Correlates of Hearing Aid Use in UK Adults: Self-Reported Hearing Difficulties, Social Participation, Living Situation, Health, and Demographics

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INTRODUCTION

Hearing loss is associated with a range of negative outcomes (Mulrow et al. 1990; Royal National Institute for Deaf and Hard of Hearing People 2006; Chia et al. 2007; Lin et al. 2013) and is ranked fifth for burden of disability (Vos et al. 2015). The socioeconomic costs of untreated hearing loss include reduced quality of life, loss of productivity due to under- and unemploy- and social care costs (Shield 2006). The World Health Organization estimates the global cost of unaddressed hearing impairment at between US$750 and US$790 billion per year (WHO 2017).

In the United Kingdom, around 29% of adults aged 55 to 74 years have a hearing impairment (pure-tone audiometric thresholds >25 dB HL in the better ear) and could benefit from a hearing aid (Davis et al. 2007). However, only 14% of United Kingdom adults aged 55 to 74 years with a hearing impairment use a hearing aid (Davis et al. 2007). Rates of hearing aid use among those with a hearing impairment is similar in younger adults; Chia et al. (2007) reported around 12% of those under 60 years old with a hearing impairment use a hearing aid. A review by Barker et al. (2014) reported that interventions designed to increase hearing aid use had limited success and the studies included in their review were criticized for poor method- odological quality.

Identifying correlates of hearing aid use would be valuable in developing interventions to promote the use of hearing aids. The aim of the present research was therefore to identify the biopsychosocial correlates of hearing aid use in adults in the United Kingdom with a hearing impairment using cross-sectional analysis.

Reviews by Vestergaard Knudsen et al. (2010) and Ng and Loke (2015) summarize studies examining the biopsychosocial correlates of hearing aid use (Supplemental Digital Content, http://links.lww.com/EANDH/A502). These biopsychosocial correlates included age, gender, educational level, hearing sensitivity, general health, longstanding illness, cognitive function, acceptance of hearing loss, and greater self-reported hearing difficulties. Hearing aid use has not been consistently associated with demographic factors such as age, gender, socioeconomic status (Vestergaard Knudsen et al. 2010; Benova et al. 2015; Ng & Loke 2015; Fuentes-López et al. 2017). Educational level was not associated with hearing aid use (Vestergaard Knudsen et al. 2010). Reviews by Vestergaard Knudsen et al. (2010) and Ng and Loke (2015) suggest that hearing sensitivity (indexed by pure-tone audiometry) was inconsistently associated with hearing aid use (Vestergaard Knudsen et al. 2010). Hearing aid use has also been associated with other biological factors such as tinnitus (Moon et al. 2015), as well as chronic illness and general health difficulties. Hearing aid use has not been consistently associated with demographic factors such as age, gender, socioeconomic status (Vestergaard Knudsen et al. 2010; Benova et al. 2015; Ng & Loke 2015; Fuentes-López et al. 2017). Educational level was not associated with hearing aid use (Vestergaard Knudsen et al. 2010). Reviews by Vestergaard Knudsen et al. (2010) and Ng and Loke (2015) suggest that hearing sensitivity (indexed by pure-tone audiometry) was inconsistently associated with hearing aid use (Vestergaard Knudsen et al. 2010). Hearing aid use has also been associated with other biological factors such as tinnitus (Moon et al. 2015), as well as chronic illness and...
general health problems including diabetes in men, lower body mass index (BMI) in women, osteoarthritis in men, and higher cognitive function in women (Fisher et al. 2015). Psychological factors associated with hearing aid use include acceptance of hearing loss and greater self-reported hearing difficulties (Vestergaard Knudsen et al. 2010; Ng & Loke 2015) and better self-reported health (Öberg et al. 2012). Participation in social activities (Fisher et al. 2015; Fuentes-López et al. 2017) and living situation (living alone versus living with others; Vestergaard Knudsen et al. 2010; Fuentes-López et al. 2017) were not associated with hearing aid use.

