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Title: The association among visual, hearing and dual sensory loss with depression and anxiety over six years: The Tromsø Study

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Objective: To examine the longitudinal association of dual and single (vision, hearing) sensory loss on symptoms of depression and anxiety in older adults.

Methods: 2890 adults aged 60 years or over who participated in the longitudinal population-based Tromsø Study, Norway, were included. The impact of objectively vision loss, self-report hearing loss, or dual sensory loss on symptoms of depression and anxiety, as assessed by the Hopkins Symptom Checklist-10, was examined at baseline and six year follow-up using linear mixed models.

Results: Hearing loss had a cross sectional relationship with increased depression ($b = 0.1750$, $SE = 0.07$, $p = .02$) and anxiety symptoms ($b = 0.1765$, $SE = 0.08$, $p = .03$), however, these relationships were not significant at six-year follow up. Both vision loss only and dual sensory loss predicted increased depression scores at follow up ($b = 0.0220$, $SE = 0.01$, $p = .03$; $b = 0.0413$, $SE = 0.02$, $p = .01$, respectively). Adjustment for social isolation did not attenuate the main depression results.

Conclusion: Dual sensory loss resulted in increased depression symptomatology over time, and posed an additional long-term risk to depression severity beyond having a single sensory loss only. Only hearing loss is associated with anxiety symptoms. Older adults with vision, hearing and dual sensory loss have different mental health profiles. Therefore, management and intervention should be tailored to the type of sensory loss.

Sensory losses in older adults rank amongst the top 10 contributors to burden of disease in Europe (Wittchen et al., 2011, Mathers and Loncar, 2006). Almost one-third of adults over 65 experience hearing loss (HL) (WHO, 2017) and prevalence of vision loss (VL) is around 25% in those aged over 70 (Stevens et al., 2013). Poorer mental health has been reported in sensory loss (Heine and Browning, 2014), having a deleterious impact on quality of life and increasing disability (Hernandez Trillo and Dickinson, 2012, Zhou et al., 2014, Yokoi et al., 2014, Eisele et al., 2015).

To date, the majority of sensory loss and mental health literature has focused on VL and depression. Prior research consistently demonstrates that older adults with VL have an increased risk of depression (Carriere et al., 2013, Hong et al., 2015, Garin et al., 2014, Bernabei et al., 2011, Ribeiro et al., 2015). Possible mechanisms include a reduction in social activities and subsequent social isolation (Schneider et al., 2011, Bookwala and Lawson, 2011). A smaller body of literature indicates that there is also a cross-sectional relationship between HL and depression (Gopinath et al., 2009, Lee et al., 2010); although not all studies corroborate this association (Mener et al., 2013, Pronk et al., 2011). One limitation of prior research is that few longitudinal studies have examined dual and single sensory loss concurrently. Depression symptoms have been reported to be more common amongst older adults with dual sensory loss (DSL) compared to single sensory loss (Lupsakko et al., 2002). Yet the three longitudinal studies to date have yielded mixed findings (McDonnall, 2009a, Chou, 2008, Kiely et al., 2013), and it remains unclear if DSL has an additional impact on mental health over and above single sensory loss (Heine and Browning, 2014). Thus, there remains an ongoing need to better differentiate the relative impact of single (VL or HL) and dual sensory loss in relation to mental health, especially longitudinally (Heine and Browning, 2014, Schneider et al., 2011).

Due to the previous narrow focus on depression, there remains a paucity of research examining anxiety in sensory loss (Heine and Browning, 2014). Indeed, anxiety has been largely overlooked in the older adult literature (Byrne and Pachana, 2010), despite being more prevalent than depression in community-dwelling older adults (Ritchie et al., 2004, Kvaal et al., 2001). Limited cross-sectional findings indicate that VL is associated with increased risk of anxiety (Kempen and Zijlstra, 2014, van der Aa et al., 2015a, Court et al., 2014). The relationship between HL and anxiety remains largely unexamined, although a small body of cross-sectional evidence indicates that older adults with HL are more likely to have anxiety than those without (Contrera et al., 2016, Bernabei et al., 2011). No studies to date have examined DSL and anxiety.

Currently, our understanding remains fragmented about the relative impact of VL, HL and DSL on mental health over time (Heine and Browning, 2014, Schneider et al., 2011) and anxiety remains largely unexplored in sensory loss. This study provides a longitudinal examination of the impact of DSL on anxiety and depression symptoms over six years. In addition, our study further aims to differentiate the impact of single and dual losses by concurrently assessing the longer-term impact of VL, HL, and DSL on mental health.

Methods

This study forms part of the SENSE-Cog multi-phase research programme, funded by European Union Horizon 2020 programme. SENSE-Cog aims to promote mental well-being in older adults with sensory and cognitive impairments (<http://www.sense-cog.eu/>). The first work package of this project aims to better

understand the links between sensory, cognitive and mental ill-health in older Europeans.

