**Hearing impairment and incident disability and all-cause mortality in older British community-dwelling men**

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**ABSTRACT**

**Background and objective:** Hearing impairment is common in older adults, and has been implicated in the risk of disability and mortality. We examined the association between hearing impairment and risk of incident disability and all-cause mortality.

**Design and setting:** Prospective cohort of community-dwelling older men aged 63-85 years followed-up for disability over 2 years and for all-cause mortality for 10 years in the British Regional Heart Study.

**Methods:** Data was collected on self-reported hearing impairment, and disability assessed as mobility limitations (problems walking/taking stairs), difficulties with activities of daily living (ADL) and instrumental ADL (IADL). Mortality data was obtained from the National Health Service registers.

**Results:** Among 3981 men, 1074 (27%) reported hearing impairment. Compared to men with no hearing impairment, men who used a hearing aid and men who could not hear despite a hearing aid had increased risks of IADL difficulties (age-adjusted OR 1.86 95%CI 1.29-2.70; OR 2.74 95%CI 1.53-4.93 respectively). The associations remained after further adjustment for covariates including social class, lifestyle factors, comorbidities, social engagement and mobility limitations. Associations of hearing impairment with incident mobility limitations, incident ADL difficulties and all-cause mortality were attenuated on adjustment for covariates.

**Conclusion:** Hearing impairment in older men is associated with an increased risk of disability associated with performing IADLs (such as shopping, light housework). The findings suggest that preventive interventions and correction of hearing impairment in later life are important to maintain ability to perform more complex everyday tasks and functional independence.

**INTRODUCTION**

Hearing impairment increases with age and is estimated to affect one in five (20%) adults in Great Britain aged ≥60 years and over.[[1-3](#_ENREF_1)] Older adults aged ≥60 years form a rapidly growing proportion of the UK population[[4](#_ENREF_4)], making hearing impairment in older age an increasingly important public health concern. Hearing impairment in older age has been associated with chronic conditions including cardiovascular disease (CVD) and poor quality of life.[[2](#_ENREF_2)] Prevention, early diagnosis and improved care of CVD and other life-threatening illnesses have led to an increase in the number of adults living with disability affecting independent living and overall well-being.[[5](#_ENREF_5)] Disability in later life often occurs first as mobility limitations (for example, difficulties walking or climbing stairs).[[6](#_ENREF_6)] Other forms of disability affect disablement in tasks essential to caring for oneself (basic activities of daily living (ADL) e.g. bathing, dressing) and more complex tasks that refer to living independently in the community (instrumental activities of daily living (IADL) e.g. shopping, telephoning).[[6](#_ENREF_6)] Previous cross-sectional studies have shown an association between hearing impairment and mobility limitations.[[7](#_ENREF_7)] Compared to those with no hearing impairment, earlier studies have demonstrated increased risks of subsequent mobility limitations among older adults with hearing impairment.[[8](#_ENREF_8), [9](#_ENREF_9)] Previous research has also shown an association between hearing impairment and incident ADL deficits in hospital-based samples of older people; however such associations have not been examined in community-dwelling older adults.[[10](#_ENREF_10), [11](#_ENREF_11)] Hearing impairment has furthermore been associated with an increased risk of incident IADL, however findings are inconsistent with some studies demonstrating no association after adjustment for socio-demographics and chronic conditions.[[8](#_ENREF_8), [12-14](#_ENREF_12)] In addition, it has been suggested that hearing impairment increases the risk of all-cause mortality,[[1](#_ENREF_1)] but some studies have shown no association after adjustment for demographic factors, physical functioning and cognition.[[14](#_ENREF_14), [15](#_ENREF_15)]

Longitudinal investigations of the influence of hearing impairment on disability and all-cause mortality are relatively few. It is important to understand the influence of hearing impairment on disability including activities of daily living in order to establish the impact of hearing impairment on functional independence in later life. Therefore, we investigated the association of self-reported hearing impairment with subsequent mobility limitations, ADL, IADL and all-cause mortality in a representative sample of older British men aged 63-85 years followed-up for 2 years for disability and 10 years for mortality. We also examined whether these associations were independent of age, social class, lifestyle factors including body mass index (BMI), smoking and physical activity, and comorbidities known to be associated with hearing impairment including cardiovascular disease (CVD), hypertension and diabetes.[[2](#_ENREF_2), [16](#_ENREF_16)]

