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► **To cite this version:**

S. Cosh, T. von Hanno, C. Helmer, G. Bertelsen, C. Delcourt, et al.. The association amongst visual, hearing, and dual sensory loss with depression and anxiety over 6 years: The Tromsø Study. *International Journal of Geriatric Psychiatry*, 2018, 33 (4), pp.598-605. 10.1002/gps.4827 . hal-01657690v2

HAL Id: hal-01657690

<https://hal.science/hal-01657690v2>

Submitted on 27 Nov 2018

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

Running Head: *Association of sensory loss with depression and anxiety*

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Acknowledgements:

“SENSE-Cog has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 668648”.

The Tromsø project has been made possible by financial support from the Research Council of Norway, North Norway Regional Health Authority and the Norwegian ExtraFoundation for Health and Rehabilitation.

Word Count : 3420

Keywords: Sensory impairment, older adults, elderly, mental health, mental wellbeing

Key Points:

- Little is known about anxiety in sensory loss, and mental health outcomes in dual sensory loss remains unclear
- Vision loss and dual sensory loss were associated with worse depression severity over six years
- Hearing loss was associated with greater anxiety symptoms
- Dual loss poses a risk for greater severity of depression symptoms beyond vision loss only

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 objective 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^{1,2}. Almost one-third of adults over 65 experience hearing loss (HL)³ and prevalence of vision loss (VL) is around 25% in those aged over 70⁴. Poorer mental health has been reported in sensory loss⁵, having a deleterious impact on quality of life and increasing disability⁶⁻⁸.

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 depression⁹⁻¹³. Possible mechanisms include a reduction in social activities and subsequent social isolation^{14,15}. It has also previously been demonstrated that depression and worse mental health outcomes are observed in those with poorer mobility and physical health¹⁶⁻¹⁸, as well as being more common amongst women¹⁷ and those who less educated, and unmarried or live alone¹⁹. Likewise, lifestyle factors such as smoking and alcohol consumption can underlie or reflect depression and poor mental health¹⁹.

A smaller body of literature indicates that there is also a cross-sectional relationship between HL and depression^{20,21}; although not all studies corroborate this association^{22,23}. 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 loss²⁴. Yet the three longitudinal studies to date have yielded mixed findings²⁵⁻²⁷, and it remains unclear if DSL has an additional impact on mental health over and above single sensory loss⁵. 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^{5,14}.

Due to the previous narrow focus on depression, there remains a paucity of research examining anxiety in sensory loss⁵. Indeed, anxiety has been largely overlooked in the older adult literature¹⁶, despite being more prevalent than depression in community-dwelling older adults^{28,29}. Limited cross-sectional findings indicate that VL is associated with increased risk of anxiety³⁰⁻³². 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^{12,33}. 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^{5,14} 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 outlined³⁴. 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 version³⁵. The Norwegian version has been validated and is widely used³⁵. 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 depression³⁶. In a Norwegian population both the depression and anxiety scales have been shown to correlate highly with the original version of the HSCL^{37,38}. 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 questionnaire³⁴. 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^{14,15}. 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 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 anxiety⁵. 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^{9,10}, 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^{20,21}. Whether dual loss confers additional risk to mental health beyond single sensory loss also remains

unclear, with mixed results to date^{14,26,39,40}. Our findings suggested an association with depression over time, beyond that attributable to VL alone. This finding is consistent with McDonnall²⁵, 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^{26,40} 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^{14,15}. 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^{9,26,41}. Those with DSL have greater ADL limitations⁴², 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 melatonin⁴³. 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^{44,45}; with light therapy a well-established treatment for both Seasonal Affective Disorder and non-seasonal Major Depressive Disorder⁴⁶. 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^{27,47} and associated loneliness²³ 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 skills²⁵ or by accessing hearing interventions and support⁴⁸, 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^{33,49} 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 anxiety³³. 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 disability¹⁶, and decreases the ability to manage one's hearing loss⁵⁰, 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 outcomes⁵¹. 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 longitudinally⁵, 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^{52,53} and VL³⁰⁻³², 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 VL³¹, 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^{47,54,55}. This is particularly important given the high rate of correctable VL in older populations⁵⁶. 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 relationship⁹. Interventions might also aim to facilitate acceptance of the loss(es), which has been shown to lead to adjustment and reduced depression over time^{25,57}. 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 services⁵⁸.

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 hearing²¹. 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.

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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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