Sample

The Tromsø Study is a longitudinal population-based study conducted in northern Norway. The first Tromsø survey was undertaken in 1974, with an additional six surveys carried out by 2017 (occurring at approximately 6 year intervals). The study selection criteria have been a combination of total and random samples of birth cohorts of the inhabitants of Tromsø. The survey includes postal questionnaires, and attendance at an interview and medical examination. The procedure of the Tromsø study has been outlined (Jacobsen et al., 2012). Ophthalmological assessments were first introduced in the fifth survey (Tromsø 5), and the current paper examines data from the Tromsø surveys 5 and 6 (conducted in 2001-02 and 2007-08, respectively; Tromsø 7 data are not yet available for analysis). Participants aged 60 years or older at the time of Tromsø 5 are included (n = 2890).

Mental health outcome measures

Depression and anxiety symptomatology were assessed using the Hopkins Symptom Checklist (HSCL)-10. This scale is derived from the HSCL-25 and has been shown to be a valid and reliable measure of psychological distress, with comparable performance to the longer version (Strand et al., 2003). The Norwegian version has been validated and is widely used (Strand et al., 2003). The HSCL-10 assesses both anxiety and depression symptoms. Respondents rate the severity of each symptom on a four-point scale. Four items assess anxiety and six examine depression (Søgaard et al., 2003). In a Norwegian population both the depression

and anxiety scales have been shown to correlate highly with the original version of the HSCL (Tambs and Moum, 1993, Tambs, 2004). Anxiety scores range from four to 16, and depression from six to 24, with higher scores indicating greater symptom severity. HSCL was administered at baseline (Tromsø 5) and six-year follow-up (Tromsø 6). Participants missing HSCL data at either time point were excluded (n = 443).

Sensory loss measures

Visual acuity was assessed using Snellen charts at a distance of 6 meters. Assessments were undertaken using participants' usual optical correction, where applicable. A Snellen score of <20/30 was classified as vision loss. Hearing loss was classified as a self-reported inability or difficulty hearing what is said in normal conversation. A further 291 participants missing sensory data were excluded.

Covariate definitions

Socio-demographic and lifestyle factors including marital status, living situation (alone, with others), level of education (elementary, secondary, higher education), smoking (past-, current- or non-smoker), alcohol consumption (less than monthly, monthly, weekly consumption), social network (self-reported having enough friends), and social activities (active involvement in 2+ clubs/associations) were collected via questionnaire (Jacobsen et al., 2012). Medical assessments provided information regarding antidepressant use, mobility (ability to walk 10 steps unaided), Body Mass Index (BMI) (>25), self-reported health (poor, average to good), and history of stroke, diabetes, myocardial infarction, and hypertension.

Statistical Analyses

Socio-demographic and health characteristics were compared across sensory loss status using chi-square tests and one-way ANOVAs. The effects of sensory loss at baseline (Tromsø 5) on depression and anxiety symptoms at baseline and six-year follow-up were examined using linear mixed models. The baseline β coefficient represents the association of a baseline sensory loss with baseline anxiety or depression score, and the β coefficient for the anxiety/depression*time interaction represents the association of baseline sensory loss with changes in anxiety/depression score over time. VL only, HL only and DSL were concurrently examined to ascertain the relative impact of each type of sensory loss. In addition, interactions between VL and HL were also examined in each model, as were interactions between sensory loss with sex and education. HSCCL anxiety and depression scores were log transformed due to positive skew and transformed scores were converted to z-scores for analysis.

Three models were used to examine each relationship; a model adjusting for sex and age; a second model also adjusting for education, living alone, marital status, and use of antidepressant medication; and a third model further adjusted for health and lifestyle covariates (BMI, smoking status, self-reported health, stroke, diabetes, myocardial infarction, hypertension, alcohol consumption, mobility). Sensitivity analyses were also conducted for depression outcome controlling for self-reported social isolation, a possible mechanism underlying the VL and depression relationship (Schneider et al., 2011, Bookwala and Lawson, 2011). Sensitivity analyses assessed whether adjusting for social network (self-reported having enough friends) and social activities (involvement in clubs/associations) attenuated the main results. We also conducted analyses to examine a higher VL threshold (Snellen

score <20/40). Results were unchanged and due to small numbers meeting this threshold, we present only the <20/30 results. Analyses were conducted using SAS 9.3 (SAS Institute, Inc., Cary, NC).

Results

Of the study sample (n = 2156), the majority was female (52.9%) (Table 1). Mean age was 66.9 (\pm 5.2) years. At baseline, prevalence of single sensory loss was 25.2% (n = 543) for vision and 13.2% (n = 285) for hearing, with 6.8% (n = 146) having DSL. Those with sensory losses were older and more likely to live alone, have mobility impairment and have a history of stroke, and myocardial infarction than those without sensory loss (Table 1). VL was more prevalent amongst women (58.6%, n = 318), whereas HL was less common among women (37.7%, n = 107).

Depression symptomatology

Severity of depression symptomatology at baseline was low (median = 7, IQR = 6-8; HSCL range 6-24). VL was did not have a cross-sectional relationship with depression symptom severity (Table 2). However, VL was associated with increased depression symptoms at six years in all models ($b = 0.0220$, $SE = 0.01$, $p = .034$). HL was associated with increased depressive symptoms at baseline in the fully adjusted model ($b = 0.1750$, $SE = 0.07$, $p = .019$), yet this relationship was not significant longitudinally. For DSL, there was no cross-sectional relationship with depression, however, DSL was associated with increased depression symptomatology over time in all models ($b = 0.0413$, $SE = 0.02$, $p = .007$). Sensitivity analyses showed that

further adjustment for social network and social activities did not attenuate the main depression results. All tested interactions were non-significant.