**METHODS**

**Study design and participants**

This study uses data from the British Regional Heart Study (BRHS), a prospective study in a socioeconomically and geographically representative sample of 7735 middle-aged men drawn from 24 general practices representing all major British Regions.[[17](#_ENREF_17)] The men were recruited in 1978-80 and have regularly been followed up for morbidity. For this study, baseline data on 3981 men, then aged 63-85 years, were obtained through self-reported questionnaires in 2003. Ethical approval was obtained from relevant local research ethics committees.

**Hearing impairment**

Self-reported data on use of hearing aid and a previously validated question on ability to follow a TV programme at a volume others find acceptable,[[18](#_ENREF_18)] allowed for participants to be divided into four groups: could follow TV and no hearing aid (could hear) (reference group), could follow TV and used hearing aid and (could hear, used aid), could not follow TV and did not use hearing aid (could not hear, no aid), and could not follow TV and used hearing aid (could not hear, used aid).

**Outcome measures**

All men were followed-up for mobility limitations, activities of daily living (ADL) and instrumental ADL (IADL) from 2003 to 2005 and for all-cause mortality from 2003 to 2013. Mobility limitations were classified as reporting problems taking the stairs and/or walking 400 yards. ADL was classified as having any difficulty undertaking one or more of the following activities: bathing, dressing, eating, getting in or out of bed or chair, toileting, and/or walking across a room.[[19](#_ENREF_19)] IADL was based on reporting any problem undertaking cooking, shopping, using public transport, managing money and/or using the telephone.[[20](#_ENREF_20)] Mortality data was collected through the established "flagging" procedures provided by the National Health Service registers. Binary outcomes assessed in the current analyses were for incident mobility limitations, difficulties in ADL, IADL and all-cause mortality.

**Covariates**
Socio-economic and lifestyle factors including social class, social engagement, cigarette smoking, obesity and physical activity were considered as covariates. Comorbidity-related covariates included doctor-diagnosed cardiovascular disease (CVD) (coronary thrombosis, myocardial infarction, angina and/or stroke), hypertension and diabetes analysed dichotomously. Participants were divided into manual and non-manual social class based on the longest-held occupation of subjects at study entry using the Registrar Generals’ Social Class Classification. The men were grouped into non-smokers (non-smokers and ex-smokers combined) and current smokers. Being obese was defined as having a body mass index (BMI) of 30 kg/m2 and over.[[21](#_ENREF_21)] Physical activity scores were based on exercise type and frequency categorised as none, occasional, light, moderate, moderately-vigorous and vigorous,[[22](#_ENREF_22)] where none or occasional activity was classified as being inactive. Findings on hearing impairment and incident disability that remained significant after adjustment for age, social class, lifestyle factors and comorbidities as listed above were further adjusted for factors that may be on the causal pathway of hearing impairment and disability including social engagement, mobility limitations, depression and balance. Low social engagement was classified as doing three or fewer activities part of a 9-item social engagement scale on a weekly basis: voluntary work, go to the pub or a club, attend religious services, play cards or games, visit the cinema, restaurants or sports events, attend a class or course of study, and, sometimes go on day or overnight trips, and been on a holiday in the last year.[[23](#_ENREF_23)] Doctor-diagnosed depression and reporting not being able to keep balance were analysed dichotomously.

**Statistical analyses**

Logistic regression was used to assess the associations of hearing impairment with incident mobility limitations, and difficulties in ADLs and IADLs. Odds ratios (OR) with 95% confidence intervals (CI) were obtained using no hearing impairment as reference group. Survival analysis was used to examine the association between sensory impairments and mortality and Cox proportional hazards regression was used to calculate hazard ratios (HR) with 95% CIs. Participants who did not answer any of the hearing-related questions (N=38) were excluded. Participants free from mobility limitations, difficulties in ADLs and IADLs were followed up for each of these types of disability. All analyses were carried out using SAS version 9.3 software (SAS Institute, Inc., Cary, North Carolina).

