SYSTEMATIC REVIEW

Risk factors common to leading eye health conditions and major non-communicable diseases: a rapid review and commentary [version 1; peer review: awaiting peer review]

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Abstract

Background: To gain an understanding of the intersection of risk factors between the most prevalent eye health conditions that are associated with vision impairment and non-communicable diseases (NCDs).

Methods: A series of rapid reviews of reviews reporting on non-modifiable risk factors, age and sex, and modifiable risk factors, including social determinants, were conducted for five common eye health conditions that are the leading causes of vision impairment globally (refractive error including uncorrected refractive error, cataract, age-related macular degeneration (AMD), glaucoma, and diabetic retinopathy) and five prevalent NCDs (cancer, cardiovascular disease, chronic respiratory disease, dementia, and depressive disorders). Articles published within approximately 5 years to the end of 2019 were identified through expert recommendation, PubMED, Ovid Medline, the Lancet Global Burden of Disease series, the International Agency for Research on Cancer and World Cancer Research Fund.

Results: Of 9,213 records identified, 320 records were eligible. Eye health conditions and NCDs share many risk factors. Increased age was found to be the most common shared risk factor, associated with increased risks of AMD, cataract, diabetic retinopathy, glaucoma, refractive error, cancer, cardiovascular disease, chronic obstructive pulmonary disease, and dementia. Other shared risk factors included

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smoking, obesity, alcohol consumption (mixed results), and physical activity was protective, though limited evidence was found for eye conditions. Social determinants are well documented as risk factors for NCDs.
Conclusion: There is substantial overlap in common established risk factors for the most frequent vision impairing eye conditions and leading NCDs. Increasing efforts should be made to integrate preventative and risk reduction interventions to improve health, with greatest shared benefits for initiatives which aim to reduce smoking, improve diet, and promote physical activity.

Keywords
vision impairment, eye health, non-communicable disease, risk factors, social determinants

This article is included in the Eye Health gateway.

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Introduction

People who have vision impairment often also present with chronic non-communicable diseases (NCDs) and thus have competing health priorities. For example, the National Health Interview Survey from the USA found that, among people with vision impairment, there was a high prevalence of chronic conditions including cancer (27%), chronic obstructive pulmonary disease (COPD, 27%), and 'heart disease' (39%).[1] Additionally, people with vision impairment have an approximate 1.5–2-times increased risk of NCDs such as lung cancer (2.1, 95% CI 1.05–3.87),[2] cardiovascular disease (CVD, 1.65 (95% CI 1.44–1.89)),[1] dementia (2.02, 95% CI 1.68–2.43),[3] and depression (1.59, 95% CI 1.4–1.81).[4] A meta-analysis of data from high- and middle-income countries found 25% of people with eye health conditions have significant depressive symptoms.[4] Depressive symptoms have also been shown to be increasingly prevalent with more severe eye health conditions.[5] The prevalence of chronic health conditions in people with vision impairment suggests common contributing factors.

Furthermore, there is evidence that vision impairment can increase the impact of chronic health conditions. For example, a study in China examining the combined effects of sensory loss and dementia found that when people have vision loss, the risk of dementia is 1.5-times higher (1.54, 95% CI 1.27–1.86).[3] Similarly, depression was found in around one-quarter of adults over 65 years with solid tumours receiving chemotherapy, but was 2.5-times more prevalent (2.5, 95% CI 1.4–4.3) among those with vision impairment in addition to their cancer diagnosis.[6] These patterns further suggest vision impairment and general health share common causal pathways.

There is evidence that eye health conditions share common, modifiable, behavioural, and metabolic risk factors such as smoking, alcohol consumption, obesity, diabetes increasing risk and physical activity being protective.[7] These are also known and established risk factors for NCDs.[8] However, the intersection between eye health conditions and NCDs has yet to be systematically investigated. To gain a more complete understanding of this intersection, this rapid review was conducted to identify shared risk factors between five common eye health conditions that can cause vision impairment (refractive error, including uncorrected refractive error, cataract, age-related macular degeneration (AMD), diabetic retinopathy, and glaucoma) and five prevalent NCDs (cancer, CVD, COPD, dementia, and depression). A series of pragmatic, rapid reviews was conducted to appraise and synthesise the available evidence.

Methods

We conducted a series of rapid reviews of reviews reporting on two non-modifiable risk factors, age and sex, and modifiable risk factors, including social determinants, for five common eye health conditions and five prevalent NCDs. Social determinants include factors such as educational attainment, socio-economic status and income. The core review question was to document evidence, expressed as pooled odds ratios or risk ratios, for associations between risk factors (age, sex, modifiable risk factors and social determinants) and the five common eye health conditions (refractive error, including uncorrected refractive error, cataract, AMD, diabetic retinopathy, and glaucoma) and five NCDs (cancer, CVD, COPD, dementia, and depression). Each of these conditions was assigned to a team with content expertise. This methodology was adapted from an overview of reviews publication,[9] and follows commonly employed rapid review methods reported by the World Health Organization.[10] Reviews were required to be published between December 2014 and December 2019, report associations between the investigated conditions and risk factors in humans and written in the English language. Searches were conducted by each team separately in December 2019, with synthesis of approximately 5 years of literature to end of 2019.

Due to the large volume of literature reporting risk factors for the five common eye health conditions and five NCDs, we used a pragmatic approach to select the most up to date evidence. The PubMED database was searched to identify risk factors and social determinants for CVDs and COPD. Risk factors and social determinants for dementia were extracted and synthesised from systematic reviews identified through expert recommendation and supplemented by a rapid review. Through expert recommendation, the latest determinations of risk factors for eye health conditions (age and sex), depression, and cancer were synthesised. For example, risk factors for eye health conditions (age and sex) and depression were extracted and synthesised from the Lancet Global Burden of Disease (GBD) series and supplemented by a rapid review using Ovid Medline for eye health conditions and PubMED for depression. Risk factors for cancer were extracted and synthesised from publications by the International Agency for Research on Cancer (IARC) and World Cancer Research Fund (WCRF) and supplemented by a PubMED database search to extract the social determinants.

The most recently published systematic reviews (or overview of systematic reviews where available) were selected to synthesise the most up to date evidence available. Where two publications occurred within the same year or covered the same research question, the publication with the most recent search dates was retained. It should be noted that due to the vast amount of extant literature, only the global top 10 cancers in 2017 (non-melanoma skin, lung, breast, colorectal, prostate, stomach, liver, cervical, non-Hodgkin lymphoma, and bladder cancer) were included in the cancer search,

and only COPD was included in the chronic respiratory diseases search. The CVDs investigated were stroke, coronary heart/artery disease, myocardial infarction, ischaemic heart disease, and mixed/unspecified CVD. Systematic reviews of cross-sectional studies and clinical trials were not included as we focused on risk associations and causality. Furthermore, genetic studies were excluded as these are non-modifiable risk factors. Repository-hosted Extended Data 2 provides further details for each search strategy conducted.[150]

All titles and abstracts were screened for relevance by one reviewer, and those selected progressed to full-text review. Data on population, sample size, number, and type of studies included in systematic reviews or meta-analyses, risk factors and pooled estimates were extracted into data tables by one reviewer. The common risk factors between five common eye health conditions and five prevalent NCDs were then identified and synthesised by the content expert teams.

Results

A total of 9,213 records were identified through expert recommendation and database searches and 8,706 records were excluded at the title and abstract screening stage for not reporting results relevant to the NCD, eye health condition or modifiable risk factors. The remaining 507 were sought for full text review, with an additional nine records identified through a reference list search. These 516 records were assessed for eligibility, where a further 196 studies were rejected for reasons including no relevant data, incorrect study design, overlapping study populations, studies in clinical populations, and studies with a focus on treatment. A total of 320 records are included in this rapid review. Figure 1 shows further details on the number of records identified for each NCD and eye health condition. Data extraction tables can be found in Repository-hosted Extended Data 3.[11]

Non-modifiable risk factors

Age

Age was the most common risk factor shared between eye health conditions and NCDs. Age is an established risk factor for many eye health conditions, where prevalence increases sharply with older age. Consequently, regions with an older population have a higher numbers of people with AMD,[12] diabetic retinopathy,[13] cataract,[14] and glaucoma[15] compared to regions with a younger population. A combination of age and protective social determinants, specifically time spent outdoors, less near work, and physical activity, contribute to the development of refractive error in childhood. An exponential increase in global myopia prevalence between the ages 0 and 39 years may be due to significant lifestyle changes such as increasing hours of near work (*e.g.* reading, writing, computer use) related to intensive education or changes in occupations, and urbanisation resulting in reduced time spent outdoors.[16]

Similarly, increasing age is strongly associated with cancer whereby adults aged 50 years and older account for 70% of incident cancer cases and 87% of cancer deaths globally, compared to 5% and 1% respectively for children and adolescents.[17] Increasing age is also an established risk factor for CVDs, with the risk of stroke reported to increase by between 64% and 70% for every 5 year increase in age after the age of 60 years.[18,19] COPD was found to be most prevalent in those aged 60 years and older.[20,21] However, there is uncertainty around whether increasing prevalence of COPD with age is an effect of age itself, or due to the higher number of years smoking or being exposed to smoke.[20] Dementia was diagnosed in 10% of those aged 65 years and older, with diagnosis increasing to 30% in those aged 85 years and older.[22] No direct association between age and depressive disorders was found.

