The relationship between hearing loss in older adults and depression over 12 years: Findings from the Three-City prospective cohort study

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Running head: Hearing loss and depression in older adults over 12 years

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Key Points:

- The relationship between hearing loss and depression in older adults is unclear and longitudinal examinations are rare
- Older adults with self-reported HL were more likely to have depression symptoms and a diagnosis of depression
- Over 12 years, mild and severe HL were associated with onset of depression symptoms, but no incident depression diagnosis

Abstract

Objective: The present study aims to examine the longitudinal relationship between hearing loss (HL) with depression in older adults over 12 years of follow up.

Method: 8344 French community-dwelling adults aged 65 and above participated in the Three-City prospective population-based study. Baseline relationships between self-reported mild and severe HL with depression - assessed by both the Mini International Neuropsychiatric Interview and by the Centre for Epidemiology Studies Depression scale - were explored using logistic regression analyses. Logistic mixed models assessed whether baseline HL was associated with incident depression diagnosis or symptom onset over 12 years in those who were depression-free at baseline.

Results: At baseline, mild and severe HL were associated with depression symptoms as assessed by the CESD (OR = 1.29 95% CIs 1.14-1.47; OR = 1.51 95% CIs 1.22-1.87; respectively), although only mild HL was significantly related to major depression diagnosis (OR = 1.51, 95% CIs 1.07-2.12). Over 12 years, mild and severe HL were associated with incident depression as assessed by the CESD in those without depression at baseline (OR = 1.36 95% CIs 1.15-1.61; OR = 1.69 95% CIs 1.15-2.30; respectively), but was not associated with a major depression diagnosis.

Conclusions: Both mild and severe thresholds of HL are associated with depression symptoms over time, but not with incident diagnosis of major depression. Improved and ongoing detection of subthreshold depression amongst older adults with HL may improve quality of life for this population.

Introduction

Hearing losses (HL) are common among older adults, with up to one third aged over 65 experiencing HL (WHO, 2012). HL substantially contributes to burden of disease (Mathers and Loncar, 2006, Wittchen et al., 2011) by increasing disability (Armstrong et al., 2016). Poorer quality of life (Chia et al., 2007, Eisele et al., 2015) and mental health has also been reported amongst those with HL (Armstrong et al., 2016, Heine and Browning, 2014). Older adults with HL experience less emotional vitality (i.e. less personal mastery and more psychological symptoms) (Contrera et al., 2016), and increased anxiety symptoms (Contrera et al., 2017, Cosh et al., 2017). Concomitantly older adults with HL also report lower levels of happiness and self-efficacy than those without HL (Contrera et al., 2016, Kramer et al., 2002).

Given that HL has been shown to significantly impinge upon the mental wellbeing of older adults, the extent to which HL might be related to depression has also been examined. Limited evidence to date indicates a cross-sectional relationship between HL and depression amongst older adults (Gopinath et al., 2009, Lee et al., 2010), and adults of all ages (Ciesla et al., 2016, Li et al., 2014). Notably reductions in activities of daily living (Gopinath et al., 2012), as well as self-efficacy and social network (Mener et al., 2013) often observed in HL, alongside increased loneliness (Pronk et al., 2013), are possible mechanisms underlying the observed relationships.

However, findings regarding the relationship between HL and depression remain equivocal (Mener et al., 2013, Tambs, 2004). Furthermore, longitudinal examinations of HL and depression are scant, and the findings thus far are also contradictory. A Taiwanese study showed that over 12 years, HL was associated with increased incidence of depression relative to matched controls (Hsu et al., 2016).

Concomitantly, an increased rate of depression symptoms following the onset of HL has also been observed (Kiely et al., 2013). Conversely, in a Dutch cohort, no relationship between HL and depression was found, although HL was associated with increased loneliness amongst men (Pronk et al., 2013, Pronk et al., 2014). HL has also been shown to have a cross-sectional relationship with depression symptoms in a sample of older Norwegian adults, but this relationship was no longer significant after six years (Cosh et al., 2017). Such variations in findings appear to reflect a range of methodological differences between studies. Notably, assessment and classification of depression has varied substantially across studies, with differential findings observed both cross-sectionally (Gopinath et al., 2009) and longitudinally depending on the classification of depression outcome. Further methodological variations include assessment of HL (Lee et al., 2010), adjustment for health or psychosocial covariates, and the average age of the sample, with the HL and depression relationships reportedly stronger amongst younger adults (Tambs, 2004).