**RESULTS**

In 2003, 3981 men aged 63-85 years completed the questionnaire (82% response rate). Of these, 3108 men had no previous mobility limitations, 3346 men had no previous ADL and 3410 men had no previous IADL. At 2-year follow-up there were 238 new cases of mobility limitations, 260 new cases of ADL and 207 new cases of IADL. All 3981 men were also followed for all-cause mortality over 10 years during which 1463 deaths occurred.

Table 1 shows the characteristics of participants by hearing impairment. Data by hearing groups shows that 63% (n=263) of men who could not hear and did not use a hearing aid were manual social class compared to 48% (n=1317) of men with no hearing impairment. More than half (54%, n=87) of men who could not hear and used an aid were physically inactive, 26% were obese and 46% had hypertension. Similarly, 41% (n=157) of men who could not hear and did not use a hearing aid were physically inactive, 21% were obese and 39% had hypertension.

Table 2 presents odds ratios (OR) with 95% CIs for incident mobility limitations, ADL and IADL for hearing impairment. Compared to men with no hearing impairment, men who could not hear and used a hearing aid had over a two-fold greater risk of mobility limitations at 2-year follow-up (age-adjusted OR 2.24, 95%CI 1.29-3.89). The association remained after further adjustment for social class, lifestyle factors and comorbidities (OR 1.89 95%CI 1.04-3.41), but was attenuated upon adjustment for social engagement. Men who could not hear, irrespective of using a hearing aid, had greater risks of developing problems performing ADL compared to men with no hearing impairment (OR 1.74 95%CI 1.19-2.55; OR 2.01 95%CI 1.16-3.46). The association was attenuated after further adjustment for social class, lifestyle factors and comorbidities among men who used an aid but remained in those who could not hear and did not use a hearing aid (OR 1.76 95%CI 1.16-2.66). The increased risk of ADL observed in men who could not hear and did not use a hearing aid remained after further adjustment for social engagement (OR 1.68 95%CI 1.11-2.55), but was attenuated after further adjustment for mobility limitations (OR 1.49 95%CI 0.97-2.29). Compared to men with no hearing impairment, those who could hear and used a hearing aid and those who could not hear despite having an aid were more likely to develop IADL problems (OR 1.86 95%CI 1.29-2.70; OR 2.74 95%CI 1.53-4.93). The associations remained after further adjustment for social class, lifestyle factors, comorbidities and social engagement (OR 2.00 95%CI 1.34-2.99; OR 2.61 95%CI 1.38-4.96). We also further adjusted for mobility limitations, depression and poor balance and the associations remained significant (OR 2.03 95%CI 1.35-3.07; OR 2.77 95%CI 1.43-5.36). Further analyses of the associations between hearing impairment and individual components of IADL showed that men who could hear and used a hearing aid and men who could not hear despite aid were both more likely to experience problems, in particular problems undertaking shopping and light housework, even after further adjustment for social class, lifestyle factors, comorbidities and social engagement. Men who could hear and used aid were also more likely to have problems using public transport. Only those who could not hear despite an aid had increased risks of difficulty cooking (OR 2.03 95%CI 1.05-3.94), but the association was attenuated after further adjustment for social class, lifestyle factors and comorbidities (results not presented). Men who could hear and used an aid and men who could not hear despite an aid were more likely to have problems telephoning with over four-fold increased risks in men who could not hear despite aid (OR 4.53 95%CI 2.25-9.10). The association remained in men who could not hear despite an aid after further adjustment for social class, lifestyle factors, comorbidities and social engagement (OR 4.29 95%CI 2.02-9.13) and after further adjustment for mobility limitations, depression and poor balance (OR 4.29 95%CI 2.00-9.18). None of the hearing impairment groups were associated with difficulties taking medications (results not presented).