Sex

Overall, females seemingly have a higher risk of eye health conditions and NCDs compared with males. Age-adjusted analyses of population-based studies, published before July 8, 2014, found that females are more likely to develop blindness or vision impairment due to diabetic retinopathy (OR 2.52, 95% CI 1.48–3.73), cataract (OR 1.21 [1.17–1.25]) and uncorrected refractive error (OR 1.07 [1.03–1.11]) compared with males.[23] Glaucoma was the exception, whereby males are more at risk of blindness or vision impairment due to glaucoma compared to females.[23] Sex was not found to be a risk factor for AMD.[23]

After menopause, females were reported to have an increased risk of CVD, whereas before menopause, females were somewhat protected from CVDs.[24] While obesity is a risk factor for depressive disorders itself, females who are obese throughout life were more at risk of depressive disorders than males who are obese throughout life.[25] Furthermore, female college students were 11% more likely to develop depressive disorders compared to their male counterparts.[26]

Contrarily, there is a male preponderance for cancer and possibly also COPD. Males accounted for 22% of incident cases and 13% cancer mortality, compared to 18% and 9% respectively for females.[27] Conflicting evidence was observed

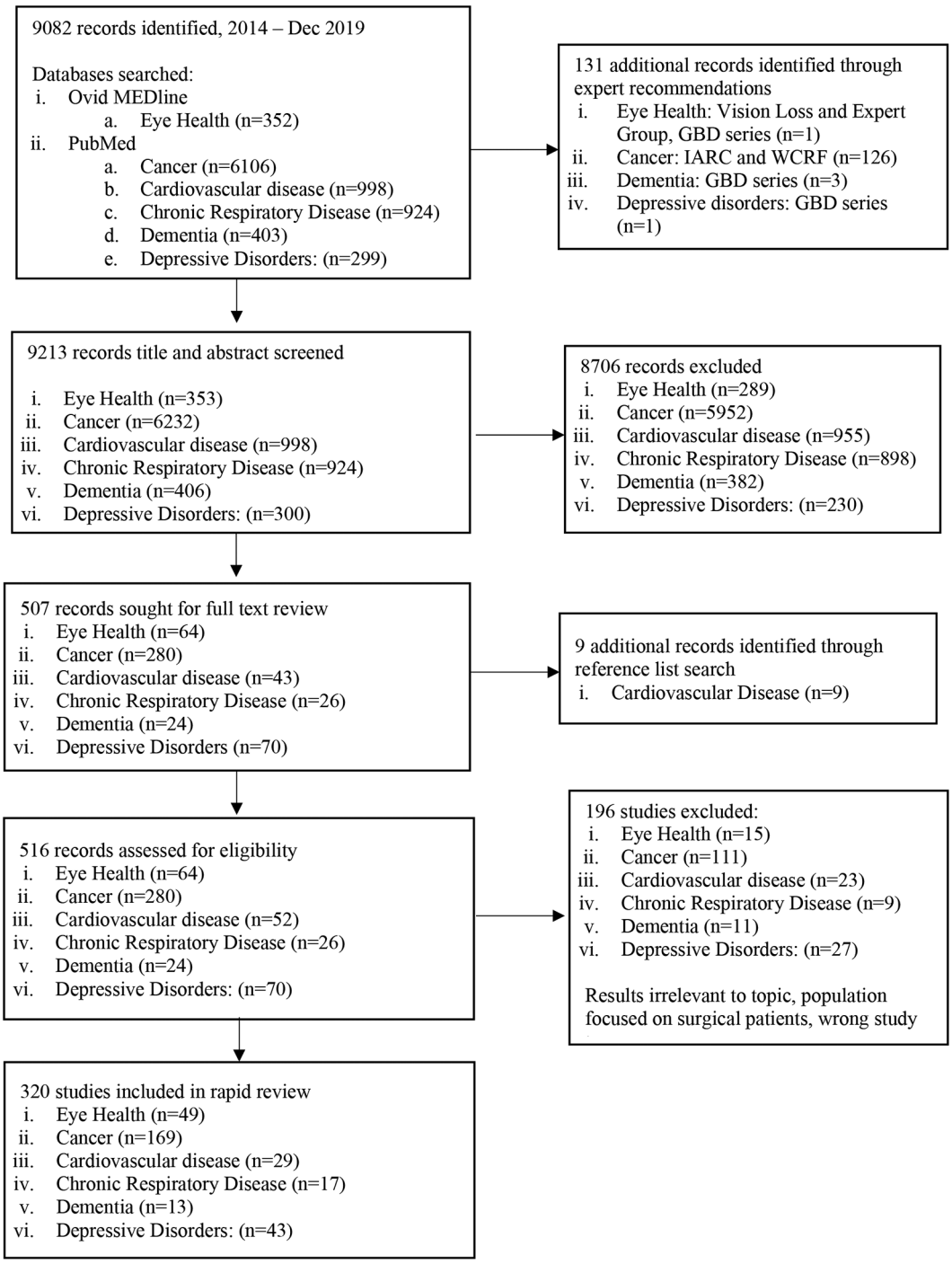

Figure 1. PRISMA flow diagram. Number of records identified for each eye health condition and non-communicable disease discussed. GBD, Global Burden of Disease; IARC, International Agency for Research on Cancer; WCRF, World Cancer Research Fund.

for COPD, with some studies reporting no differences between sexes,[20] while others report males have a higher COPD prevalence in six of the seven World Health Organization regions.[28] There was no evidence found on the association between sex and dementia.

Modifiable behavioural risk factors

Smoking

Smoking is a known and established risk factor for many health conditions, and the most common modifiable risk factor for eye health conditions and NCDs. Smoking is strongly associated with the development of cataract, increasing risk by up to 57%.[29] There was limited evidence for the link between smoking and diabetic retinopathy, where smokers with type 1 diabetes were reported to have increased risk (ranging 23–48%) of diabetic retinopathy, while smokers with type 2 diabetes have reduced risk (ranging 8–32%).[30] There was also limited evidence available for the association between glaucoma and smoking as studies were limited to heavy smoker populations.[31,32] No reported link was found between smoking during pregnancy and children with refractive error.[33] In addition, it should be noted that although no new evidence was published during the period selected for this search, smoking is strongly associated with AMD.[34]

Any former or current smoking was consistently reported as a risk factor for cancer, with the latter having demonstrably greater risk. The most significant risk was for lung cancer, with former and current smokers reported to have increased risk by 213% and between 599–633%, respectively.[35,36] Former smokers have increased risk by between 12% and 83% for bladder, stomach, cervical, liver, and colorectal cancer, whereas current smokers have increased risk by between 29% and 214%.[36–40] There was limited evidence of a link between smoking and breast cancer.[41]

Even one cigarette per day was reported to increase risks for stroke and coronary heart/artery disease by between 52% and 65%, with 20 cigarettes per day increasing risk by up to four-times.[42] There was also strong evidence that current smokers have a 30% increased risk of dementia, however the risk is reduced when people stop smoking.[43]

These odds are slight in comparison to the 400% increased risk of COPD in smokers—whether it be cigarettes, tobacco, or marijuana—compared with non-smokers.[44] However, non-smokers are also at a 44% increased risk of COPD development when exposed to passive smoke for just one hour per day. Constant exposure to passive smoke during childhood and adulthood can also increase COPD risk by 72%.[44] In addition, some studies report children born from mothers who smoked during pregnancy may have had their lung development in utero affected, and thus are at an increased risk of COPD development in later life.[20,45] Passive smoke also increased depressive symptoms between 30% and 60%.[46,47]

Alcohol consumption

Heavy alcohol consumption is strongly associated with the development of cataract and AMD, reported to increase risks by 25%[48] and 20%,[49] respectively. The association between diabetic retinopathy and alcohol consumption is uncertain, with studies reporting no association, protective benefits with wine consumption,[50] and increased risk by 30%.[51]

Alcohol was a consistent risk factor for breast, colorectal and liver cancer, with increased risks ranging from 4% to 114%.[52–54] It is also an established risk factor for CVDs, however studies have conflicting results. Some studies report heavy alcohol consumption increases the risk of stroke, particularly in women,[55] whereas others report low to moderate consumption was protective of stroke as well as coronary heart/artery disease.[55,56] Limited evidence exists on the association between alcohol and ischaemic heart disease,[57] and no reported links between heavy alcohol consumption and COPD, dementia, and depressive disorders were found.

Physical activity

The most consistent factor protective against eye health conditions and NCDs was physical activity. CVDs receive the most benefit from physical activity, reducing risk for all investigated CVDs. Physically active individuals were between 17% and 25% less likely to develop CVDs in comparison to less active individuals.[58,59] In addition, there was strong evidence that increasing levels of cardiorespiratory fitness, a proxy for physical activity, leads to decreasing risk of depressive disorder development. Individuals with poor cardiorespiratory fitness were 80% more likely to develop depressive disorders, while those with medium cardiorespiratory fitness were only 20% more likely than people with high cardiorespiratory fitness.[60,61] There was strong evidence that physical activity can be protective of colorectal cancer, with reduced risks by up to 16%.[62]

Finally, there was limited evidence to support the protective effects of physical activity on dementia,[9] AMD,[63] diabetic retinopathy,[64] and refractive error.[65] This was also the case for breast cancer in post-menopausal women,[62] lung cancer,[66] and liver cancer.[66] There was no evidence of an association between physical activity and stomach cancer, prostate cancer, and non-Hodgkin lymphoma risk.[62]

Sun exposure/time spent outdoors

There was strong evidence that sun exposure is a risk factor for cataract whereby individuals with long-term sun exposure have increased risk of between 19% and 120%.[67] On the contrary, time spent outdoors, which could be a proxy for sun exposure, is protective against the development of refractive error; however, limited evidence exists on its protective effect on refractive error progression.[68] Furthermore, there is conflicting evidence for the association between sun exposure and AMD, where some studies report an association and others no association.[69,70]

Excessive sun exposure is an established cause of melanoma and non-melanoma skin cancer, increasing risk by 30% and 95–97% respectively.[71] In those who experience sunburn, the risk of melanoma and non-melanoma skin cancer increased by between 83–169%[71–75] and 41–122%,[71,76–78] respectively.