Anxiety symptomatology

Anxiety symptoms were also low in severity (median = 4, IQR = 4-5; HSCL range 4-16). VL was also not significantly related to anxiety symptoms, either at baseline or after six years (Table 3). HL was associated with increased anxiety symptoms at baseline, even after full adjustment for covariates ($b = 0.1765$, $SE = 0.08$, $p = .026$), however, this relationship was not significant over time. DSL was associated cross-sectionally with anxiety symptoms in the partially adjusted models, although this relationship was non-significant after full adjustment for covariates. The examined interactions were also non-significant.

Discussion

This paper offers a longitudinal analysis of depression and anxiety symptoms in older adults with sensory loss and provided the first longitudinal analysis of DSL and anxiety (Heine and Browning, 2014). DSL was found to have a longitudinal relationship with depression, but not anxiety. Our analysis also demonstrated that VL, HL and DSL have different mental health profiles, with HL related cross-sectionally to both depression and anxiety, whereas VL and DSL have a longitudinal association with depression. DSL poses an additive depression risk longitudinally beyond that attributable to VL.

Sensory loss and depression

Consistent with previous findings (Carriere et al., 2013, Hong et al., 2015), VL was associated with increased depression symptoms over time, although no cross-sectional relationship was observed. Conversely, we showed that HL had a cross-sectional, but not longitudinal, association with depression. While results exploring hearing and depression have yielded mixed findings, our results build support for the previously reported cross-sectional association between HL and depression in older adults (Lee et al., 2010, Gopinath et al., 2009). Whether dual loss confers additional risk to mental health beyond single sensory loss also remains unclear, with mixed results to date (Armstrong et al., 2016, Chou, 2008, Capella-McDonnall, 2005, Schneider et al., 2011). Our findings suggested an association with depression over time, beyond that attributable to VL alone. This finding is consistent with McDonnall (2009a), who showed that depression symptomatology increased at a faster rate after the onset of DSL than those without DSL, regardless of a prior single sensory loss. Conversely, two previous studies (Capella-McDonnall, 2005, Chou, 2008) reported that those with DSL were not more likely than those with VL alone to experience depression. However, in both of those studies, depression was examined as a dichotomous variable rather than an assessment of symptom severity. Taken together, these findings suggest that DSL does not pose an additional risk beyond VL for developing depression symptoms, but rather, those with DSL experience a higher severity of depression symptoms than observed in VL alone. Thus our findings suggest that older adults with VL and DSL are both at long term risk of developing depression, and the population with DSL are particularly at risk of experiencing more severe depression long-term.

Possible suggested mechanisms through which VL and DSL are associated with depression include reduced social interaction, social isolation and loneliness due to the sensory loss (Bookwala and Lawson, 2011, Schneider et al., 2011). In our sensitivity analyses, adjustment for social activities and number of friends did not attenuate depression results, suggesting that the relationship is better explained through other factors; or that these variables do not adequately capture social isolation. A reduction in activities of daily living (ADLs) has also been argued to be a mechanism through which VL and DSL are linked with depression (Chou, 2008, Evans et al., 2007, Carriere et al., 2013). Those with DSL have greater ADL limitations (Brennan, Horowitz & Su, 2005), possibly underlying their risk for a greater severity of depression. Moreover, it has been argued that reduced light absorption in VL might lead to disturbed synthesis of melatonin (Tosini et al., 2012). Disrupted melatonin secretion substantially impacts the body's circadian rhythms, including sleep-wake patterns and social rhythms, which can lead to mood disturbance and depression (Lieverse et al., 2011, Even et al., 2008); with light therapy a well-established treatment for both Seasonal Affective Disorder and non-seasonal Major Depressive Disorder (Golden et al., 2005). Reduced light absorption impeding melatonin synthesis may be particularly pertinent in our Norwegian population which already has low light exposure. Such a mechanism also better explains why VL and DSL, but not HL alone, have a longitudinal association with depression.

Our results also highlight that older adults with HL are at increased risk of depression, but that this relationship attenuates over time. Thus, in the case of HL, there is possibly a period of adjustment, after which symptoms no longer increase. Restricted communication (Kiely et al., 2013, McDonnall, 2009b) and associated loneliness (Pronk et al., 2011) may partially explain the observed cross-sectional

association with depression. It is plausible that older adults with HL were able to adjust to their loss via modifying or improving their communication skills (McDonnall, 2009a) or by accessing hearing interventions and support (Acar et al., 2011), thereby protecting older adults from subsequent or ongoing psychopathology. Further study of possible psychosocial adjustment to HL and mechanisms thereof would be a valuable focus of future research. This would facilitate a better understanding of how to support older people with sensory loss and promote adjustment, thereby minimising the adverse impact of sensory loss on mental well-being.