In previous studies, summarized in the reviews by Vestergaard Knudsen et al. (2010) and Ng and Loke (2015), researchers focused on a limited selection of correlates (Supplemental Digital Content, http://links.lww.com/EANDH/A502). Focusing on a subset of possible correlates of hearing aid use may give a misleading or incomplete impression of the significance of any one factor due to bias from omitted variables (Barreto & Howland 2005). The present study aimed to model biopsychosocial predictors of hearing aid use simultaneously. The UK Biobank data set is unique in size, inclusiveness, and the wide range of measures of biological, psychological, and social factors available, including data on hearing difficulty (based on performance on the Digit Triplet test) and hearing aid use. The aim was to model a wide range of candidate biological, psychological, and social correlates of hearing aid use in a cross-section of 18,730 adults with poor hearing.

MATERIALS AND METHODS

Participants
This research was conducted using the UK Biobank Resource. The UK Biobank was established to support investigations of genetic, lifestyle, and environmental causes of disease in middle and older age adults (Collins 2012). Potential participants were identified through National Health Service records and 9.2 million invitation letters were sent between 2006 and 2010. Data were obtained from 503,325 adults from the United Kingdom aged between 40 and 69 years, yielding a response rate of 5.47% (Collins 2012). The UK Biobank National Health Service North West Multi-centre Research Ethics Committee granted ethical approval. The present study focused on a subset of 18,730 of respondents aged 40 to 69 years with a hearing impairment. Hearing impairment was identified based on speech recognition in noise performance measured with the Digit Triplet test (Smits et al. 2004; see below).

Study Design • The study had a cross-sectional design. All participants attended a UK Biobank assessment center and provided written informed consent. Participants then completed a 90-min test battery that included a computerized questionnaire about biopsychosocial factors and hearing aid use. Participants also completed physical measures including the Digit Triplet test (Smits et al. 2004, described below). All UK biobank data are available to bona fide researchers and no additional data were obtained for this study.

Figure 1 presents a diagram illustrating selection of the study sample. From those who consented to take part, 145,968 participants completed the Digit Triplet Hearing test. Of those who complete the hearing test, further exclusion criteria were (1) performance on the hearing test within the normal range and (2) being aged outside the 40 to 69 years of age inclusion criteria.

Measures
Potential correlates of hearing aid use were identified based on reviews of previous studies and reviews (Hartley et al. 2010; Vestergaard Knudsen et al. 2010; Gopinath et al. 2011; Nash et al. 2013; Bainbridge & Ramachandran 2014; Fisher et al. 2015; Ng & Loke 2015; Fuentes-López et al. 2017). The potential correlates included were gender, age, ethnicity, socioeconomic status, education, objective hearing difficulty (average speech recognition threshold for the better ear), tinnitus, diabetes, osteoarthritis, cardiovascular disorder, long-standing illness, self-reported hearing difficulties and self-reported hearing difficulties in background noise, cognitive function, self-reported health status, number of social activities, and current living situation (Supplemental Digital Content, http://links.lww.com/EANDH/A502).
Higher National Certificate (HNC)” were categorized as “qualification post primary school.” Participants who responded “No education post primary school” were categorized as no qualification postelementary/primary school. Employment status was categorized as either “employed,” “retired,” “unemployed,” “student,” or “other.” Participants who selected “unable to work because of sickness or disability,” volunteer,” or “looking after home and/or family,” or “none of the above” were coded as “other.”