Modifiable metabolic risk factors

Obesity/high BMI

Obesity, a high BMI, or a high body fat percentage was the second-most common shared risk factor identified between eye health conditions and NCDs. Conflicting evidence was found on the association between obesity, a high BMI and diabetic retinopathy, with some studies reporting no association,[79,80] while others an increased risk of 20%.[81] Some studies have also reported reduced risk of diabetic retinopathy by between 53% and 61% in those who underwent bariatric surgery, a procedure which is usually reserved for individuals with obesity.[82,83]

A high body fat percentage was strongly associated with breast, colorectal, stomach, and liver cancer. Post-menopausal women with a high BMI were 12% more likely to develop breast cancer than post-menopausal women with a low BMI.[62] High BMI was also shown to increase the risk of colorectal (30%), stomach (80%), and liver cancer (80%).[62,84] There was limited evidence to suggest those with a high BMI have a higher risk of prostate cancer[62,84,85] and non-Hodgkin lymphoma.[84,86]

Obesity is also an established risk factor for CVDs. Individuals who are obese or have a high BMI are more at risk of developing coronary heart/artery disease (39%) and stroke (14%) compared to their healthier counterparts.[87,88] For every 5-unit increase in BMI, individuals were 10% more at risk of stroke.[87]

Furthermore, obesity is associated with dementia, where individuals who were obese in mid-life are at 41% increased risk of dementia. Interestingly, individuals who are underweight in later-life have an increased risk of 17%.[9] Obesity throughout life can also contribute to depressive disorders in women.[25] There was limited evidence on the association between depressive disorders and obesity in childhood and adolescents.[89]

Diet

Consumption of a healthy diet was the second most common protective factor after physical activity, providing protective effects across all NCDs except COPD, and some eye health conditions. Amongst the eye health conditions, high fish and low meat consumption may be protective of AMD.[49] There was limited evidence for the effect of diet on cancer.[62] High fruit intake may be protective of stomach cancer, whereas high salt consumption may increase risks.[62,90–93] A high vegetable intake may also provide protective effects for breast cancer. An overall healthy diet with high fruit and vegetable intake may reduce the risk of lung and colorectal cancer,[62,94–97] as well as depressive disorders.[98] Fish consumption may also reduce the risk of depressive disorders by 20%.[99]

A Mediterranean diet, in particular, has protective effects against NCDs studied. Individuals were reported to be protected against the onset of diabetic retinopathy through consumption of a Mediterranean diet, high consumption of fruit and vegetable, oily fish, polyunsaturated fatty acids, dietary supplements, and fibre.[51,100] A high adherence to a Mediterranean diet could also reduce an individual's risk by up to 30% for stroke, coronary heart/artery disease[101] and dementia.[101,102]

Finally, specific micronutrient intake is associated with the development of eye health conditions and NCDs. Vitamin D was strongly associated with diabetic retinopathy, with low levels of vitamin D reported to increase risk by between 27% and 103%.[103,104] Lower blood concentration of vitamin D3 may also decrease the risk of myopia by 10%, adjusting for sunlight exposure and time spent outdoors.[105] Low vitamin D levels were also reported to increase an individual's risk of depressive disorders by 30%, and thereby higher vitamin D levels may be protective against development of depressive disorders.[106] There was limited evidence available to suggest vitamin A and C may reduce risk of diabetic retinopathy,

cataract, and glaucoma.[107–111] In addition, dietary zinc and iron were reported to reduce risk of depressive disorders by 30% and 40% respectively.[112]

Diabetes

For every year living with diabetes, individuals have a 9% increased risk of developing diabetic retinopathy.[79] With every increase in fasting blood glucose mmol/L and Hba1c%, there was a 33% and 15% increased risk of diabetic retinopathy respectively.[79] Furthermore, individuals with diabetes have a 48% increased risk of glaucoma.[113]

Finally, individuals previously diagnosed with diabetes, but not newly diagnosed diabetes or those experiencing impaired glucose metabolism, were found to be 29% more at risk of depressive disorders.[114] Those with type 2 diabetes also have an increased risk of dementia, with females (68%) reported to have a slightly higher risk than males (61%).[43] Diabetes can also contribute to CVDs, particularly in older adults.[18]

Social determinants

There were no systematic reviews on social determinants and their association with eye health conditions. As such this rapid review did not document the common social determinants of eye health conditions and NCDs. There was however systematic review evidence of social determinants' influence on NCDs.

The level of attained education was the most commonly cited social determinant for NCDs. Compared to higher education levels, lower education levels were associated with increased risk of breast (25%),[115] lung (females, 54%: males, 84%),[116] colon (3%),[117] prostate (60%),[118] stomach (197%),[119] liver (females, 30%: males, 55%),[120] cervical (21%),[121] non-Hodgkin lymphoma (females, 14%; males, 10%),[122] and bladder (females, 37%; males, 15%)[122] cancer. Lower education levels were associated with a high risk of CVDs, ranging from 23% to 50%,[123] COPD (61%),[124] and dementia (81%).[43]

Socioeconomic status (SES) and income earned also influence NCD development. Individuals with a lower SES or lower income earners have an approximate 25% higher risk of breast,[125] stomach,[119] and cervical cancer[121] than those with a higher SES or income. Individuals with a lower SES or income are also more likely to develop CVDs (ranging between 30% and 49%),[123] depression (14%),[126] and have a higher prevalence of COPD[127] than those with a higher SES or income.

Discussion

Eye health conditions and NCDs are going to be increasingly co-prevalent with ageing of the global population, considering that all investigated conditions are more prevalent in older adults.[12–15] Sex disparities in health were evident too, with females more at risk of diabetic retinopathy, cataract, uncorrected refractive error,[128,129] CVDs,[24] and depressive disorders,[25] while males were more at risk of glaucoma,[28] cancer,[27] and COPD.[20]

This rapid review provided strong support for smoking cessation to prevent co-morbid eye health conditions and NCDs. Smoking was associated with cancer of the lung, colorectum, stomach, liver, cervix, and bladder,[36] COPD,[44] stroke and coronary heart/artery disease,[42] dementia,[43] and many eye conditions including cataract,[29] age-related macular degeneration,[34] and diabetic retinopathy,[30] with weaker evidence for glaucoma.[31] Public health campaigns to reduce harmful effects of sun exposure are similarly likely to reduce risk of cataract[67] and skin cancer.[130] This review also found poor diet, obesity and low physical activity were common risk factors between NCDs and eye health conditions.

Dietary recommendations specifically derived from this review are more complex. Consumption of vegetables and fruits were protective for some common cancers[130] and depression.[98] The Mediterranean diet was protective against stroke, coronary heart/artery disease and mixed CVD,[101] and also diabetic retinopathy.[51] There was evidence that certain food groups and micronutrients can reduce the risk of depressive disorders[98,99,112] but also eye conditions like cataract,[107–109] diabetic retinopathy,[51,100,103,104] glaucoma,[110] and AMD.[34] However, there was insufficient evidence that dietary supplementation with multivitamins can reduce the risk of cataract,[131] and limited evidence for AMD[132] and diabetic retinopathy.[51] Our evidence synthesis suggests that dietary modification should be considered holistically in conjunction with other risk factors, and ocular and systemic comorbidities.

Physical activity can be protective against a range of general health conditions including CVD[58,59] and depressive disorders,[133] and there was some protective effect against AMD,[63] diabetic retinopathy,[64] and refractive error.[65] Preventative initiatives which aim to reduce smoking, improve diet, and promote physical activity are thus likely to have the greatest shared benefits for general and eye health. A summary diagram highlighting established common risk factors between eye health conditions and NCDs is shown in Figure 2.