Sensory loss and anxiety

Building on the limited extant research exploring the association between sensory loss and anxiety, it was found that sensory loss did not have a longitudinal association with anxiety symptoms. In our study, only HL was related to anxiety and, as with depression symptoms, this relationship was only cross-sectional. Our findings are consistent with the scant research to date (Contrera et al., 2016, Ciesla et al., 2016) which also shows a cross-sectional relationship between anxiety and HL. Thus it appears that those with HL have a short-term increase in global psychological distress, but symptoms do not increase over time, possibly indicative of adjustment to HL. Social isolation and sensory deprivation are possible mechanisms underlying the relationship between HL and anxiety (Contrera et al., 2016). It remains plausible that improvements made in communication skills might partially account for the change observed in psychological symptomatology over time. Conversely, anxiety is characterized by marked avoidance, with avoidance of anxiety-inducing places and situations reducing the frequency of experiencing anxiety symptoms (as measured on

self-report questionnaires). It is therefore possible that those with HL became increasingly avoidant of anxiety-inducing situations (e.g., social situations, going out alone) and thus report less symptomatology over time, which is not captured by the HSCL.

Anxiety has a deleterious impact on quality of life, increases levels of disability (Byrne and Pachana, 2010), and decreases the ability to manage one's hearing loss (Hogan et al., 2015), therefore, anxiety symptoms should be addressed when older adults develop HL to prevent further disability and any worsening of the sensory loss. Furthermore, patients with comorbid anxiety and depression have increased mental health symptom severity and chronicity, as well as greater functional loss and worse treatment outcomes (Penninx, 2015). The association of HL with both depression and anxiety suggests that comorbid depression and anxiety may be common in this population, further underscoring the need for rehabilitation and mental health service provision for HL.

DSL and anxiety have not previously been examined longitudinally (Heine and Browning, 2014), and our study found that DSL does not pose a risk for anxiety symptoms. Although some studies have suggested cross-sectional relationships between anxiety and eye diseases (Eramudugolla et al., 2013, Lim et al., 2016) and VL (Kempen and Zijlstra, 2014, van der Aa et al., 2015a, Court et al., 2014), we found no such cross-sectional effect. These differing results may be due to our use of a less severe threshold for VL. Additionally, there is substantial heterogeneity in anxiety measures used across studies. The HSCL measures general anxiety and some symptoms of panic, but does not measure avoidance and social anxiety; both of which might be more strongly linked with sensory loss. The anxiety and sensory loss literature remains scant but has predominantly examined only a broad range of

anxiety symptoms rather than undertaking anxiety disorder-specific examinations. Anxiety disorders are heterogeneous with different etiologies and may be differentially related to aspects of physical health. Prevalence rates differ for specific anxiety disorders amongst those with VL (van der Aa et al., 2015a), with agoraphobia and social phobia being the most common. It is likely that single and dual sensory loss would have differential relationships with varying anxiety disorders; which necessitate specific and targeted treatment and intervention. Ongoing research examining disorder-specific relationships with sensory loss will be invaluable for providing a clearer and more comprehensive picture of the mental health needs of older adults.

In contributing to understanding of the interplay between sensory loss and mental well-being, this paper provides a strong rationale for improving health services and interventions to better meet to the mental health needs of older adults with sensory loss(es). An increased focus on optimising aids and corrections is needed, given that use of assistive aids has been shown to reduce depression and mental health burden (McDonnall, 2009b, Mener et al., 2013, Owsley et al., 2007). This is particularly important given the high rate of correctable VL in older populations (Taylor et al., 2007). Furthermore, older adults with VL and DSL, particularly, would benefit from depression intervention, whilst those with HL appear to have an immediate need for support regarding both depression and anxiety. Treatment of depression in those with VL is especially critical given the bidirectional nature of the VL-depression relationship (Carriere et al., 2013). Interventions might also aim to facilitate acceptance of the loss(es), which has been shown to lead to adjustment and reduced depression over time (McDonnall, 2009a, Senra et al., 2015). It is particularly pertinent that services are directed towards older adults with sensory

loss, given that over one third of older adults with VL and comorbid mental disorders do not receive mental health services (van der Aa et al., 2015b).

Strengths and Limitations

This study is presented with several strengths including concurrent examination of DSL and single sensory loss. A further strength is that both anxiety and depression symptoms were explored, allowing for a better insight into the mental health profiles of sensory loss in older people. However, this study has some limitations. Firstly, the mean age is relatively young (66.9 years) and thus may not adequately reflect functioning in the very old. Although we have undertaken one of the only longitudinal analyses of anxiety in sensory loss, there is only one follow up time point, thus we can draw limited conclusions regarding the evolution of longer-term psychological symptoms. Moreover, the study relies on self-reported hearing, which can have differential associations with mental health than measured hearing (Lee et al., 2010). Due to study requirements that participants attend a clinic visit, there are few participants meeting severe VL thresholds; thus we are unable to establish the relationship between severe VL and mental wellbeing. Finally, anxiety was assessed by four non disorder-specific items. A more comprehensive assessment of anxiety would be of benefit for future research.

Conclusion

This study provides the first longitudinal examination of depression and anxiety symptoms for concurrent sensory loss. HL has a unique relationship with anxiety symptoms and DSL poses an additional long-term risk to depression severity

beyond single sensory loss. An ongoing focus on improving service provision in order to enhance uptake of targeted mental health interventions may help to reduce the burden of disease attributable to sensory loss and mental ill-health in the elderly population.