Biological Factors
Objective Hearing Difficulty, Tinnitus, Diabetes, Osteoarthritis, Cardiovascular Disorder, Long-Standing Illness, and BMI • Objective hearing difficulty was indexed by performance on the Digit Triplet test, a test of speech recognition in noise (Smits et al. 2004; Hall 2006). The Digit Triplet test is described in greater detail elsewhere (http://biobank.ctsu.ox.ac.uk/crystal/label.cgi?id=100026). Briefly, the Digit Triplet test involves the presentation of 15 sets of 3 spoken monosyllabic digits (e.g., 2-4-9) in a background of noise shaped to match the spectrum of the speech stimuli. To determine the 50% correct recognition threshold, the level of background noise varies contingent on correct identification of the digits. Stimuli are presented via circumaural headphones (Sennheiser HD-25). Each ear was tested separately with the order of testing randomized. The test time for both ears was approximately 4 minutes. Hearing aid users completed the test without wearing their hearing aid. The speech recognition threshold for each ear was taken as the mean signal to noise ratio of the last eight triplets. Hence, better performance corresponds to lower (more negative) scores. In the present study, hearing impairment was identified if the better ear speech recognition threshold was ≥−5.5 dB signal to noise ratio* consistent with previous studies (Smits et al. 2004; Hall 2006; Vlaming et al. 2011; Dawes et al. 2015).

Tinnitus was defined as participants reporting currently experiencing ringing or buzzing in their head, or in one or both ears that lasts for more than 5 minutes at a time. Diabetes was identified on the basis of self-reported type 1 or type 2 diabetes mellitus, or if participants stated that they were taking insulin for diabetes. Osteoarthritis was identified on the basis of self-reported osteoarthritis. Cardiovascular disorder was identified on the basis of self-reported cardiovascular problems, including angina, heart attack, heart failure, stroke, transient ischemic attack, intermittent claudication, arterial embolism, or deep venous thrombosis. Participants were asked “Do you have any long-standing illness, disability or infirmity?” (Yes/No). BMI was calculated by dividing participants’ weight by height squared (kg/m²).

Psychological Factors
Self-Reported Hearing Difficulties, Self-Reported Health, and Cognitive Function • Participants were asked “Do you have any difficulty with your hearing?” (Yes/No) and “In general how would you rate your overall health?” (Excellent/Good/Fair/Poor). An index of cognitive function was produced for all participants from a factor analysis of three cognitive tests: reaction time, fluid intelligence, and pairs matching (Dawes et al. 2015). The reaction time test involved presentation of two shapes and participants were asked to press a response button as quickly as possible when two matching shapes were presented. Reaction times to matching pairs were recorded in milliseconds. For the fluid intelligence test, participants had 2 minutes to complete 13 questions involving logic and reasoning. Each uncompleted question scored zero. The pairs matching test involved memorizing the positions of cards to select pairs of matching cards. The first round was arranged in a 2 × 3 matrix and the second round was arranged in a 3 × 4 matrix, participants were asked to match as many pairs as possible. Further information about the cognitive tests is available elsewhere (http://biobank.ctsu.ox.ac.uk/crystal/label.cgi?id=100026).

Social Factors
Living Alone and Number of Social Activities • Living alone was determined by the question “Including yourself, how many people are living together in your household?” Number of social activities was calculated from the sum of the responses to the question “Which of the following do you attend once a week or more often? (You can select more than one; sports club or gym, pub or social club, religious group, adult education class, other group activity).”

Data Analysis
Analyses were performed with IBM SPSS version 22. Descriptive statistics (frequencies, means, and Standard Deviations [SDs]) were calculated for participants’ biological, psychological, and social characteristics at baseline. t test and $\chi^2$ tests were conducted to explore differences between hearing aid and

* Performance poorer than 2 SDs below the mean in comparison to a normative sample of young normally hearing listeners (Dawes et al. 2014).
nonhearing aid users’ and the biopsychosocial factors. Backward stepwise multivariable logistic regressions were then used to model associations between hearing aid use and biopsychosocial correlates selected based on previous research. The backward stepwise method was selected due to the forward stepwise method being more likely to exclude variables involved in suppressor effects (Field 2013). The Nagelkerke $r^2$ statistic provides the total variance explained by the multivariable model.

