma at presentation
Owen et al 2006 (52)	1994-2003	UK	Retrospective review	131 general practices across the United Kingdom	To study trends in the prevalence of being treated for glaucoma and ocular hypertension and to examine factors determining treatment in 2002.
Owen et al 2009 (69)	1993-2005	UK	Retrospective medical note reviews	5670 registered patients newly prescribed an ocular hypotensive drug	To examine trends and demographic factors affecting persistence with ocular hypotensive therapy
Patel et al 2007 (36)	1998-2001	UK	Questionnaire	3652 (23 towns) Older Women aged 62-83	To examine socioeconomic position and self-reported use of 6 preventative

					and therapeutic services including eye services
Rahi et al 2008 (53)	Unclear	UK	Cohort study	9271 members of the 1958 British birth cohort	To investigate frequency of visual impairment due to undiagnosed RE and its associations with vision-related quality of life (VRQOL), general health and social circumstances
Sabates & Feinstein 2008 (54)	1991-2003	UK	Analysis of data from national survey	Approx. 10,000 individuals	To investigate whether permanent and transitory income effects mask the impact of unobservable factors on the uptake of health check-ups in Britain
Saidkasimova et al 2009 (62)	2007-2008	Scotland, UK	Prospective, multi-centre population-based observational study	572 patients with retinal detachment	To investigate any association between retinal detachment, macular status at presentation and deprivation.
Scanlon et al 2008 (55)	1998-2003	England, UK	Cross-sectional	13,304 patient records in data set 1. 10,312 patients with diabetic retinopathy in data set 2	To investigate socioeconomic variations in diabetes prevalence, uptake of screening for diabetic retinopathy, and prevalence of diabetic retinopathy.
Sherwin et al 2012 (66)	2006	England, UK	Prospective study	4428 participants between 48-89 years old	To investigate the prevalence of, and demographic associations with, uncorrected refractive error (URE) in an older British population.
Shickle & Farragher 2014 (37)	2011	UK, England (Leeds)	Population based	17,680 eye examinations taken from general ophthalmic services claim forms	To explore the geographical differences in the uptake of general ophthalmic services
Sukumar et al 2009 (63)	1995-2005	England, UK	Retrospective study	113 glaucoma patients	To investigate the relationship between socioeconomic status and the extent of visual field loss in glaucoma and treated ocular hypertension patients at their first presentation to eye clinic

Van der Pols et al 1999 (56)	1994-1995	UK	Cross-sectional study	1275 subjects with a successful measurement of distance visual acuity and no mental impairment	To investigate the time since a last eye test and relations to socioeconomic factors
Wallace et al 2008 (64)	1990-1999	UK	Retrospective case note review and a cross-sectional interview of 29 patients	87 case notes and 29 patients registered blind with glaucoma were interviewed	To study patient characteristics and management profile in advanced glaucoma.
Waqar et al 2012 (38)	2009-2010	England, UK	Retrospective study	2137 patients who did not attend diabetic retinopathy screening	To ascertain the relationship between socioeconomic status and non-attendance alongside the role of geodemographic analysis in identifying reasons for non-attendance
Yip et al 2013 (70)	2004-2011	UK, England	Multicentre prospective study	8467 persons with completed eye examinations	Prospective investigation into the relationship between area deprivation and poor vision
Yip et al 2014 (72)	2004-2011	UK	Cross sectional study within a longitudinal cohort study	5344 pairs of fundus photos AMD patients	Investigate relationship between area deprivation, SES and AMD