References

- Acar, B., Yurkeli, M. F., Babademez, M. A., Karabulut, H. & Karasen, R. M. 2011. Effects of hearing aids on cognitive functions and depressive signs in elderly people. *Arch Gerontol Geriatr*, 52, 250-2.
- Armstrong, T. W., Surya, S., Elliott, T. R., Brossart, D. F. & Burdine, J. N. 2016. Depression and Health-Related Quality of Life Among Persons With Sensory Disabilities in a Health Professional Shortage Area. *Rehabil Psychol*.
- Banjeree, A., Kumar, S., Kulhara, P. & Gupta, A. 2008. Prevalence of depression and its effect on disability in patients with age-related macular degeneration. *Indian J Ophthalmol*, 56, 469-74.
- Bernabei, V., Morini, V., Moretti, F., Marchiori, A., Ferrari, B., Dalmonte, E., De Ronchi, D. & Rita Atti, A. 2011. Vision and hearing impairments are associated with depressive--anxiety syndrome in Italian elderly. *Aging Ment Health*, 15, 467-74.
- Bookwala, J. & Lawson, B. 2011. Poor vision, functioning, and depressive symptoms: a test of the activity restriction model. *Gerontologist*, 51, 798-808.
- Brennan, M, Horowitz, A. & Su, Y. P. (2005). Dual sensory loss and its impact on everyday competence. *Gerontologist*, 45(3), 337-346.
- Byrne, G. J. & Pachana, N. A. 2010. Anxiety and depression in the elderly: do we know any more? *Curr Opin Psychiatry*, 23, 504-9.
- Capella-McDonnall, M. E. 2005. The effects of single and dual sensory loss on symptoms of depression in the elderly. *Int J Geriatr Psychiatry*, 20, 855-61.
- Carriere, I., Delcourt, C., Daien, V., Peres, K., Feart, C., Berr, C., Ancelin, M. L. & Ritchie, K. 2013. A prospective study of the bi-directional association between vision loss and depression in the elderly. *J Affect Disord*, 151, 164-70.
- Chou, K. L. 2008. Combined effect of vision and hearing impairment on depression in older adults: evidence from the English Longitudinal Study of Ageing. *J Affect Disord*, 106, 191-6.
- Ciesla, K., Lewandowska, M. & Skarzynski, H. 2016. Health-related quality of life and mental distress in patients with partial deafness: preliminary findings. *Eur Arch Otorhinolaryngol*, 273, 767-76.
- Contrera, K. J., Betz, J., Deal, J., Choi, J. S., Ayonayon, H. N., Harris, T., Helzner, E., Martin, K. R., Mehta, K., Pratt, S., Rubin, S. M., Satterfield, S., Yaffe, K., Simonsick, E. M. & Lin, F. R. 2016. Association of Hearing Impairment and Anxiety in Older Adults. *J Aging Health*.
- Court, H., McLean, G., Guthrie, B., Mercer, S. W. & Smith, D. J. 2014. Visual impairment is associated with physical and mental comorbidities in older adults: a cross-sectional study. *BMC Medicine*, 12.
- Cruikshanks, K. J., Wiley, T. L., Tweed, T. S., Klein, B. E., Klein, R., Mares-Perlman, J. A. & Nondahl, D. M. 1998. Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin. The Epidemiology of Hearing Loss Study. *Am J Epidemiol*, 148, 879-86.
- Eisele, M., Kaduszkiewicz, H., Konig, H. H., Lange, C., Wiese, B., Prokein, J., Weyerer, S., Werle, J., Riedel-Heller, S. G., Lupp, M., Hesser, K., Koppa, A., Mosch, E., Weeg, D., Fuchs, A., Pentzek, M., Maier, W., Scherer, M. & Hajek, A. 2015. Determinants of health-related quality of life in older primary care patients: results of the longitudinal observational AgeCoDe Study. *Br J Gen Pract*, 65, e716-23.