Additional exploratory analyses were conducted to investigate associations between hearing aid use and ethnic subgroup based on subgroups described above (“demographic variables”). For a logistic regression, a minimum of 10 cases per variable is required (Concato et al. 1995; Peduzzi et al. 1996). The present study had 17 predictors so ethnic subgroups (e.g., Chinese and Bangladeshi) with less than n = 170 (the number of predictors x10) participants were excluded from all the analysis. The additional analyses involved logistic regression within ethnic subgroup and the variables identified as being statistically significantly associated with hearing aid use in the final backward stepwise multivariable logistic regressions (age, self-reported hearing difficulties, objective hearing difficulty, tinnitus, self-reported health, long-standing illness, and living with others) as predictor variables and hearing aid use as the outcome variable.

**RESULTS**

**Descriptive Analysis**

Among the subset of UK Biobank participants with hearing impairment, 1732 (9.25%) reported owning and using a hearing aid at baseline, with 16,963 nonhearing aid users (Supplemental Digital Content, http://links.lww.com/EANDH/A502). Hearing aid users were more likely to be older, retired, male, of higher socioeconomic status, lower educational level, have poorer hearing, higher BMI, and poorer self-reported health compared with nonusers. Hearing aid users were more likely to have a longstanding illness, tinnitus, arthritis, and cardiovascular disease compared with nonusers. Hearing aid users were likely to be involved in more social activities than nonusers.

**Inferential Analysis**

In the final multivariable logistic regression model for hearing aid use, factors positively associated with hearing aid use were older age, self-reported hearing difficulties, poorer hearing based on performance on the Digit Triple test, tinnitus, white ethnicity, long-standing illness, and living with others (Table 1). The Nagelkerke $r^2$ for the model was 0.37.

Self-reported hearing difficulties were the strongest correlate of hearing aid use (odds ratio [OR] = 110.69 [confidence interval = 65.12 to 188.16]). The ORs for other correlates ranged from 0.26 to 1.93. For each year of age, individuals were 5% more likely to use a hearing aid. In other words, controlling for objective hearing difficulty, individuals aged 69 years old were 145% more likely to use an aid compared with individuals aged 40 years old. Individuals from an ethnic minority background and individuals who live alone were 0.53 and 0.80 times less likely to use a hearing aid, respectively. Individuals with tinnitus or a long-standing illness were 43% and 97% more likely to use a hearing aid, respectively. Participants who reported fair health (but not good or poor health) had reduced odds of hearing aid use compared with those who reported excellent health. Socioeconomic status and number of social activities were not associated with hearing aid use.

The proportion of those who reported using a hearing aid was statistically significantly lower ($X^2 [7, N = 17,722] = 173.41, p < 0.001$) among people who reported ethnic minority background (Table 2). Indian, Caribbean, and African backgrounds were associated with reduced likelihood of hearing aid use compared with those who reported white British ethnic background (Table 2).

**TABLE 1. The ORs from the multivariable logistic model of hearing aid use**

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age*</td>
<td>1.05 (1.04–1.06)</td>
</tr>
<tr>
<td>Ethnicity (ethnic minority)*</td>
<td>0.53 (0.39–0.72)</td>
</tr>
<tr>
<td>Socioeconomic status (quartile 1 [most affluent])</td>
<td>-</td>
</tr>
<tr>
<td>Quartile 2</td>
<td>0.84 (0.70–1.00)</td>
</tr>
<tr>
<td>Quartile 3</td>
<td>1.05 (0.87–1.26)</td>
</tr>
<tr>
<td>Quartile 4 (most deprived)</td>
<td>0.90 (0.75–1.09)</td>
</tr>
<tr>
<td>Objective hearing difficulty (mean speech recognition threshold for better ear)*</td>
<td>1.17 (1.15–1.20)</td>
</tr>
<tr>
<td>Tinnitus (yes)*</td>
<td>1.43 (1.26–1.63)</td>
</tr>
<tr>
<td>Self-reported longstanding illness (yes)*</td>
<td>1.97 (1.71–2.28)</td>
</tr>
<tr>
<td>Self-reported hearing difficulties (yes)*</td>
<td>110.69 (65.12–188.16)</td>
</tr>
<tr>
<td>Self-reported health status (excellent)</td>
<td>-</td>
</tr>
<tr>
<td>Good</td>
<td>0.96 (0.77–1.19)</td>
</tr>
<tr>
<td>Fair †</td>
<td>0.70 (0.54–0.89)</td>
</tr>
<tr>
<td>Poor</td>
<td>0.78 (0.57–1.06)</td>
</tr>
<tr>
<td>Number of social activities</td>
<td>1.07 (0.99–1.15)</td>
</tr>
<tr>
<td>Lives alone (yes) †</td>
<td>0.80 (0.68–0.94)</td>
</tr>
</tbody>
</table>