Additional studies are thus needed to better ascertain the long-term relationship between HL and depression (Contrera et al., 2016). Moreover, comparison of depression diagnosis compared with presence of depression symptoms is needed to further clarify the currently inconsistent findings. Therefore, the present study aims to examine the association between HL with depression over 12 years amongst older adults, specifically examining depression outcome as both diagnosis of Major Depressive Disorder (MDD) and presence of elevated depression symptoms.

Methods

This study forms part of the SENSE-Cog multi-phase research programme, funded by the 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 (Cosh et al., Forthcoming).

Sample

Participants were recruited as part of the multi-center Three-City study (The 3C Study Group, 2003), a population-based cohort of community-dwelling persons aged 65 years and over. Between 1999 and 2001, 9294 participants were recruited from the electoral rolls of three French cities (Bordeaux, Dijon and Montpellier). A standardized evaluation with a face-to-face interview, as well as clinical examinations were undertaken at baseline as well as 2-3 year intervals for up to 12 years (see Figure 1). Of the initial sample, 7560 (90.6%) participated in at least one wave of follow up over the 12-year period; 116 participants had died before the first follow-up and 1411 by the end of the 12-year period (for a detailed overview of 3C sampling and methods see The 3C Study Group, 2003). The study protocol was approved by the Ethical Committees of the University–Hospitals of Bicêtre and Nîmes (France) and written informed consent was obtained from each participant.

Depression Measures

The Mini International Neuropsychiatric Interview (MINI) (Sheehan et al., 1998) assessed current MDD diagnosis, according to DSM-IV criteria. The MINI is a standardized and well validated diagnostic interview, which has been validated in France (Lecrubier et al., 1997). The MINI was administered at baseline, as well as at 7, 10 and 12 years. Prevalent cases were defined as current MDD at baseline and incident cases were defined as those presenting with a new and current diagnosis of MDD at a follow-up visit.

Depression symptoms were assessed via the 20-item Centre for Epidemiology Studies-Depression Scale (Radloff, 1977) at all follow-up points. The CESD is a well-validated and reliable self-report depression screening tool. The French version of the CESD has also been validated in a population of community dwelling French adults (Morin et al., 2011). Items are rated on a 4 point scale indicating symptom frequency in the past week, with higher scores indicative of greater symptom severity. Participants with a score ≥16 were classified as having depression symptoms (Lewinsohn et al., 2003).

Hearing Measurement

Self-reported Hearing Loss was assessed during standardized face-to-face interview administrated by trained psychologists or nurses at each follow up time point. HL was determined by the response to the question “do you hear what is said in everyday conversation?” Participants were given four response categories (yes without difficulties; some difficulties hearing someone who speaks normally;

difficulties hearing someone who speaks loudly; no/deafness). Mild HL was classified as self-reported difficulty understanding a conversation (normal or loud speaking) and severe HL was classified as self-reported deafness or inability to hear a conversation.

Covariates

Socio-demographic and health-related information was collected during the standardized interview. These included education level (elementary, secondary, higher education), monthly income (<€760, €760-2280, >€2280, withheld/missing), and marital status (married/de facto, single/widowed/divorced). Information regarding alcohol consumption (<10, 10-40, >40 grams per day), tobacco use (current-, past -, or non-smoker), and falls during the past 12 months was also obtained. A composite score representing functional ability was calculated based the Rosow-Breslau scale, the Lawton-Brody Brody Instrumental Activities of Daily living (IADL) scale and the Katz Index of Independence in Activities of Daily Living (categorized as autonomous; dependent for mobility; mobility and IADL limitations; and dependent in 3+ areas; missing) (Barberger-Gateau et al., 2000). History of myocardial infarction, diabetes (fasting glycemia≥7mmol/L and/or anti-diabetic treatment), and use of psychotropic medication in the past month (ATC classification codes: N05A-C, N06A-B) was obtained. During the medical examination blood pressure was measured using a digital electronic tensiometer OMRON M4. Hypertension was defined using the 140/90 mmHg threshold or treatment with blood-pressure lowering drugs (ATC codes: C02, C03, C07, C08). Cognitive functioning was also assessed using the Mini Mental State Examination (MMSE; <24 ≥24).

Statistical Analysis

Socio-demographic and health characteristics were compared according to sensory loss using chi-squares and one-way ANOVAs. Baseline associations between HL with both MDD diagnosis and depression symptoms (16+ CESD score) were examined using logistic regression analyses. The longitudinal associations between baseline HL and depression were examined using mixed logistic models (Carriere and Bouyer, 2002). Logistic mixed models take into account within-subject correlation and model the individual's evolutions of depression over time across the 12 years of follow-up. Logistic mixed models allow for the reversibility of outcomes, and are thus sensitive to remitted cases of depression, and are also robust to missing data. The effect of baseline HL on incident MDD in those free of MDD at baseline and the relationship of baseline HL with incident depression symptoms in those free of depression symptoms at baseline were examined.