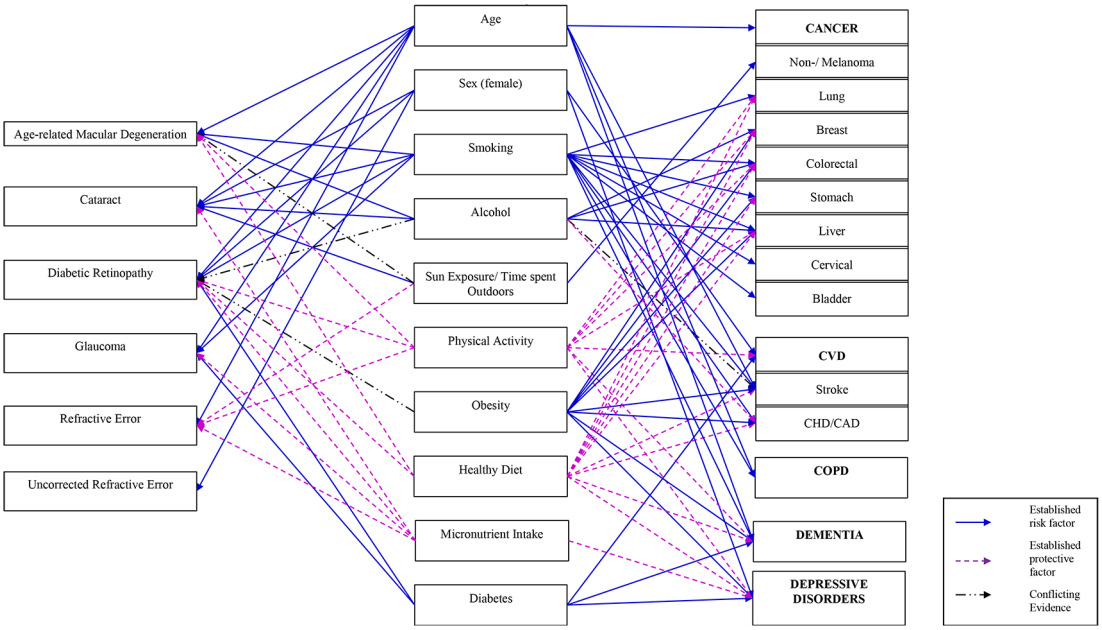

Figure 2. Shared risk factors between common eye health conditions that cause vision impairment and non-communicable diseases. Established risk factors are shown in a solid line, established protective factors are shown in a dashed line, and risk factors with conflicting evidence are shown in a dotted and dashed line. CVD, cardiovascular disease; CHD/CAD, coronary heart disease/coronary artery disease; COPD, chronic obstructive pulmonary disorder.

These causal associations can be bidirectional and vision impairment can act as a barrier to accessing health care. Individuals with blindness or vision impairment are less able to access or receive medical care and prescription medicines, and may also delay accessing care, compared to those without vision impairment. Transportation[134] and lack of accommodation[135] were identified as significant barriers to medical care accessibility in those with blindness. In addition, the Million Women Study in the UK showed that women with visual loss were 47% less likely to participate in breast cancer screening and 30% less likely to take part in bowel cancer screening compared to women with no disabilities.[136]

Furthermore, functional limitations, which can be a consequence of vision impairment and general health conditions, limit an individual's ability to travel for health care. In older adults with diabetes, approximately 37% and 29% found it difficult to walk and climb stairs respectively. However, when vision impairment was also present, 53% and 44% found it difficult to perform these activities respectively.[137] This reflects an almost sixfold increase in functional limitations in older adults with comorbid general and eye health conditions compared to their healthy peers.[137] Vision impairment itself also contributes to greater difficulty in walking and climbing stairs.[137,138] Older people with vision impairment take approximately 26% fewer steps each day,[139] spend 48% less time in moderate or vigorous physical activity[139] and do not travel as far from home[140] as their normally-sighted peers.

Qualitative studies have reported that individuals will prioritise accessing health care for conditions they consider more urgent or time sensitive, over conditions that cause vision impairment.[141,142] A study based in Cameroon and India, found individuals do not place the same amount of effort into treating eye conditions compared to NCDs, despite access to free vision services, and were often more accepting of vision impairment as they believed it was a normal part of ageing.[142] In order to prevent or reduce the risks of comorbidity, competing health priorities, and inaccessibility of health care, increasing efforts should be placed into merging eye health into NCD risk reduction and prevention programs, especially given that they share common risk factors.

Lower levels of education, lower socio-economic status and lower income earned were associated with increased risks of cancer,[115–122,125] CVDs,[123] and COPD.[124,127] Lower education levels was also associated with increased risk of dementia,[43] while lower SES and lower income earned was associated with depressive disorders.[126] This review did not capture evidence about social determinants of eye health conditions as no systematic reviews reporting associations were captured in Ovid Medline between the selected search dates. The association between social determinants of health and eye health warrants further research and attention as several individual studies suggest social determinants influence eye health conditions. For example, myopia is more prevalent in individuals who completed higher levels of education

compared to those who completed primary or secondary levels of education.[143] Geographical location can also influence myopia, where the risk of myopia is greater in children from urban areas than those from rural areas.[144]

The inverse is true for cataract blindness, where a higher prevalence is seen in those with lower levels of attained education and those living in rural areas.[145] Increased cataract severity is also seen in individuals with lower levels of SES and lower income earned compared to those of higher levels of SES and higher income earned.[146] Furthermore, disparities in access to care and affordability of health care most often affect individuals of lower SES and income earned.[145,147,148] Such individuals are less likely to access cataract treatment[145] or undergo diabetic retinopathy screening[147] compared to their wealthier counterparts. A meta-analysis based on the US population found that irrespective of an individual's age or diabetes status, lower incomes were associated with decreased utilisation of eye care services.[148] Reducing out-of-pocket costs and service reach to rural communities and those living with disadvantage, were identified as one of the grand challenges in global eye health by the *Lancet* Commission.[149] This highlights the importance of reducing inequities and disparities experienced by people living with disadvantage as this could lead to risk reductions in eye and general health.

Strengths and limitations

The strength of this rapid review is the use of a pragmatic search strategy which allowed a broad overview of the shared risk factors between common eye health conditions and NCDs. With the inclusion of systematic reviews and overviews of systematic reviews, the most up to date evidence was synthesised. Furthermore, this review extracted risk factors from world-leading research authorities who regularly curate, update and publish global evidence. The GBD series is the largest international epidemiological study, regularly updating evidence on risk factors, morbidity, and mortality of major diseases at a national, regional, and global level. IARC and WCRF are widely respected, international authorities on cancer control and regularly evaluate and publish evidence on the causality of exposures and agents for cancer. This rapid review also had significant strengths in the breadth of expertise of authors, providing a broad overview of the intersection between two major categories of global burdens of disease, enabling more strategic interventions in NCD and eye health prevention programs in future.

Limitations in this rapid review were largely driven by constraints which are intrinsic to rapid reviews. Rapid reviews are resource-limited systematic reviews, used to provide evidence to policy-makers in a timely manner.[10] The accelerated timeline limited title and abstract screening, full-text review, data extraction, and synthesis to one reviewer, introducing potential for reviewer bias. This was exacerbated by the potential for selection bias through searching of one database per condition and studies not being assessed for quality and bias. Further bias was potentially introduced through synthesising studies with different populations, statistical analyses, reporting methods, and low-quality evidence. Only the most prevalent top 10 cancers in 2017 were included in the cancer search, and only COPD was included in the Chronic Respiratory Disease search, as these impact large groups of people.

We identified risk factors shared between eye health conditions and NCDs. While these can contribute to the development of health conditions, the effect of multiple risk factors upon health conditions was not investigated. Rather than multiple independent relationships, there are most likely complex interactions and potential synergistic effects of multiple risk factors, strength of association, and development and severity of disease. Furthermore, comorbidity likely exacerbates certain risk factors, in particular access to health care.

Age is one of the most established risk factors for eye conditions and NCD development. Further exploration into how age contributes to increased risks can help understand its role in the global burden of disease. The role of social determinants in the development of eye health conditions also needs further investigation.

Conclusion

This rapid review provides an overview of the shared risk factors between eye health conditions that can cause vision impairment and NCDs. Given the substantial overlap of risk factors between the investigated conditions, increasing efforts should be made to integrate their respective preventative and risk reduction initiatives to achieve shared benefits in the future.

Data availability

Extended data

Zenodo: Supporting Data for: Risk factors common to leading eye health conditions and major non-communicable diseases: a rapid review and commentary, https://doi.org/10.5281/zenodo.7297022.[150]

This project contains the following extended data:

1. PRISMA checklist. The checklist used to report the preferred reporting items for systematic reviews in this rapid review.

2. Search Strategy. The search strategy used to identify the risk factors for each eye health condition and noncommunicable disease discussed in this rapid review.

All data collected for the study is held in the below repositories and will be available at the time of publication with the journal.

Repository: Supporting Data and Information for "Risk factors common to leading eye health conditions and major non-communicable diseases: a rapid review and commentary", Dryad Dataset, https://doi.org/10.5061/dryad.gxd2547q0.[11]

- Data Extraction Tables. Evidence synthesis for risk factors of health condition discussed, where the scientific evidence has been systematically assessed.

Tables provided in Extended Data 3

Table 1: Evidence synthesis for eye diseases with overlapping risk factors with non-communicable diseases, where the scientific evidence has been systematically assessed

Table 2: Evidence synthesis for cancer risk factors, where the scientific evidence has been systematically assessed

Table 3: Evidence synthesis for social determinants of cancer, where the scientific evidence has been systematically assessed

Table 4: Evidence synthesis for cardiovascular diseases risk factors, where the scientific evidence has been systematically assessed

Table 5: Evidence synthesis for COPD risk factors, where the scientific evidence has been systematically assessed

Table 6: Results for dementia risk factors, where the scientific evidence has been systematically assessed

Table 7: Risks factors of depressive disorders, where the scientific evidence has been systematically assessed. Results are displayed as odds ratios, unless otherwise specified.