† $p < 0.001.$  ‡ $p < 0.01.$  § $p < 0.05.$  CI, confidence interval; OR, odds ratio.

**TABLE 2. The percentage of hearing aid users for each ethnic subgroup and ORs from the final multivariable logistic model within ethnic subgroups**

<table>
<thead>
<tr>
<th>Ethnic subgroup</th>
<th>Proportion of Hearing Aid Users Within Each Ethnic Subgroup (%)</th>
<th>OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White British</td>
<td>13,743</td>
<td>11.0</td>
</tr>
<tr>
<td>White Irish</td>
<td>633</td>
<td>8.5</td>
</tr>
<tr>
<td>Other white</td>
<td>1074</td>
<td>5.6</td>
</tr>
<tr>
<td>Background</td>
<td>Indian†</td>
<td>848</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>Other Asian</td>
<td>487</td>
</tr>
<tr>
<td></td>
<td>background</td>
<td>Caribbean‡</td>
</tr>
<tr>
<td></td>
<td>African§</td>
<td>533</td>
</tr>
</tbody>
</table>

*OR from a logistic regression model including age, socioeconomic status, hearing level, tinnitus, self-reported longstanding illness, self-reported hearing difficulties, self-reported health status, and lives alone.

† $p < 0.01.$  ‡ $p < 0.001.$  § $p < 0.05.$  CI, confidence interval; OR, odds ratio.
DISCUSSION

The present study identified a range of biological, social, and psychological factors associated with hearing aid use in cross-sectional analysis with a large and diverse sample of UK adults. The study overcomes some of the limitations of previous studies by modeling a wide range of potential correlates of hearing aid use simultaneously.

Hearing Aid Use

Both self-reported hearing difficulties and objective hearing difficulty were associated with hearing aid use, consistent with previous research (Supplemental Digital Content, http://links.lww.com/EANDH/A502). In the present study, self-reported hearing loss and objective hearing difficulty had a weak positive relationship ($r = 0.16$). Individuals may not be aware of their hearing difficulties because age-related hearing loss has a gradual onset (Rabinowitz 2000). Moreover, they may perceive hearing difficulties as resulting from external factors. For example, a person with hearing impairment may attribute difficulty understanding spoken conversation to “mumbling” by others (Action on Hearing Loss n.d.). Healthcare professionals may need to identify hearing loss earlier through screening and work with patients to help them identify hearing difficulties attributable to a hearing impairment rather than external factors.

After controlling for objective hearing difficulty, older age was positively associated with greater hearing aid use, as reported in previous studies (although some studies reported no association with age; see Supplemental Digital Content, http://links.lww.com/EANDH/A502). Older age may be independently associated with greater hearing aid use because of social or psychological factors (e.g., negative attitudes and perceptions of hearing aids being “for old people” may present a barrier to hearing aid use by younger people). Alternatively, the association between age and hearing aid use may be due to residual confounding of age with objective hearing difficulties.