Table 3 shows hazard ratios (HR) with 95% CIs for all-cause mortality associated with hearing impairment. Compared to men with no hearing impairment, those who could not hear and did not use a hearing aid had a significantly greater risk of all-cause mortality (HR 1.19, 95%CI 1.01-1.40) but the association was attenuated on further adjustments. No other hearing impairment group was associated with increased risk of all-cause mortality.

**DISCUSSION**

This study investigated the association of hearing impairment with incident disability (mobility limitations, ADL, IADL) and all-cause mortality in a prospective cohort of older British men. Our findings show that men with hearing impairment had greater risks in particular of disability affecting IADLs. The associations observed between hearing impairment and incident mobility limitations, incident ADL and all-cause mortality were attenuated on further adjustment for covariates.

The association between hearing impairment and mobility limitations was attenuated particularly on adjustment for social engagement. Communication problems due to hearing impairment may restrict social engagement.[[9](#_ENREF_9)] Being socially engaged can motivate maintenance of physical functioning,[[24](#_ENREF_24)] reducing the risk of incident disability.[[25](#_ENREF_25)] Only men who could not hear and did not use a hearing aid had greater risk of subsequent ADL deficits after adjustment for age, social class, lifestyle factors, comorbidities and social engagement. However the association was attenuated after further adjustment for mobility limitations. In contrast, men who could hear with an aid and men who could not hear despite an aid had increased risks of subsequent IADL difficulties and the associations remained after further adjustment for social class, lifestyle factors, comorbidities and social engagement. The associations also remained statistically significant after further adjustment for mobility limitations, depression and poor balance. This suggests that hearing impairment has a greater impact on IADLs which involve more complex tasks (such as shopping and light housework) than basic tasks including ADL and mobility limitations.[[26](#_ENREF_26)] However, the observed associations between hearing impairment and IADL could also be explained by residual confounding due to unmeasured factors such as cognitive functioning, which is important for complex IADL tasks.[[15](#_ENREF_15), [27](#_ENREF_27)] The degradation hypothesis suggests that a decline in hearing impairment in older age increases the demands on cognitive functioning.[[10](#_ENREF_10)] Previous research also suggests that family members may steer away older relatives with poor physical and cognitive functions from responsibilities and tasks such as IADLs.[[10](#_ENREF_10)] Finally, the association observed between hearing impairment and incident IADL could be due to inflammation, which is related to both hearing impairment and disability. [[28](#_ENREF_28), [29](#_ENREF_29)]

Men who could not hear and did not use hearing aid had greater risks of all-cause mortality compared to men with no hearing impairment. However, the association was attenuated after adjustment for social class, lifestyle factors and comorbidities. This is consistent with earlier studies demonstrating no association after adjustment for potential confounders including social class and physical functioning.[[14](#_ENREF_14), [15](#_ENREF_15)]

**Strengths and limitations**

The major strengths of this study are that it was a large socio-economically representative cohort with negligible loss to follow-up for disability and mortality.[[17](#_ENREF_17)] In addition, the cohort was followed up for 2 years for disability and for 10 years for mortality and the models were adjusted for several confounding variables.

Limitations include that hearing impairment was self-reported rather than objectively measured. However, the questions used have been validated against objective measures.[[18](#_ENREF_18)] Furthermore, previous research has demonstrated comparable findings when investigating both self-reported and measured hearing impairment and 10-year mortality risk.[[14](#_ENREF_14)] Further, the question on hearing aid use did not specify whether the participants have been offered a hearing aid and chosen not to use it or whether they do not have a hearing aid at all. Furthermore, hearing impairment was measured at baseline only and no information on the primary cause of and change in hearing impairment were investigated. Finally, the study was in older men, predominantly of white British ethnic origin, and generalisation of findings to women and to other ethnic groups is limited.

**Conclusions and implications**

In summary, our study shows that older men with hearing impairment have greater risks of disability affecting IADLs. IADLs refer to more complex tasks of daily living including shopping and telephoning and are important for maintaining functional independence in later life. Effective preventive interventions and correction of hearing impairment in older adults may be important in order to maintain their ability to perform everyday tasks and functional independence. Future longitudinal studies are required to further assess the association between hearing impairment and incident disability, taking cognitive impairment and inflammation into account.