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References

1. Crews JE, Chou CF, Sekar S, *et al.*: **The prevalence of chronic conditions and poor health among people with and without vision impairment, aged >/=65 years, 2010-2014.** *Am J. Ophthalmol.* 2017; **182**: 18–30.
PubMed Abstract | Publisher Full Text

2. Mohile SG, Fan L, Reeve E, *et al.*: **Association of cancer with geriatric syndromes in older Medicare beneficiaries.** *J. Clin. Oncol.* 2011; **29**(11): 1458–1464.
PubMed Abstract | Publisher Full Text

3. Luo Y, He P, Guo C, *et al.*: **Association between sensory impairment and dementia in older adults: evidence from China.** *J. Am. Geriatr. Soc.* 2018; **66**(3): 480–486.
PubMed Abstract | Publisher Full Text

4. Zheng Y, Wu X, Lin X, *et al.*: **The prevalence of depression and depressive symptoms among eye disease patients: a systematic review and meta-analysis.** *Sci. Rep.* 2017; **7**: 46453.
PubMed Abstract | Publisher Full Text

5. Skalicky S, Goldberg I: **Depression and quality of life in patients with glaucoma: a cross-sectional analysis using the Geriatric Depression Scale-15, assessment of function related to vision, and the Glaucoma Quality of Life-15.** *J. Glaucoma.* 2008; **17**(7): 546–551.
PubMed Abstract | Publisher Full Text

6. Soto-Perez-de-Celis E, Sun CL, Tew WP, *et al.*: **Association between patient-reported hearing and visual impairments and functional, psychological, and cognitive status among older adults with cancer.** *Cancer.* 2018; **124**(15): 3249–3256.
PubMed Abstract | Publisher Full Text

7. World Health Organisation: *World report on vision.* Geneva: 2019. Contract No.: Licence: CC BY-NC-SA 3.0 IGO.

8. N. C. D. Countdown collaborators: **NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4.** *Lancet.* 2018; **392**(10152): 1072–1088.
Publisher Full Text

9. Peters R, Ee N, Peters J, *et al.*: **Common risk factors for major noncommunicable disease, a systematic overview of reviews and commentary: the implied potential for targeted risk reduction.** *Ther. Adv. Chronic Dis.* 2019; **10**: 204062231988039.
Publisher Full Text

10. Tricco A, Langlois E, Straus S: *Rapid reviews to strengthen health policy and systems: a practical guide.* Geneva: World Health Organisation; 2017. Contract No.: License: CC BY-NC-SA 3.0 IGO.

11. Keay L, Ren K, Nguyen H, *et al.*: **Supporting Data and Information for "Risk factors common to leading eye health conditions and major non-comunicable diseases: a rapid review and commentary".** *Dryad.* 2022.
Publisher Full Text

12. Jonas JB, Bourne RR, White RA, *et al.*: **Visual impairment and blindness due to macular diseases globally: a systematic review and meta-analysis.** *Am. J. Ophthalmol.* 2014; **158**(4): 808–815.
PubMed Abstract | Publisher Full Text

13. Leasher JL, Bourne RR, Flaxman SR, *et al.*: **Global estimates on the number of people blind or visually impaired by diabetic retinopathy: a meta-analysis from 1990 to 2010.** *Diabetes Care.* 2016; **39**(9): 1643–1649.
Publisher Full Text

14. Khairallah M, Kahloun R, Bourne R, *et al.*: **Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010.** *Invest. Ophthalmol. Vis. Sci.* 2015; **56**(11): 6762–6769.
Publisher Full Text

15. Bourne RR, Taylor HR, Flaxman SR, *et al.*: **Number of people blind or visually impaired by glaucoma worldwide and in world regions 1990-2010: a meta-analysis.** *PLoS One.* 2016; **11**(10): e0162229.
PubMed Abstract | Publisher Full Text

16. Holden BA, Fricke TR, Wilson DA, *et al.*: **Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050.** *Ophthalmology.* 2016; **123**(5): 1036–1042.
PubMed Abstract | Publisher Full Text

17. Roser M, Ritchie H: **Cancer Our World In Data 2019.**
Reference Source

18. North BJ, Sinclair DA: **The intersection between aging and cardiovascular disease.** *Circ. Res.* 2012; **110**(8): 1097–1108.
PubMed Abstract | Publisher Full Text

19. WHO CVD Risk Chart Working Group: **World Health Organization cardiovascular disease risk charts: revised models to estimate risk in 21 global regions.** *Lancet Glob. Health.* 2019; **7**: e1332–e1345.

20. Global Initiative for Chronic Obstructive Lung Disease (GOLD): *Global strategy for the diagnosis, management, and prevention for chronic obstructive pulmonary disease (2020 Report).* Fontana, WI: GOLD; 2020.

21. Varmaghani M, Dehghani M, Heidari E, *et al.*: **Global prevalence of chronic obstructive pulmonary disease: systematic review and meta-analysis.** *East Mediterr. Health J.* 2019; **25**(1): 47–57.
Publisher Full Text

22. Dementia Australia: **Dementia: Key facts and statistics: Dementia Australia.** 2019.
Reference Source

23. Flaxman SR, Bourne RRA, Resnikoff S, *et al.*: **Global causes of blindness and distance vision impairment 1990-2020: a systematic review and meta-analysis.** *Lancet Glob. Health.* 2017; **5**(12): e1221–e1234.
PubMed Abstract | Publisher Full Text

24. Rodgers JL, Jones J, Bolleddu SI, *et al.*: **Cardiovascular risks associated with gender and aging.** *J. Cardiovasc. Dev. Dis.* 2019; **6**(2): 19.
PubMed Abstract | Publisher Full Text

25. Pereira-Miranda E, Costa PRF, Queiroz VAO, *et al.*: **Overweight and obesity associated with higher depression prevalence in adults: a systematic review and meta-analysis.** *J. Am. Coll. Nutr.* 2017; **36**(3): 223–233.
PubMed Abstract | Publisher Full Text

26. Schuch FB, Vancampfort D, Sui X, *et al.*: **Are lower levels of cardiorespiratory fitness associated with incident depression? A systematic review of prospective cohort studies.** *Prev. Med.* 2016; **93**: 159–165.
PubMed Abstract | Publisher Full Text

27. International Agency for Research on Cancer: *All Cancers: Factsheet.* Internatonal Agency for Research on Cancer; 2018.

28. Ntritsos G, Franek J, Belbasis L, *et al.*: **Gender-specific estimates of COPD prevalence: a systematic review and meta-analysis.** *Int. J. Chron. Obstruct. Pulmon. Dis.* 2018; **13**: 1507–1514.
PubMed Abstract | Publisher Full Text

29. Ye J, He J, Wang C, *et al.*: **Smoking and risk of age-related cataract: a meta-analysis.** *Invest. Ophthalmol. Vis. Sci.* 2012; **53**(7): 3885–3895.
PubMed Abstract | Publisher Full Text

30. Cai X, Chen Y, Yang W, *et al.*: **The association of smoking and risk of diabetic retinopathy in patients with type 1 and type 2 diabetes: a meta-analysis.** *Endocrine.* 2018; **62**(2): 299–306.
PubMed Abstract | Publisher Full Text

31. Jain V, Jain M, Abdull MM, *et al.*: **The association between cigarette smoking and primary open-angle glaucoma: a systematic review.** *Int. Ophthalmol.* 2017; **37**(1): 291–301.
PubMed Abstract | Publisher Full Text

32. Zhou Y, Zhu W, Wang C: **The effect of smoking on the risk of primary open-angle glaucoma: an updated meta-analysis of six observational studies.** *Public Health.* 2016; **140**: 84–90.
PubMed Abstract | Publisher Full Text

33. Fernandes M, Yang X, Li JY, *et al.*: **Smoking during pregnancy and vision difficulties in children: a systematic review.** *Acta Opthalmologica.* **93**(3): 213–223.
PubMed Abstract | Publisher Full Text

34. Smith W, Assink J, Klein R, *et al.*: **Risk factors for age-related macular degeneration: pooled findings from three continents.** *Ophthalmology.* 2001; **108**(4): 697–704.
Publisher Full Text

35. O'Keeffe LM, Taylor G, Huxley RR, *et al.*: **Smoking as a risk factor for lung cancer in women and men: a systematic review and meta-analysis.** *BMJ Open.* 2018; **8**(10): e021611.
PubMed Abstract | Publisher Full Text

36. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans: *A review of human carcinogens. Part E: Personal habits and indoor combustions.* Lyon France: IARC; 2009.

37. Li W-Y, Han Y, Xu H-M, *et al.*: **Smoking status and subsequent gastric cancer risk in men compared with women: a meta-analysis of prospective observational studies.** *BMC Cancer.* 2019; **19**(1): 377.
PubMed Abstract | Publisher Full Text

38. Ordóñez-Mena JM, Walter V, Schöttker B, *et al.*: **Impact of prediagnostic smoking and smoking cessation on colorectal cancer prognosis: a meta-analysis of individual patient data from cohorts within the CHANCES consortium.** *Ann. Oncol.* 2017; **29**(2): 472–483.