Individuals reporting ethnic minority backgrounds were less likely to use a hearing aid in line with previous studies in the United States (Tomita et al. 2001; Bainbridge & Ramachandran 2014). Additional studies conducted in the United States reported ethnicity was no longer associated with hearing aid use when education and income were taken into account (Lin et al. 2011; Nieman et al. 2016). However, in the United States, individuals from ethnic minority groups are more likely to have lower educational levels and lower income compared with the majority white population (Emmett & Francis 2015; Musu-Gillette et al. 2016). The lower use of hearing aids among minority groups in the United States may therefore be due to socioeconomic factors (Mamo et al. 2016). In the present study, socioeconomic status was not associated with hearing aid use. The lower odds of hearing aid use for individuals reporting an ethnic minority background in the United Kingdom may be explained by differences in accessing National Health Service services and cultural beliefs regarding hearing loss and the stigma of hearing aid use (Supplemental Digital Content, http://links.lww.com/EANDH/A502). Reduced uptake of services among ethnic minority groups may be due to a lack of awareness of the availability of services, knowledge of how to access services, and language barriers (Szczepura 2005; Scheppers et al. 2006; Fuentes-López et al. 2017). Lower hearing aid use among ethnic minority groups is of concern because of the negative consequences of hearing loss (Gopinath et al. 2009, 2012; Lin et al. 2013) and the increased likelihood of hearing impairment among people from ethnic minority groups in the United Kingdom (Dawes et al. 2015). The number of people with ethnic minority backgrounds in the United Kingdom is growing (Office for National Statistics 2012). There is therefore an urgent need to understand and address the reasons for low hearing aid use among ethnic minority groups in the United Kingdom.

Socioeconomic status and education were not associated with hearing aid use. Associations between socioeconomic status and education and hearing aid use in previous research are inconsistent. Studies conducted in New Zealand (Jerram & Purdy 2001) and in the United Kingdom (Benova et al. 2015) reported no association between socioeconomic status and hearing aid use, while other studies conducted in the United States (Bainbridge & Ramachandran 2014) and Finland (Lupsakko et al. 2005) reported that those from higher socioeconomic backgrounds were more likely to use a hearing aid than those from lower socioeconomic backgrounds. The discrepancy between studies could be due to the differences in health system and provision of hearing aids in the countries where those studies were carried out. Hearing aids are provided free in Finland, but hearing aid users have to buy batteries for their hearing aids, which was reported as a barrier to use (Lupsakko et al. 2005). In the United States, hearing aids cost an average of $2300 each (Anderson & Preditch 2016), and most health insurers do not cover the cost of hearing aids. The association between higher socioeconomic status and hearing aid use may only occur in countries with a significant financial cost attached to hearing aids (e.g., in the United States or Finland), with no association between socioeconomic status and hearing aid use in countries with comprehensive socially subsidized hearing care (e.g., New Zealand and the United Kingdom). A recent study by Fuentes-López et al. (2017) supported the suggestion that socioeconomic status is associated with use in countries with a significant financial cost but not in countries with subsidized hearing care. Fuentes-López et al. found that among individuals who were aware of a government program to assist with hearing healthcare costs, income was not associated with hearing aid use. Among individuals who were not aware of the assistance program, income was associated with hearing aid use.

Educational level was not associated with hearing aid use in the present study similar to previous studies (Supplemental Digital Content, http://links.lww.com/EANDH/A502). Popelka et al. (1998) found in the United States that higher educational level was associated with hearing aid use. However, Popelka et al. (1998) did not adjust for income level, so this may be because higher educational level relates to higher income levels, and income rather than educational level is the more important correlate of hearing aid use. Taking into account the patterns of association with socioeconomic status and education across studies, it seems that cost may be a more significant barrier to hearing aid use than educational level, in countries without socially subsidized hearing health care.