For each analysis, three models were undertaken to provide a more comprehensive understanding of the relative impact of psychosocial and physical health covariates on the HL-depression relationship. Model 1 adjusted for sex, study center, and age; Model 2 further adjusted for known psychosocial covariates; education, income, marital status, and psychotropic medication; and Model 3 also adjusted for physical health; functional ability, falls in past 12 months, hypertension, diabetes, smoking, alcohol, cognitive function (MMSE), and myocardial infarction. We also systematically searched for potential interactions between HL with sex, income and education level. Analyses were conducted using SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

Of the 8344 participants with baseline hearing and depression data, 60.4% (n = 5043) were female and mean age was 74.2 (SD = 5.5) years. At baseline, prevalence of mild HL was 30.7% (n=2558) and 7.8% (n = 654) for severe HL. Those with HL were older, more likely to be male, less educated, more commonly a past-smoker and in poorer physical health on all assessed covariates (see Table 1). Baseline prevalence of MDD was 1.9% (n=154) with a further 202 (2.2%) cases of incident MDD over 12 years. At baseline 20.1% (n = 1679) reported depression symptoms, with a further 1484 (22.3%) reporting onset of depression symptoms over follow-up. Both those with MDD and depression symptoms were more likely to be female, and unmarried (<.001). Those reporting depression symptoms also consumed more alcohol and had a lower income (<.001).

At baseline (Table 2), mild but not severe HL was associated with MDD (OR = 1.51, 95% CIs 1.07-2.12; OR = 1.48 95% CIs 0.79-2.79; respectively) in all models, whereas both mild and severe HL were associated with depression symptoms (OR = 1.29 95% CIs 1.14-1.47; OR = 1.51 95% CIs 1.22-1.87; respectively). HL was not associated with incident MDD over 12 years (Table 3). On the other hand, both mild and severe HL were related to incident depression symptoms (OR = 1.36 95% CIs 1.15-1.61; OR = 1.69 95% CIs 1.15-2.30; respectively) in all models. No interactions were significant.

Discussion

This study contributes to the currently limited and equivocal literature examining the longitudinal relationship between HL and depression. Those with self-reported HL were more likely to have elevated depression symptoms and diagnosed MDD at baseline. Furthermore, mild and severe HL were also associated with incident depression symptoms over 12 years in those depression-free at baseline, however HL was to related to incident MDD.

Consistent with prior findings, our results showed a significant cross-sectional relationship between HL and depression (Gopinath et al., 2009, Lee et al., 2010), and both mild and severe HL thresholds were related to elevated depression symptoms. Although differential relationships between HL and depression have been reported depending on how depression was assessed (Gopinath et al., 2009), associations between HL and MDD diagnosis have been less commonly explored (Mener et al., 2013). Our results showed that mild HL was associated with MDD diagnosis. Results for severe HL were in the same direction, however, did not reach statistical significance. This may be due to a reduced statistical power owing to the lower numbers reporting severe HL.

Furthermore, our results contribute to the small and contradictory evidence regarding the longitudinal association between HL and depression. Previous longitudinal studies examining severity of depression symptoms have found no association between HL and depression (Pronk et al., 2013, Cosh et al., 2017), whereas difference in depression symptoms pre- and post- HL onset have been observed (Kiely et al., 2013). Our findings highlight a significant longitudinal association between HL with presence of depression symptoms. Thus HL appears to

be related to presence of elevated depression symptoms, rather than directly impinging on symptom severity.

Although an association between HL and incident MDD has been reported previously (Hsu et al., 2016), we did not find an association with MDD. Differences in findings might be explained by the older mean age of our sample, with some evidence suggesting a stronger relationship between HL and depression in younger ages (Tambs, 2004). Notably, although the result was non-significant, an increased OR for MDD was observed for severe HL. It is likely that due to the few cases of incident MDD, our lack of an association may be due to analyses being underpowered.

Our results further suggest that differences in prior findings are likely reflective of varying methods of assessing depression. We found that HL was associated over time with presence of elevated symptoms, rather than depression diagnosis. The relationship with presence of increased symptomatology but lack of an association with MDD might reflect that subsyndromal depression is more common in older adults than major depression (Blazer, 2003); with self-report depression measures (such as the CESD) frequently used in the sensory loss literature failing to distinguish between MDD and subsyndromal depression.