39. Abdel-Rahman O, Helbling D, Schöb O, *et al.*: **Cigarette smoking as a risk factor for the development of and mortality from hepatocellular carcinoma: an updated systematic review of 81 epidemiological studies.** *J. Evid. Based Med.* 2017; **10**(4): 245–254.
PubMed Abstract | Publisher Full Text

40. Appleby P, Beral V, Berrington de Gonzalez A, *et al.*: **Carcinoma of the cervix and tobacco smoking: collaborative reanalysis of individual data on 13,541 women with carcinoma of the cervix and 23,017 women without carcinoma of the cervix from 23 epidemiological studies.** *Int. J. Cancer.* 2006; **118**(6): 1481–1495.
PubMed Abstract

41. Macacu A, Autier P, Boniol M, *et al.*: **Active and passive smoking and risk of breast cancer: a meta-analysis.** *Breast Cancer Res. Treat.* 2015; **154**(2): 213–224.
PubMed Abstract | Publisher Full Text

42. Hackshaw A, Morris JK, Boniface S, *et al.*: **Low cigarette consumption and risk of coronary heart disease and stroke: meta-analysis of 141 cohort studies in 55 study reports.** *BMJ.* 2018; **360**: j5855.
Publisher Full Text

43. Anstey KJ, Ee N, Eramudugolla R, *et al.*: **A systematic review of meta-analyses that evaluate risk factors for dementia to evaluate the quantity, quality, and global representativeness of**

evidence. *J. Alzheimers Dis.* 2019; **70**(s1): S165–S186.
PubMed Abstract | Publisher Full Text

44. Jayes L, Haslam PL, Gratziou CG, *et al.*: **SmokeHaz: Systematic reviews and meta-analyses of the effects of smoking on respiratory health.** *Chest.* 2016; **150**(1): 164–179.
PubMed Abstract | Publisher Full Text

45. Savran O, Ulrik CS: **Early life insults as determinants of chronic obstructive pulmonary disease in adult life.** *Int. J. Chron. Obstruct. Pulmon. Dis.* 2018; **13**: 683–693.
PubMed Abstract | Publisher Full Text

46. Han C, Liu Y, Gong X, *et al.*: **Relationship between secondhand smoke exposure and depressive symptoms: a systematic review and dose-response meta-analysis.** *Int. J. Environ. Res. Public Health.* 2019; **16**(8): 1356.
PubMed Abstract | Publisher Full Text

47. Zeng Y-N, Li Y-M: **Secondhand smoke exposure and mental health in adults: a meta-analysis of cross-sectional studies.** *Soc. Psychiatry Psychiatr. Epidemiol.* 2016; **51**(9): 1339–1348.
PubMed Abstract | Publisher Full Text

48. Gong Y, Feng K, Yan N, *et al.*: **Different amounts of alcohol consumption and cataract: a meta-analysis.** *Optom. Vis. Sci.* 2015; **92**(4): 471–479.
PubMed Abstract | Publisher Full Text

49. Dinu M, Pagliai G, Casini A, *et al.*: **Food groups and risk of age-related macular degeneration: a systematic review with meta-analysis.** *Eur. J. Nutr.* 2019; **58**(5): 2123–2143.
PubMed Abstract | Publisher Full Text

50. Zhu W, Meng YF, Wu Y, *et al.*: **Association of alcohol intake with risk of diabetic retinopathy: a meta-analysis of observational studies.** *Sci. Rep.* 2017; **7**(1): 4.
PubMed Abstract | Publisher Full Text

51. Dow C, Mancini F, Rajaobelina K, *et al.*: **Diet and risk of diabetic retinopathy: a systematic review.** *Eur. J. Epidemiol.* 2018; **33**(2): 141–156.
PubMed Abstract | Publisher Full Text

52. Bagnardi V, Blangiardo M, La Vecchia C, *et al.*: **Alcohol consumption and the risk of cancer: a meta-analysis.** *Alcohol Res. Health.* 2001; **25**(4): 263–270.
PubMed Abstract

53. McNabb S, Harrison TA, Albanes D, *et al.*: **Meta-analysis of 16 studies of the association of alcohol with colorectal cancer.** *Int. J. Cancer.* 2019; **146**: 861–873.
Publisher Full Text

54. Chuang SC, Lee YC, Wu GJ, *et al.*: **Alcohol consumption and liver cancer risk: a meta-analysis.** *Cancer Causes Control.* 2015; **26**(9): 1205–1231.
Publisher Full Text

55. Zheng YL, Lian F, Shi Q, *et al.*: **Alcohol intake and associated risk of major cardiovascular outcomes in women compared with men: a systematic review and meta-analysis of prospective observational studies.** *BMC Public Health.* 2015; **15**: 773.
PubMed Abstract | Publisher Full Text

56. Zhang XY, Shu L, Si CJ, *et al.*: **Dietary patterns, alcohol consumption and risk of coronary heart disease in adults: a meta-analysis.** *Nutrients.* 2015; **7**(8): 6582–6605.
PubMed Abstract | Publisher Full Text

57. Roerecke M, Rehm J: **Chronic heavy drinking and ischaemic heart disease: a systematic review and meta-analysis.** *Open Heart.* 2014; **1**(1): e000135.
PubMed Abstract | Publisher Full Text

58. Wahid A, Manek N, Nichols M, *et al.*: **Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis.** *J. Am. Heart Assoc.* 2016; **5**(9).
PubMed Abstract | Publisher Full Text

59. Kyu HH, Bachman VF, Alexander LT, *et al.*: **Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013.** *BMJ.* 2016; **354**: i3857.
Publisher Full Text

60. Theorell T, Hammarström A, Aronsson G, *et al.*: **A systematic review including meta-analysis of work environment and depressive symptoms.** *BMC Public Health.* 2015; **15**: 738.
PubMed Abstract | Publisher Full Text

61. Rugulies R, Aust B, Madsen IE: **Effort-reward imbalance at work and risk of depressive disorders. A systematic review and meta-analysis of prospective cohort studies.** *Scand. J. Work Environ. Health.* 2017; **43**(4): 294–306.
PubMed Abstract | Publisher Full Text

62. World Cancer Research Fund International: *Diet, nutrition, physical activity and cancer: a global perspective - the third expert report.* London UK: WCRF International; 2018.

63. McGuinness MB, Le J, Mitchell P, *et al.*: **Physical activity and age-related macular degeneration: a systematic literature review and meta-analysis.** *Am. J. Ophthalmol.* 2017; **180**: 29–38.
PubMed Abstract | Publisher Full Text

64. Ren C, Liu W, Li J, *et al.*: **Physical activity and risk of diabetic retinopathy: a systematic review and meta-analysis.** *Acta Diabetol.* 2019; **56**(8): 823–837.
PubMed Abstract | Publisher Full Text

65. Suhr Thykjaer A, Lundberg K, Grauslund J: **Physical activity in relation to development and progression of myopia - a systematic review.** *Acta Opthalmologica.* 2017; **95**(7): 651–659.
PubMed Abstract | Publisher Full Text

66. Baumeister SE, Leitzmann MF, Linseisen J, *et al.*: **Physical activity and the risk of liver cancer: A systematic review and meta-analysis of prospective studies and a bias analysis.** *J. Natl. Cancer Inst.* 2019; **111**(11): 1142–1151.
PubMed Abstract | Publisher Full Text

67. Modenese A, Gobba F: **Cataract frequency and subtypes involved in workers assessed for their solar radiation exposure: a systematic review.** *Acta Ophthalmol.* 2018; **96**(8): 779–788.
PubMed Abstract | Publisher Full Text

68. Xiong S, Sankaridurg P, Naduvilath T, *et al.*: **Time spent in outdoor activities in relation to myopia prevention and control: a meta-analysis and systematic review.** *Acta Ophthalmol.* 2017; **95**(6): 551–566.
PubMed Abstract | Publisher Full Text

69. Modenese A, Gobba F: **Macular degeneration and occupational risk factors: a systematic review.** *Int. Arch. Occup. Environ. Health.* 2019; **92**(1): 1–11.
PubMed Abstract | Publisher Full Text

70. Zhou H, Zhang H, Yu A, *et al.*: **Association between sunlight exposure and risk of age-related macular degeneration: a meta-analysis.** *BMC Ophthalmol.* 2018; **18**(1): 331.
PubMed Abstract | Publisher Full Text

71. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans: *A review of human carcinogens. Part D: Radiation.* Lyon France: IARC; 2009.

72. Caini S, Gandini S, Sera F, *et al.*: **Meta-analysis of risk factors for cutaneous melanoma according to anatomical site and clinico-pathological variant.** *Eur. J. Cancer.* 2009; **45**(17): 3054–3063.
PubMed Abstract | Publisher Full Text

73. Gandini S, Sera F, Cattaruzza MS, *et al.*: **Meta-analysis of risk factors for cutaneous melanoma: I. Common and atypical naevi.** *Eur. J. Cancer.* 2005; **41**(1): 28–44.
PubMed Abstract | Publisher Full Text

74. Gandini S, Sera F, Cattaruzza MS, *et al.*: **Meta-analysis of risk factors for cutaneous melanoma: II. Sun exposure.** *Eur. J. Cancer.* 2005; **41**(1): 45–60.
PubMed Abstract | Publisher Full Text

75. Savoye I, Olsen CM, Whiteman DC, *et al.*: **Patterns of ultraviolet radiation exposure and skin cancer risk: the E3N-SunExp Study.** *J. Epidemiol.* 2018; **28**(1): 27–33.
PubMed Abstract | Publisher Full Text

76. Jiao L, Stolzenberg-Solomon R, Zimmerman TP, *et al.*: **Dietary consumption of advanced glycation end products and pancreatic cancer in the prospective NIH-AARP Diet and Health Study.** *Am. J. Clin. Nutr.* 2015; **101**(1): 126–134.
PubMed Abstract | Publisher Full Text

77. Han J, Colditz GA, Hunter DJ: **Risk factors for skin cancers: a nested case-control study within the Nurses' Health Study.** *Int. J. Epidemiol.* 2006; **35**(6): 1514–1521.
PubMed Abstract | Publisher Full Text

78. Xiang F, Lucas R, Hales S, *et al.*: **Incidence of nonmelanoma skin cancer in relation to ambient UV radiation in white populations, 1978-2012: empirical relationships.** *JAMA Dermatol.* 2014; **150**(10): 1063–1071.
PubMed Abstract | Publisher Full Text