- Eramudugolla, R., Wood, J. & Anstey, K. J. 2013. Co-morbidity of depression and anxiety in common age-related eye diseases: a population-based study of 662 adults. *Front Aging Neurosci*, 5, 56.
- Evans, J. R., Fletcher, A. E. & Worwald, R. P. 2007. Depression and anxiety in visually impaired older people. *Ophthalmology*, 114, 283-8.
- Even, C., Schroder, C. M., Friedman, S. & Rouillon, F. 2008. Efficacy of light therapy in nonseasonal depression: a systematic review. *J Affect Disord*, 108, 11-23.
- Fasih, U., Hamirani, M. M., JAFRI, A. R., RIAZ, S. U. & SHAIKH, A. 2010. Assessment of Anxiety and Depression in Primary Open Angle Glaucoma Patients (A Study of 100 Cases). *Pak J Ophthalmol*, 26.
- Garin, N., Olaya, B., Lara, E., Moneta, M. V., Miret, M., Ayuso-Mateos, J. L. & Haro, J. M. 2014. Visual impairment and multimorbidity in a representative sample of the Spanish population. *BMC Public Health* 14.
- Golden, R. N., Gaynes, B. N., Ekstrom, R. D., Hamer, R. M., Jacobsen, F. M., Suppes, T., Wisner, K. L. & Nemeroff, C. B. 2005. The efficacy of light therapy in the treatment of mood disorders: a review and meta-analysis of the evidence. *Am J Psychiatry*, 162, 656-62.
- Gopinath, B., Wang, J. J., Schneider, J., Burlutsky, G., Snowdon, J., McMahon, C. M., Leeder, S. R. & Mitchell, P. 2009. Depressive symptoms in older adults with hearing impairments: the Blue Mountains Study. *J Am Geriatr Soc*, 57, 1306-8.
- Heine, C. & Browning, C. J. 2014. Mental health and dual sensory loss in older adults: a systematic review. *Front Aging Neurosci*, 6, 83.
- Hernandez Trillo, A. & Dickinson, C. M. 2012. The impact of visual and nonvisual factors on quality of life and adaptation in adults with visual impairment. *Invest Ophthalmol Vis Sci*, 53, 4234-41.
- Hogan, A., Phillips, R. L., Brumby, S. A., Williams, W. & Mercer-Grant, C. 2015. Higher social distress and lower psycho-social wellbeing: examining the coping capacity and health of people with hearing impairment. *Disabil Rehabil*, 37, 2070-5.
- Hong, T., Mitchell, P., Burlutsky, G., Gopinath, B., Liew, G. & Wang, J. J. 2015. Visual impairment and depressive symptoms in an older Australian cohort: longitudinal findings from the Blue Mountains Eye Study. *Br J Ophthalmol*, 99, 1017-21.
- Jacobsen, B. K., Eggen, A. E., Mathiesen, E. B., Wilsgaard, T. & Njolstad, I. 2012. Cohort profile: the Tromso Study. *Int J Epidemiol*, 41, 961-7.
- Kempen, G. I. & Zijlstra, G. A. 2014. Clinically relevant symptoms of anxiety and depression in low-vision community-living older adults. *Am J Geriatr Psychiatry*, 22, 309-13.
- Kiely, K. M., Anstey, K. J. & Luszcz, M. A. 2013. Dual sensory loss and depressive symptoms: the importance of hearing, daily functioning, and activity engagement. *Front Hum Neurosci*, 7, 837.
- Kvaal, K., Macijauskiene, J., Engedal, K. & Laake, K. 2001. High prevalence of anxiety symptoms in hospitalized geriatric patients. *Int J Geriatr Psychiatry*, 16, 690-3.
- Lee, A. T., Tong, M. C., Yuen, K. C., Tang, P. S. & VanHasselt, C. A. 2010. Hearing impairment and depressive symptoms in an older chinese population. *J Otolaryngol Head Neck Surg*, 39, 498-503.
- Lieverse, R., Van Someren, E. J., Nielen, M. M., Uitdehaag, B. M., Smit, J. H. & Hoogendijk, W. J. 2011. Bright light treatment in elderly patients with nonseasonal major depressive disorder: a randomized placebo-controlled trial. *Arch Gen Psychiatry*, 68, 61-70.

- Lim, N. C., Fan, C. H., Yong, M. K., Wong, E. P. & Yip, L. W. 2016. Assessment of Depression, Anxiety, and Quality of Life in Singaporean Patients With Glaucoma. *J Glaucoma*.
- Lupsakko, T., Mantyjarvi, M., Kautianien, H. & Silkava, R. 2002. Combined hearing and visual impairment and depression in a population aged 75 years and older. *Int J Geriatr Psychiatry*, 17, 808-13.
- Mabuchi, F., Yoshimura, K., Kashiwagi, K., SHioe, K., Yamagata, Z., Kanba, S., Iijima, H. & Tsukahara, S. 2008. High prevalence of anxiety and depression in patients with primary open-angle glaucoma. *J Glaucoma*, 17, 552-7.
- Mathers, C. D. & Loncar, D. 2006. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med*, 3, e442.
- McDonnall, M. C. 2009a. The effects of developing a dual sensory loss on depression in older adults: a longitudinal study. *J Aging Health*, 21, 1179-99.
- McDonnall, M. C. 2009b. Risk factors for depression among older adults with dual sensory loss. *Aging Ment Health*, 13, 569-76.
- Mehta, K. M., Simonsick, E. M., Pennix, B. W., Schulz, R., Rubin, S. M., Satterfield, S. & Yaffe, K. 2003. Prevalence and correlates of anxiety symptoms in well-functioning older adults: findings from the health aging and body composition study. *J Am Geriatr Soc*, 51, 499-504.
- Mener, D. J., Betz, J., Genther, D. J., Chen, D. & Lin, F. R. 2013. Hearing loss and depression in older adults. *J Am Geriatr Soc*, 61, 1627-9.
- Owsley, C., McGwin JR., G., Scilley, K., Meek, G. C., Seker, D. & Dyer, A. 2007. Effect of refractive error correction on health-related quality of life and depression in older nursing home residents. *Archives of Ophthalmology*, 125, 1471-1477.
- Park, S. Y., Kim, M. J., Sikandaner, H., Kim, D. K., Yeo, S. W. & Park, S. N. 2016. A causal relationship between hearing loss and cognitive impairment. *Acta Otolaryngol*, 1-4.
- Pennix, B. W. 2015. Depression and anxiety: their insidious dance. *Lancet Psychiatry*, 2, 479-80.
- Prince, M. J., Wu, F., Guo, Y., Gutierrez Robledo, L. M., O'Donnell, M., Sullivan, R. & Yusuf, S. 2015. The burden of disease in older people and implications for health policy and practice. *Lancet*, 385, 549-62.
- Pronk, M., Deeg, D. J., Smits, C., Van Tilburg, T. G., Kuik, D. J., Festen, J. M. & Kramer, S. E. 2011. Prospective effects of hearing status on loneliness and depression in older persons: identification of subgroups. *Int J Audiol*, 50, 887-96.
- Ribeiro, M. V., Hasten-Reiter Jnr, H. N., Ribeiro, E. A., Juca, M. J., Barbosa, F. T. & Sousa-Rodrigues, C. F. 2015. Association between visual impairment and depression in the elderly: a systematic review. *Arq Bras Oftalmol*, 78, 197-201.
- Ritchie, K., Artero, S., Beluche, I., Ancelin, M. L., Mann, A., Dupuy, A. M., Malafodde, A. & Boulenger, J. P. 2004. Prevalence of DSM-IV psychiatric disorder in the elderly French population *British Journal of Psychiatry*, 184, 147-152.
- Schneider, J. M., Gopinath, B., McMahon, C. M., Leeder, S. R., Mitchell, P. & Wang, J. J. 2011. Dual sensory impairment in older age. *J Aging Health*, 23, 1309-24.
- Senra, H., Barbosa, F., Ferriera, P., Vieira, C. R., Perrin, P. B., Rogers, H., Rivera, D. & Leal, I. 2015. Psychologic adjustment to irreversible vision loss in adults: a systematic review. *Ophthalmology*, 122, 851-61.
- Sogaard, A. J., Bjelland, I., Tell, G. S. & Roysamb, E. 2003. A comparison of the CONOR Mental Health Index to the HSCL-10 and HADS. *Norsk Epidemiologi*, 13, 279-284.