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Table 1. Socio-economic and lifestyle characteristics, comorbidities and mean age by hearing impairment in a cohort of British men aged 63-85 years in 2003

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| %(n) | Overall | Could hear | Could hear, used aid | Could not hear, no aid | Could not hear, used aid |
| *Totals* | 100 (3981) | 73 (2851) | 12 (482) | 11 (424) | 4 (168) |
| *Covariates* |  |  |  |  |  |
| Manual social class | 51 (1962) | 48 (1317) | 53 (245) | 63 (263) | 60 (98) |
| Current smokers | 10 (389) | 10 (284) | 7 (33) | 13 (54) | 9 (15) |
| Ex-smokers | 60 (2385) | 59 (1681) | 66 (314) | 58 (244) | 69 (115) |
| Never smoked | 30 (1174) | 31 (870) | 27 (131) | 29 (123) | 22 (37) |
| Physical inactivity | 38 (1430) | 36 (971) | 44 (196) | 41 (157) | 54 (87) |
| Obese  | 17 (639) | 16 (445) | 13 (61) | 21 (85) | 26 (42) |
| CVD | 27 (1087) | 26 (728) | 32 (153) | 26 (112) | 43 (72) |
| Hypertension | 39 (1547) | 38 (1092) | 41 (196) | 39 (165) | 46 (78) |
| Diabetes | 10 (393) | 10 (281) | 9 (45) | 10 (41) | 11 (19) |
| *Age* |  |  |  |  |  |
| Mean age in years | 72 | 72 | 75 | 72 | 74 |

Table 2. Odds ratios (OR) with 95% CIs for associations between incidence of mobility limitations, ADL and IADL and hearing impairment in British men aged 63-85 years in 2003 followed up for 2 years to 2005

|  |  |  |
| --- | --- | --- |
|  |  | Hearing impairment |
|  |  | Could hear | Could hear, used aid | Could not hear, no aid | Could not hear, used aid |
| **Limitations in mobility** | n (%) | 150 (7) | 39 (11) | 23 (8) | 17 (16) |
| Model 1 | OR (95% CI) | 1.00 | 1.40 (0.95-2.05) | 1.16 (0.73-1.83) | 2.24 (1.29-3.89) |
| Model 2 |  | 1.00 | 1.40 (0.92-2.12) | 1.26 (0.78-2.03) | 1.89 (1.04-3.41) |
| Model 2 + social engagement |  | 1.00 | 1.41 (0.93-2.14) | 1.24 (0.77-2.01) | 1.79 (0.98-3.27) |
|  |  |  |  |  |  |
| **ADL** |  | 161 (7) | 41 (10) | 37 (11) | 17 (15) |
| Model 1 |  | 1.00 | 1.30 (0.90-1.88) | 1.74 (1.19-2.55) | 2.01 (1.16-3.46) |
| Model 2 |  | 1.00 | 1.23 (0.82-1.84) | 1.76 (1.16-2.66) | 1.62 (0.90-2.94) |
| Model 2 + social engagement |  | 1.00 | 1.25 (0.83-1.87) | 1.68 (1.11-2.55) | 1.59 (0.87-2.88) |
|  |  |  |  |  |  |
| **IADL** |  | 126 (5) | 44 (11) | 19 (6) | 15 (15) |
| Model 1 |  | 1.00 | 1.86 (1.29-2.70) | 1.09 (0.66-1.79) | 2.74 (1.53-4.93) |
| Model 2 |  | 1.00 | 2.03 (1.36-3.01) | 1.01 (0.59-1.75) | 2.56 (1.35-4.86) |
| Model 2 + social engagement |  | 1.00 | 2.00 (1.34-2.99) | 0.95 (0.54-1.67) | 2.61 (1.38-4.96) |

Model 1: adjusted for age

Model 2: adjusted for age, social class, BMI, smoking, physical activity, CVD, hypertension and diabetes