79. Song P, Yu J, Chan KY, *et al.*: **Prevalence, risk factors and burden of diabetic retinopathy in China: a systematic review and meta-analysis.** *J. Glob. Health.* 2018; **8**(1): 010803.
PubMed Abstract | Publisher Full Text

80. Zhou Y, Zhang Y, Shi K, *et al.*: **Body mass index and risk of diabetic retinopathy: a meta-analysis and systematic review.** *Medicine (Baltimore).* 2017; **96**(22): e6754.
PubMed Abstract | Publisher Full Text

81. Zhu W, Wu Y, Meng YF, *et al.*: **Association of obesity and risk of diabetic retinopathy in diabetes patients: a meta-analysis of prospective cohort studies.** *Medicine (Baltimore).* 2018; **97**(32):

e11807.
PubMed Abstract | Publisher Full Text

82. Kim YJ, Kim BH, Choi BM, *et al.*: **Bariatric surgery is associated with less progression of diabetic retinopathy: a systematic review and meta-analysis.** *Surg. Obes. Relat. Dis.***13**(2): 352–360.
PubMed Abstract | Publisher Full Text

83. Merlotti C, Ceriani V, Morabito A, *et al.*: **Bariatric surgery and diabetic retinopathy: a systematic review and meta-analysis of controlled clinical studies.** *Obes. Rev.***18**(3): 309–316.
PubMed Abstract | Publisher Full Text

84. Lauby-Secretan B, Scoccianti C, Loomis D, *et al.*: **Body fatness and cancer — viewpoint of the IARC Working Group.** *N. Engl. J. Med.* 2016; **375**(8): 794–798.
PubMed Abstract | Publisher Full Text

85. Xie B, Zhang G, Wang X, *et al.*: **Body mass index and incidence of nonaggressive and aggressive prostate cancer: a dose-response meta-analysis of cohort studies.** *Oncotarget.* 2017; **8**(57): 97584–97592.
PubMed Abstract | Publisher Full Text

86. Cerhan JR, Kricker A, Paltiel O, *et al.*: **Medical history, lifestyle, family history, and occupational risk factors for diffuse large B-cell lymphoma: the interLymph non-Hodgkin lymphoma subtypes project.** *JNCI Monographs.* 2014; **2014**: 15–25.
Publisher Full Text

87. Liu X, Zhang D, Liu Y, *et al.*: **A J-shaped relation of BMI and stroke: systematic review and dose-response meta-analysis of 4.43 million participants.** *Nutr. Metab. Cardiovasc. Dis.* 2018; **28**(11): 1092–1099.
PubMed Abstract | Publisher Full Text

88. Lu Y, Hajifathalian K, Ezzati M, *et al.*: **Metabolic mediators of the effects of body-mass index, overweight, and obesity on coronary heart disease and stroke: a pooled analysis of 97 prospective cohorts with 1.8 million participants.** *Lancet.* 2014; **383**(9921): 970–983.
PubMed Abstract | Publisher Full Text

89. Quek Y-H, Tam WWS, Zhang MWB, *et al.*: **Exploring the association between childhood and adolescent obesity and depression: a meta-analysis.** *Obes. Rev.* 2017; **18**(7): 742–754.
PubMed Abstract | Publisher Full Text

90. Wang Q, Chen Y, Wang X, *et al.*: **Consumption of fruit, but not vegetables, may reduce risk of gastric cancer: results from a meta-analysis of cohort studies.** *Eur. J. Cancer.* 2014; **50**(8): 1498–1509.
Publisher Full Text

91. Bae J-M, Kim EH: **Dietary intakes of citrus fruit and risk of gastric cancer incidence: an adaptive meta-analysis of cohort studies.** *Epidemiol. Health.* 2016; **38**: e2016034.
PubMed Abstract | Publisher Full Text | Free Full Text

92. Goh KL, Cheah PL, Md N, *et al.*: **Ethnicity and H. pylori as risk factors for gastric cancer in Malaysia: a prospective case control study.** *Am. J. Gastroenterol.* 2007; **102**(1): 40–45.
PubMed Abstract | Publisher Full Text

93. Fang X, Wei J, He X, *et al.*: **Landscape of dietary factors associated with risk of gastric cancer: a systematic review and dose-response meta-analysis of prospective cohort studies.** *Eur. J. Cancer.* 2015; **51**(18): 2820–2832.
PubMed Abstract | Publisher Full Text

94. Schwingshackl L, Schwedhelm C, Hoffmann G, *et al.*: **Food groups and risk of colorectal cancer.** *Int. J. Cancer.* 2018; **142**(9): 1748–1758.
Publisher Full Text

95. Vieira AR, Abar L, Vingeliene S, *et al.*: **Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis.** *Ann. Oncol.* 2016; **27**(1): 81–96.
PubMed Abstract | Publisher Full Text

96. Wang Y, Li F, Wang Z, *et al.*: **Fruit and vegetable consumption and risk of lung cancer: a dose-response meta-analysis of prospective cohort studies.** *Lung Cancer.* 2015; **88**(2): 124–130.
PubMed Abstract | Publisher Full Text

97. Wang M, Qin S, Zhang T, *et al.*: **The effect of fruit and vegetable intake on the development of lung cancer: a meta-analysis of 32 publications and 20,414 cases.** *Eur. J. Clin. Nutr.* 2015; **69**(11): 1184–1192.
PubMed Abstract | Publisher Full Text

98. Saghafian F, Malmir H, Saneei P, *et al.*: **Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies.** *Br. J. Nutr.* 2018; **119**(10): 1087–1101.
PubMed Abstract | Publisher Full Text

99. Li F, Liu X, Zhang D: **Fish consumption and risk of depression: a meta-analysis.** *J. Epidemiol. Community Health.* 2016; **70**(3): 299–304.
PubMed Abstract | Publisher Full Text

100. Wong MYZ, Man REK, Fenwick EK, *et al.*: **Dietary intake and diabetic retinopathy: a systematic review.** *PLoS One.* 2018; **13**(1): e0186582.
PubMed Abstract | Publisher Full Text

101. Rosato V, Temple NJ, La Vecchia C, *et al.*: **Mediterranean diet and cardiovascular disease: a systematic review and meta-analysis of observational studies.** *Eur. J. Nutr.* 2019; **58**(1): 173–191.
PubMed Abstract | Publisher Full Text

102. Galbete C, Schwingshackl L, Schwedhelm C, *et al.*: **Evaluating Mediterranean diet and risk of chronic disease in cohort studies: an umbrella review of meta-analyses.** *Eur. J. Epidemiol.* 2018; **33**(10): 909–931.
PubMed Abstract | Publisher Full Text

103. Luo BA, Gao F, Qin LL: **The association between vitamin D deficiency and diabetic retinopathy in type 2 diabetes: a meta-analysis of observational studies.** *Nutrients.* 2017; **9**(3).
PubMed Abstract | Publisher Full Text

104. Zhang J, Upala S, Sanguankeo A: **Relationship between vitamin D deficiency and diabetic retinopathy: a meta-analysis.** *Can. J. Ophthalmol.* 2017; **52**(Suppl 1): S39–S44.
PubMed Abstract | Publisher Full Text

105. Tang SM, Lau T, Rong SS, *et al.*: **Vitamin D and its pathway genes in myopia: systematic review and meta-analysis.** *Br. J. Ophthalmol.* 2019; **103**(1): 8–17.
PubMed Abstract | Publisher Full Text

106. Anglin RE, Samaan Z, Walter SD, *et al.*: **Vitamin D deficiency and depression in adults: systematic review and meta-analysis.** *Br. J. Psychiatry.* 2013; **202**: 100–107.
PubMed Abstract | Publisher Full Text

107. Jiang H, Yin Y, Wu CR, *et al.*: **Dietary vitamin and carotenoid intake and risk of age-related cataract.** *Am. J. Clin. Nutr.* 2019; **109**(1): 43–54.
PubMed Abstract | Publisher Full Text

108. Zhang Y, Jiang W, Xie Z, *et al.*: **Vitamin E and risk of age-related cataract: a meta-analysis.** *Public Health Nutr.* 2015; **18**(15): 2804–2814.
PubMed Abstract | Publisher Full Text

109. Wei L, Liang G, Cai C, *et al.*: **Association of vitamin C with the risk of age-related cataract: a meta-analysis.** *Acta Ophthalmol.* 2016; **94**(3): e170–e176.
PubMed Abstract | Publisher Full Text

110. Ramdas WD, Schouten J, Webers CAB: **The effect of vitamins on glaucoma: a systematic review and meta-analysis.** *Nutrients.* 2018; **10**(3).
PubMed Abstract | Publisher Full Text

111. Ramdas WD: **The relation between dietary intake and glaucoma: a systematic review.** *Acta Opthalmologica.* 2018; **96**(6): 550–556.
PubMed Abstract | Publisher Full Text

112. Li Z, Li B, Song X, *et al.*: **Dietary zinc and iron intake and risk of depression: a meta-analysis.** *Psychiatry Res.* 2017; **251**: 41–47.
PubMed Abstract | Publisher Full Text

113. Zhao D, Cho J, Kim MH, *et al.*: **Diabetes, fasting glucose, and the risk of glaucoma: a meta-analysis.** *Ophthalmology.***122**(1): 72–78.
PubMed Abstract | Publisher Full Text

114. Tong A, Wang X, Li F, *et al.*: **Risk of depressive symptoms associated with impaired glucose metabolism, newly diagnosed diabetes, and previously diagnosed diabetes: a meta-analysis of prospective cohort studies.** *Acta Diabetol.* 2016; **53**(4): 589–598.
PubMed Abstract | Publisher Full Text