- Strand, B. H., Dalgard, O. S., Tambs, K. & Rognerud, M. 2003. Measuring the mental health status of the Norwegian population: a comparison of the instruments SCL-25, SCL-10, SCL-5 and MHI-5 (SF-36). *Nord J Psychiatry*, 57, 113-8.
- Stevens, G.A., White, R.A., Flaxman, S.R., et al (2013). Global prevalence of vision impairment and blindness: magnitude and temporal trends, 1990–2010. *Ophthalmol*, 120, 2377-2384.
- Tambs, K. 2004. Moderate effects of hearing loss on mental health and subjective well-being: results from the Nord-Trondelag Hearing Loss Study. *Psychosom Med*, 66, 776-82.
- Tambs, K. & Moum, T. 1993. How well can a few questionnaire items indicate anxiety and depression? *Acta Psychiatr Scand*, 87, 364-7.
- Taylor, H. R., Peszullo, M. L., Nesbitt, S. J. & Keeffe, J. E. 2007. Costs of interventions for visual impairment. *American Journal of Ophthalmology*, 143, 561–565.
- Tosini, G., Baba, K., Hwang, C. K. & Iuvone, P. M. 2012. Melatonin: an underappreciated player in retinal physiology and pathophysiology. *Experimental Eye Research*, 103, 82–89.
- Van der Aa, H. P., Comijs, H. C., Pennix, B. W., Van Rens, G. H. & Van Nispen, R. M. 2015a. Major depressive and anxiety disorders in visually impaired older adults. *Invest Ophthalmol Vis Sci*, 56, 849-54.
- Van der Aa, H. P., Hoeben, M., Rainey, L., Van Rens, G. H., Vreeken, H. L. & Van Nispen, R. M. 2015b. Why visually impaired older adults often do not receive mental health services: the patient's perspective. *Qual Life Res*, 24, 969-78.
- WHO 2017. Mortality and burden of diseases. World Health Organisation
- Wittchen, H. U., Jacobi, F., Rehm, J., Gustavsson, A., Svensson, M., Jonsson, B., Olesen, J., Allgulander, C., Alonso, J., Faravelli, C., Fratiglioni, L., Jennum, P., Lieb, R., Maercker, A., Van Os, J., Preisig, M., Salvador-Carulla, L., Simon, R. & Steinhausen, H. C. 2011. The size and burden of mental disorders and other disorders of the brain in Europe 2010. *Eur Neuropsychopharmacol*, 21, 655-79.
- Yokoi, T., Moriyama, M., Hayashi, K., Shimada, N., Tomita, M., Yamamoto, N., Nishikawa, T. & Ohno-Matsui, K. 2014. Predictive factors for comorbid psychiatric disorders and their impact on vision-related quality of life in patients with high myopia. *Int Ophthalmol*, 34, 171-83.
- Zhou, C., Qian, S., Wu, P. & Qiu, C. 2014. Quality of life of glaucoma patients in China: sociodemographic, clinical, and psychological correlates—a cross-sectional study. *Qual Life Res*, 23, 999-1008.