Notably, however, elevated depression symptoms or subsyndromal depression can result in poor outcomes including increased mortality rates (Pennix et al., 1999a) and suicidal ideation (Geiselmann et al., 2001). Subsyndromal depression substantially contributes to reduced quality of life, increased disability (Pennix et al., 1999b) and increased negative attitudes towards ageing (Chachamovich et al., 2008). Thus even in the absence of an MDD diagnosis, treatment and intervention for

depression symptoms remain important in the elderly with HL. Given that depression symptoms often go unnoticed and undiagnosed in the elderly (Teresi et al., 2001), and communication barriers frequently limit access to mental health support for those with HL (Sheppard and Badger, 2010, Turner et al., 2007), targeted intervention may be beneficial for this population.

A reduction in the ability to carry out activities of daily living is a proposed mechanism contributing to the association between HL and depression (Chou, 2008), however adjustment for functional abilities did not attenuate results. Odds ratios in our studies remained similar across levels of adjustment, suggesting that other common processes might better explain these relationships. Communication difficulties observed in HL (Kiely et al., 2013, McDonnall, 2009) may underlie the association with depression, especially through increased social isolation and loneliness (Pronk et al., 2011, Schneider et al., 2012); with perceived lack of social support associated with depression onset (Pennix et al., 1999b). Furthermore, reductions in help seeking (Sheppard and Badger, 2010) and increases in comorbid anxiety (Cosh et al., 2017) might also contribute to the depression and HL relationship.

Strengths and Limitations

Strengths of this study include the length of follow up and large sample size. Moreover, this study substantially contributes to the current HL and depression literature, not only by providing a rare longitudinal examination, but also by exploring depression both as an MDD diagnosis and as the presence of elevated depression symptoms. Such analysis allowed for increased insight into the nature of associations

of HL and depression in older adults. Limitations include that HL was self-reported. Such self-reports may represent underestimates of actual HL, due to perceptions that hearing decline is a natural part of aging. Conversely, those who have depression might be more likely to self-report HL, or concentration deficits associated with depression might increase the likelihood of difficultly hearing a conversation. Although, given that those with baseline depression were excluded from longitudinal analyses, it appears that the HL-depression association extends beyond only self-reporting bias. Although relationships remained significant after adjustment for cognitive functioning, the extent to which underlying cognitive decline might have influenced self-report HL and the ability to hear a conversation cannot be fully ascertained. Furthermore, from this study we cannot exclude the possibility that depression onset might have been a prodromal aspect of dementia. However, given the dearth of longitudinal studies of HL and depression, our findings contribute valuable insight, although ongoing research with objective assessments of HL would be invaluable to corroborate such associations.

Although a CESD cut off score of 16 has empirical support, there is also debate as to the most appropriate cut off score (see Vilagut et al., 2016). Different thresholds may result in differences in findings. MDD was assessed only at three time points, thus additional MDD cases that may have occurred and remitted between assessments were not included. Our MDD results were also likely underpowered, especially for severe HL and we cannot be certain of the lack of associations.

Conclusion

Older adults with self-reported HL have poorer mental health outcomes, in particular subthreshold depression over time. Both mild and severe self-reported HL are associated with depression symptoms at baseline as well as over 12 years. Especially given possible communication and help-seeking barriers in HL, increased focus on assessment and identification of depression, including subthreshold symptomatology, may be warranted to improve quality of life amongst older adults with HL. Concomitantly, improved identification and management of HL might crucially limit depression amongst older adults.

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Table 1: Baseline characteristics of the study population by hearing loss. Three-City Study 1999-2001, N=8344.