115. Lundqvist A, Andersson E, Ahlberg I, *et al.*: **Socioeconomic inequalities in breast cancer incidence and mortality in Europe-a systematic review and meta-analysis.** *Eur. J. Pub. Health.* 2016; **26**(5): 804–813.
PubMed Abstract | Publisher Full Text | Free Full Text

116. Hovanec J, Siemiatycki J, Conway DI, *et al.*: **Lung cancer and socioeconomic status in a pooled analysis of case-control studies.** *PLoS One.* 2018; **13**(2): e0192999.
PubMed Abstract | Publisher Full Text

117. Manser CN, Bauerfeind P: **Impact of socioeconomic status on incidence, mortality, and survival of colorectal cancer patients: a systematic review.** *Gastrointest. Endosc.* 2014; **80**(1): 42–60.e9.
PubMed Abstract | Publisher Full Text

118. Brown CR, Hambleton I, Hercules SM, *et al.*: **Social determinants of prostate cancer in the Caribbean: a systematic review and meta-analysis.** *BMC Public Health.* 2018; **18**(1): 900.
PubMed Abstract | Publisher Full Text

119. Uthman OA, Jadidi E, Moradi T: **Socioeconomic position and incidence of gastric cancer: a systematic review and meta-analysis.** *J. Epidemiol. Community Health.* 2013; **67**(10): 854–860.
PubMed Abstract | Publisher Full Text

120. Spadea T, Zengarini N, Kunst A, *et al.*: **Cancer risk in relationship to different indicators of adult socioeconomic position in Turin, Italy.** *Cancer Causes Control.* 2010; **21**(7): 1117–1130.
PubMed Abstract | Publisher Full Text

121. Parikh S, Brennan P, Boffetta P: **Meta-analysis of social inequality and the risk of cervical cancer.** *Int. J. Cancer.* 2003; **105**(5): 687–691.
PubMed Abstract | Publisher Full Text

122. Dalton SO, Schuz J, Engholm G, *et al.*: **Social inequality in incidence of and survival from cancer in a population-based study in Denmark, 1994-2003: summary of findings.** *Eur. J. Cancer.* 2008; **44**(14): 2074–2085.
PubMed Abstract | Publisher Full Text

123. Khaing W, Vallibhakara SA, Attia J, *et al.*: **Effects of education and income on cardiovascular outcomes: a systematic review and meta-analysis.** *Eur. J. Prev. Cardiol.* 2017; **24**(10): 1032–1042.
PubMed Abstract | Publisher Full Text

124. Yang Y, Mao J, Ye Z, *et al.*: **Risk factors of chronic obstructive pulmonary disease among adults in Chinese mainland: a systematic review and meta-analysis.** *Respir. Med.* 2017; **131**: 158–165.
PubMed Abstract | Publisher Full Text

125. Akinyemiju TF, Genkinger JM, Farhat M, *et al.*: **Residential environment and breast cancer incidence and mortality: a systematic review and meta-analysis.** *BMC Cancer.* 2015; **15**(1): 191.
PubMed Abstract | Publisher Full Text

126. Richardson R, Westley T, Gariépy G, *et al.*: **Neighborhood socioeconomic conditions and depression: a systematic review and meta-analysis.** *Soc. Psychiatry Psychiatr. Epidemiol.* 2015; **50**(11): 1641–1656.
PubMed Abstract | Publisher Full Text

127. Sutradhar I, Das Gupta R, Hasan M, *et al.*: **Prevalence and risk factors of chronic obstructive pulmonary disease in Bangladesh: a systematic review.** *Cureus.* 2019; **11**(1): e3970.
PubMed Abstract | Publisher Full Text

128. Lewallen S, Mousa A, Bassett K, *et al.*: **Cataract surgical coverage remains lower in women.** *Br. J. Ophthalmol.* 2009; **93**(3): 295–298.
PubMed Abstract | Publisher Full Text

129. Mganga H, Lewallen S, Courtright P: **Overcoming gender inequity in prevention of blindness and visual impairment in Africa.** *Middle East Afr. J. Ophthalmol.* 2011; **18**(2): 98–101.
PubMed Abstract | Publisher Full Text

130. International Agency for Research on Cancer: *IARC Monographs on the identification of carcinogenic hazards to humans.* Lyon, France: World Health Organisation; 2019.

131. Chakravarthy U, Wong TY, Fletcher A, *et al.*: **Clinical risk factors for age-related macular degeneration: a systematic review and meta-analysis.** *BMC Ophthalmol.* 2010; **10**: 31.
PubMed Abstract | Publisher Full Text

132. Evans JR, Lawrenson JG: **Antioxidant vitamin and mineral supplements for slowing the progression of age-related macular degeneration.** *Cochrane Database Syst. Rev.* 2017; **2017**: CD000254.
Publisher Full Text

133. Schuch FB, Vancampfort D, Firth J, *et al.*: **Physical activity and incident depression: a meta-analysis of prospective cohort studies.** *Am. J. Psychiatry.* 2018; **175**(7): 631–648.
PubMed Abstract | Publisher Full Text

134. Spencer C, Frick K, Gower EW, *et al.*: **Disparities in access to medical care for individuals with vision impairment.** *Ophthalmic Epidemiol.* 2009; **16**(5): 281–288.
PubMed Abstract | Publisher Full Text

135. Iezzoni LI, Rao SR, Ressalam J, *et al.*: **Incidence of accommodations for patients with significant vision limitations in physicians' offices in the US.** *JAMA Ophthalmol.* 2022; **140**(1): 79–84.
PubMed Abstract | Publisher Full Text

136. Floud S, Barnes I, Verfurden M, *et al.*: **Disability and participation in breast and bowel cancer screening in England: a large prospective study.** *Br. J. Cancer.* 2017; **117**(11): 1711–1714.
PubMed Abstract | Publisher Full Text

137. Crews J, Jones G, Kim K: **Double jeopardy: the effects of comorbid conditions among older people with vision loss.** *J. Vis. Impair. Blind.* 2006; **100**(1): 824–848.
Publisher Full Text

138. Swenor BK, Munoz B, West SK: **Does visual impairment affect mobility over time? The Salisbury Eye Evaluation Study.** *Invest. Ophthalmol. Vis. Sci.* 2013; **54**(12): 7683–7690.
PubMed Abstract | Publisher Full Text

139. Willis JR, Jefferys JL, Vitale S, *et al.*: **Visual impairment, uncorrected refractive error, and accelerometer-defined physical activity in the United States.** *Arch. Ophthalmol.* 2012; **130**(3): 329–335.
PubMed Abstract | Publisher Full Text

140. Curriero FC, Pinchoff J, van Landingham SW, *et al.*: **Alteration of travel patterns with vision loss from glaucoma and macular degeneration.** *JAMA Ophthalmol.* 2013; **131**(11): 1420–1426.
PubMed Abstract | Publisher Full Text

141. Whitson HE, Steinhauser K, Ammarell N, *et al.*: **Categorizing the effect of comorbidity: a qualitative study of individuals' experiences in a low-vision rehabilitation program.** *J. Am. Geriatr. Soc.* 2011; **59**(10): 1802–1809.
PubMed Abstract | Publisher Full Text

142. Zuurmond M, Mactaggart I, Kannuri N, *et al.*: **Barriers and facilitators to accessing health services: a qualitative study amongst people with disabilities in Cameroon and India.** *Int. J. Environ. Res. Public Health.* 2019; **16**(7).
PubMed Abstract | Publisher Full Text

143. Williams KM, Bertelsen G, Cumberland P, *et al.*: **Increasing prevalence of myopia in Europe and the impact of education.** *Ophthalmology.* 2015; **122**(7): 1489–1497.
PubMed Abstract | Publisher Full Text

144. Rudnicka AR, Kapetanakis VV, Wathern AK, *et al.*: **Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention.** *Br. J. Ophthalmol.* 2016; **100**(7): 882–890.
PubMed Abstract | Publisher Full Text

145. Ramke J, Zwi AB, Lee AC, *et al.*: **Inequality in cataract blindness and services: moving beyond unidimensional analyses of social position.** *Br. J. Ophthalmol.* 2017; **101**(4): 395–400.
PubMed Abstract | Publisher Full Text

146. Wesolosky JD, Rudnisky CJ: **Relationship between cataract severity and socioeconomic status.** *Can. J. Ophthalmol.* 2013; **48**(6): 471–477.
PubMed Abstract | Publisher Full Text

147. Piyasena M, Murthy GVS, Yip JLY, *et al.*: **Systematic review on barriers and enablers for access to diabetic retinopathy screening services in different income settings.** *PLoS One.* 2019; **14**(4): e0198979.
PubMed Abstract | Publisher Full Text

148. Wagner LD, Rein DB: **Attributes associated with eye care use in the United States: a meta-analysis.** *Ophthalmology.* 2013; **120**(7): 1497–1501.
PubMed Abstract | Publisher Full Text

149. Ramke J, Evans JR, Habtamu E, *et al.*: **Grand Challenges in global eye health: a global prioritisation process using Delphi method.** *Lancet Healthy Longev.* 2022; **3**(1): e31–e41.
PubMed Abstract | Publisher Full Text

150. Keay L, Ren K, Nguyen H, *et al.*: **Supporting data for: Risk factors common to leading eye health conditions and major non-communicable diseases: A rapid review and commentary.** *Zenodo.* 2022.
Publisher Full Text