Table 2 continued

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **IADL components** |  |  |  |  |  |
| *Shopping* |  | 73 (3) | 31 (7) | 17 (5) | 13 (9) |
| Model 1 |  | 1.00 | 2.05 (1.32-3.20) | 1.63 (0.95-2.80) | 2.80 (1.50-5.23) |
| Model 2 |  | 1.00 | 1.96 (1.20-3.19) | 1.56 (0.87-2.82) | 2.39 (1.22-4.68) |
| Model 2 + social engagement |  | 1.00 | 2.01 (1.23-3.28) | 1.46 (0.80-2.68) | 2.30 (1.15-4.60) |
|  |  |  |  |  |  |
| *Light housework* |  | 66 (2) | 25 (6) | 12 (3) | 12 (8) |
| Model 1 |  | 1.00 | 1.93 (1.19-3.12) | 1.24 (0.66-2.32) | 3.08 (1.61-5.88) |
| Model 2 |  | 1.00 | 1.76 (1.05-2.95) | 1.05 (0.54-2.05) | 2.73 (1.39-5.34) |
| Model 2 + social engagement |  | 1.00 | 1.80 (1.07-3.04) | 1.02 (0.52-2.00) | 2.73 (1.39-5.38) |
|  |  |  |  |  |  |
| *Telephoning* |  | 43 (2) | 17 (4) | 7 (2) | 11 (8) |
| Model 1 |  | 1.00 | 1.85 (1.03-3.32) | 1.10 (0.49-2.47) | 4.53 (2.25-9.10) |
| Model 2 |  | 1.00 | 1.64 (0.88-3.04) | 0.75 (0.29-1.93) | 3.82 (1.80-8.09) |
| Model 2 + social engagement |  | 1.00 | 1.74 (0.93-3.24) | 0.78 (0.30-2.03) | 4.29 (2.02-9.13) |
|  |  |  |  |  |  |
| *Managing money* |  | 59 (2) | 16 (4) | 10 (3) | 14 (9) |
| Model 1 |  | 1.00 | 1.27 (0.71-2.25) | 1.13 (0.57-2.23) | 3.68 (1.99-6.82) |
| Model 2 |  | 1.00 | 1.29 (0.71-2.35) | 0.97 (0.45-2.07) | 3.49 (1.84-6.62) |
| Model 2 + social engagement |  | 1.00 | 1.32 (0.72-2.41) | 0.95 (0.44-2.04) | 3.68 (1.94-6.98) |
|  |  |  |  |  |  |
| *Using public transport* |  | 75 (3) | 33 (8) | 13 (4) | 7 (5) |
| Model 1 |  | 1.00 | 1.98 (1.28-3.06) | 1.20 (0.66-2.20) | 1.42 (0.64-3.19) |
| Model 2 |  | 1.00 | 1.97 (1.23-3.16) | 1.16 (0.61-2.20) | 1.33 (0.58-3.05) |
| Model 2 + social engagement |  | 1.00 | 1.93 (1.20-3.11) | 1.13 (0.59-2.14) | 1.36 (0.60-3.13) |

Model 1: adjusted for age

Model 2: adjusted for age, social class, BMI, smoking, physical activity, CVD, hypertension and diabetes

Table 3. Hazard ratios (HR) with 95% CIs for associations between all-cause mortality and hearing impairment in British men aged 63-85 years in 2003 followed up for 10 years to 2013

|  |  |  |
| --- | --- | --- |
|  |  | Hearing impairment |
|  |  | Could hear | Could hear, used aid | Could not hear, no aid | Could not hear, used aid |
|  | Rates / 1000 (n) | 39 (974) | 54 (216) | 48 (169) | 58 (76) |
| Model 1 | HR (95% CI) | 1.00 | 1.03 (0.88-1.19) | 1.19 (1.01-1.40) | 1.18 (0.93-1.49) |
| Model 2 |  | 1.00 | 1.01 (0.86-1.19) | 1.12 (0.93-1.34) | 1.14 (0.89-1.45) |

Model 1: adjusted for age

Model 2: adjusted for age, social class, BMI, smoking, physical activity, CVD, hypertension and diabetes