	No hearing loss n= 5132		**Mild Hearing Loss n=** 2558		**Severe Hearing Loss n=** 654		**p**
Age: Mean (SD)	73.3	5.1	74.8	5.6	78.1	6.2	<.001 [a]
Female (n, %)	3395	66.2	1342	52.5	306	46.8	<.001
Education (reference: high)							<.001
Low	1256	24.5	680	26.6	228	34.9	<.001
Mid	2931	57.2	1395	54.6	312	47.8	<.001
Income (reference = high)							.08
Low (<€760)	276	5.7	138	5.8	47	7.9	.10
Mid (€760-€2280)	2864	59.3	1404	58.5	365	61.0	.50
Withheld/missing	302	5.9	157	6.1	56	8.6	.03
Married	3047	59.4	1559	61.0	396	60.6	.41
Smoking(reference: non-smoker)							<.001
Current smoker	297	5.8	141	5.5	33	5.1	.70
Past smoker	1542	30.1	967	37.8	265	40.5	<.001
Psychotropic medication use	1422	27.7	746	29.2	235	35.9	<.001
Alcohol consumption (reference: high)							<.001
Low (>10 grams per day)	3071	59.84	1411	55.16	365	55.81	<.001
Moderate (10-40 per day)	1760	34.29	938	36.67	233	35.63	.12
Fall in past 12 months	936	18.3	503	19.7	148	22.7	.01
Hypertension	3914	76.3	2032	79.6	531	81.2	<.001
Myocardial infarction	213	4.2	154	6.0	43	6.6	<.001
MMSE (<24)	49	0.9	38	1.5	20	3.1	<.001
Functional ability (reference: autonomous)							<.001
Dependent for mobility	1803	36.2	997	40.2	272	43.3	<.001
Mobility and IADL limitations	319	6.4	234	9.4	133	21.2	<.001
Dependent in 3+ areas	30	0.6	27	1.1	7	1.1	.25
Missing	145	2.8	79	3.1	26	4	.25
Diabetes	385	7.5	228	9.0	66	10.2	.02
MDD (current diagnosis)	85	1.7	58	2.3	11	1.9	.18
Depression (CESD 16+)	962	18.8	556	21.7	161	24.6	<.001

SD: Standard deviation, [a] = determined by one-way ANOVA, all other p values determine by Chi square tests
Except for age, results are presented as n, %.

Table 2: Association of baseline hearing loss with baseline MDD and depression symptoms (CESD)

	OR	95% Cis		p
MDD diagnosis				
Mild Hearing Loss				
Model 1	1.54	1.10	2.17	.01
Model 2	1.50	1.06	2.11	.02
Model 3	1.51	1.07	2.12	.02
Severe Hearing Loss				
Model 1	1.55	0.82	2.93	.17
Model 2	1.48	0.78	2.80	.23
Model 3	1.48	0.79	2.79	.22
Depression symptoms				
Mild Hearing Loss				
Model 1	1.33	1.17	1.50	<.001
Model 2	1.31	1.16	1.48	<.001
Model 3	1.29	1.14	1.47	<.001
Severe Hearing Loss				
Model 1	1.64	1.34	2.00	<.001
Model 2	1.59	1.29	1.96	<.001
Model 3	1.51	1.22	1.87	<.001

Model 1: adjusted for sex, age, centre
Model 2: adjusted for sex, age, centre, education, income, marital status, psychotropic medication use
Model 3: adjusted for sex, age, centre, education, income, marital status, psychotropic medication use, MMSE, functional ability, falls, BMI, hypertension, diabetes, smoking, alcohol consumption, and history of stroke and myocardial infarction
MDD analyses: Model 1 n = 8157; Model 2 n = 8137; Model 3 n =8079
Depression analyses: Model 1 n = 8344; Model 2 n = 8328; Model 3 n =8268

Table 3: Association of baseline hearing loss with incident MDD and depression symptoms (CESD)

	OR	95% Cis		p
MDD diagnosis				
Mild Hearing Loss				
Model 1	0.86	0.18	4.05	.85
Model 2	0.83	0.18	3.92	.81
Model 3	0.86	0.18	4.05	.84
Severe Hearing Loss				
Model 1	2.65	0.29	24.33	.39
Model 2	2.45	0.27	22.62	.43
Model 3	2.27	0.24	21.85	.48
Depression symptoms				
Mild Hearing Loss				
Model 1	1.43	1.20	1.70	<.001
Model 2	1.38	1.16	1.64	<.001
Model 3	1.36	1.15	1.61	<.001
Severe Hearing Loss				
Model 1	1.90	1.39	2.60	<.001
Model 2	1.75	1.29	2.38	<.001
Model 3	1.69	1.15	2.30	<.001

Model 1: adjusted for sex, age, centre
Model 2: adjusted for sex, age, centre, education, income, marital status, psychotropic medication use
Model 3: adjusted for sex, age, centre, education, income, marital status, psychotropic medication use, MMSE, functional ability, falls, BMI, hypertension, diabetes, smoking, alcohol consumption, and history of stroke and myocardial infarction
MDD analyses: Model 1 n = 8003; Model 2 n = 7984; Model 3 n =7927
Depression analyses: Model 1 n = 6665; Model 2 n = 6657; Model 3 n =6614

Figure Legend:

Figure 1: Flow chart of participants

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