Table 1: Baseline characteristics by sensory loss (wave 5)

	No loss (n=1182)	Vision Loss (n=543)	Hearing Loss (n=285)	Dual Sensory Loss (n=146)	p
Age M(SD)	65.43 (4.47)	67.83 (5.28)	73.34 (2.91)	73.96 (2.97)	<.001[‡]
Female %	52.41	58.60	37.66	55.73	<.001
HSCCL depression (range 6-24)	7.34 (2.19)	7.47 (2.31)	7.59 (2.29)	7.19 (1.68)	.305 [‡]
HSCCL anxiety (range 4-16)	4.71 (1.24)	4.80 (1.29)	4.89 (1.28)	4.96 (1.33)	.052 [‡]
Low education (0-7 years) %	27.88	36.08	36.24	53.54	<.001
Mid education (8-13 years) %	55.51	51.55	54.36	40.94	.009
Lives alone	22.76	30.24	25.97	40.31	<.001
Married/de facto	73.09	66.00	68.83	59.54	.004
BMI over 25	67.91	64.39	66.88	62.60	.351
Current smoker	20.91	23.74	11.76	17.56	.011
Past smoker	43.83	38.43	61.44	55.73	<.001
Anti-depressant use	1.63	1.39	2.92	1.68	.006[†]
Low alcohol (less than monthly)	41.62	45.40	53.64	60.63	<.001
Moderate alcohol (monthly)	42.78	39.67	31.79	27.56	<.001
Poor subjective health	36.10	37.60	40.52	42.06	.417
Myocardial infarction	6.56	8.43	12.42	9.38	.033
Stroke	2.44	3.65	3.92	6.35	.046[†]
Diabetes	3.52	4.85	3.92	1.56	.304
Poor mobility	10.53	14.81	22.07	23.58	<.001
Hypertension (treated)	23.24	26.32	30.00	27.69	.142
Social network (Enough friends)	93.21	92.37	91.49	95.37	.613
Activities (Participates in 2+ social clubs)	37.66	39.50	52.35	43.80	.004

[‡] One-way ANOVA; [†] Fisher's exact test; All other analyses = chi square tests.

VL vision loss; HL hearing loss; DSL dual sensory loss; HSCCL Hopkins Symptom Checklist

Table 2: Association between baseline sensory loss and depression symptoms

	Model 1			Model 2			Model 3			Sensitivity Analysis		
	b	SE	p	b	SE	p	b	SE	p	b	SE	p
Vision Loss alone												
Baseline score	-0.0055	0.066	.933	-0.0381	0.070	.587	-0.0906	0.071	.200	-0.0945	0.072	.188
Six year score	0.0216	0.009	.017	0.0241	0.010	.014	0.0220	0.010	.034	0.0233	0.011	.030
Hearing Loss alone												
Baseline score	0.2544	0.070	<.001	0.2264	0.073	.002	0.1750	0.074	.019	0.2071	0.077	.007
Six year score	0.0085	0.010	.396	0.0068	0.011	.523	0.0022	0.011	.844	0.0028	0.011	.804
Dual Loss												
Baseline score	0.0449	0.120	.708	0.0089	0.098	.928	-0.1144	0.105	.275	-0.0852	0.109	.436
Six year score	0.0499	0.017	.004	0.0487	0.014	<.001	0.0413	0.015	.007	0.0478	0.016	.003

Model 1: n =2064; adjusted for age and sex

Model 2: n =1829; adjusted for age, sex, education, living alone, marital status, and use of antidepressant medication

Model 3: n =1784; adjusted for age, sex, education, living alone, marital status, use of antidepressant medication, BMI, smoking status, self-reported health, stroke, diabetes, myocardial infarction, hypertension, alcohol consumption, mobility

Sensitivity analysis: n=1549, adjusted for age, sex, education, living alone, marital status, use of antidepressant medication, BMI, smoking status, self-reported health, stroke, diabetes, myocardial infarction, hypertension, alcohol consumption, mobility, social network, social activities

Table 3: Association between baseline sensory loss and anxiety symptoms

	Model 1			Model 2			Model 3		
	b	SE	p	b	SE	p	b	SE	p
Vision Loss alone									
Baseline score	0.0631	0.066	.338	0.0788	0.069	.255	-0.0149	0.070	.832
Six year score	0.0041	0.010	.680	-0.0013	0.011	.907	-0.0013	0.011	.910
Hearing Loss alone									
Baseline score	0.3112	0.074	<.001	0.2648	0.077	.001	0.1765	0.079	.026
Six year score	0.0078	0.012	.507	0.0080	0.013	.522	0.0163	0.013	.224
Dual Loss									
Baseline score	0.3082	0.120	.010	0.2165	0.098	.028	0.0384	0.106	.717
Six year score	0.0245	0.019	.198	0.0200	0.016	.187	0.0286	0.017	.091

Model 1: n =2064; adjusted for age and sex

Model 2: n =1829; adjusted for age, sex, education, living alone, marital status, and use of antidepressant medication

Model 3: n =1784; adjusted for age, sex, education, living alone, marital status, use of antidepressant medication, BMI, smoking status, self-reported health, stroke, diabetes, myocardial infarction, hypertension, alcohol consumption, mobility



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