Living with others was positively associated with hearing aid use. Individuals who live alone may not have the social support to encourage them to seek help for their hearing (Brooks 1989; Kochkin 2007) or use a hearing aid (Erber et al. 1996; Carson 2005). Alternatively, individuals who live alone may be less aware of their hearing difficulties and therefore less likely to perceive a need for a hearing aid (Kochkin 2000). In
contrast to the general pattern of findings, Fuentes-López et al. (2017) found individuals who live with one or more persons were less likely to use hearing aids. Fuentes-López et al. did not explain why hearing aid use might be lower in individuals who lived with others. Other studies found that living arrangements were not correlated with hearing aid use (Hickson et al. 1986, 1999). However, these studies compared rates of hearing aid use among those living alone in the community versus those living in a nursing home. Hearing aid use is reported to be low in nursing homes (for reasons including hearing aids getting lost and staff not trained to support hearing aid users; Cohen-Mansfield & Taylor 2004), so rates of hearing aid use among those living alone and those living in nursing homes may be similarly low. On balance, living with others seems to be a correlate of hearing aid use, possibly due to the social support and the need to use a hearing aid that living with others provides.

Cognition was not associated with hearing aid use in the present study. This contradicts previous studies by Lupsakko et al. (2005) and Fisher et al. (2015) that reported an association between higher cognitive function and hearing aid use. Those with higher cognitive level may have had better insight into hearing difficulties and the decision making and problem-solving skills to support the process of obtaining and using a hearing aid. Alternatively, the associations between hearing aid use and cognitive ability may have been due to residual confounding with demographic factors. Hearing aid users tended to be from a more affluent socioeconomic background and have a higher educational background than nonusers, and socioeconomic position and educational background are associated with cognitive ability (Bennett et al. 2003; Koster et al. 2005). The discrepancy between Lupsakko et al. and Fisher et al. and the present study may be due to (1) more effective statistical control for demographic confounds and (2) a younger, still working, and generally more cognitively able sample (previous studies involved aids and perceived benefits from hearing aids have previously been implicated with hearing aid use (Vestergaard Knudsen et al. 2010; Ng & Loke 2015). The factors modeled in the present study accounted for 36% of the variance in hearing aid use among adults with poor hearing. Future studies may need to include attitudes and beliefs, in addition to the factors included in the present study, for a more complete account of the correlates of hearing aid use.

With respect to ethnicity, the small samples of each ethnic subgroup may not be representative of ethnic communities in the United Kingdom in general because individuals had to speak fluent English to take part in the study. The implication of this selection bias against ethnic minority groups is that the rates of hearing aid use among ethnic minority groups reported in the present study may be over-estimated. Some ethnic minority groups, including Chinese, Bangladeshi, and mixed race were not included in the analyses because of small numbers of people in some groups. The demographics of the UK Biobank sample are not reflective of the UK population (Fry et al. 2017). However, the size and inclusiveness of the sample means that the associations among demographic, lifestyle, and biological factors with health outcomes are reliable (Allen et al. 2012; Collins 2012). Additionally, the UK Biobank was designed to collect information and biological samples on a number of health-related topics rather than being specifically about hearing. Therefore, awareness or concern about hearing difficulties was unlikely to influence the decision to participate.

The large sample size of UK biobank facilitates statistical power to detect small effects. Although there was a statistically significant difference between users and nonusers in terms of BMI, and number of social activities, the effect sizes were small and therefore unlikely to be clinically significant.

The age of the UK Biobank sample is younger than those who typically seek help for hearing difficulties for the first time. The average age of those who consult their general practitioner about their hearing difficulties for the first time is 75 years old, and people seek help after having experienced hearing difficulties for an average of 15 to 20 years (Davis et al. 2007). This delay in seeking help is problematic; individuals who are fitted earlier gain more lifetime benefit (Davis et al. 2007; Vestergaard Knudsen et al. 2018). Understanding correlates of hearing aid use in adults under 75 years old may help address this problem. The present study focused on a sample of adults aged 40 to 69 years, and so offered potentially important insights into characteristics of “early adopters” of hearing aids.

Pure-tone audiometric threshold data were not available, so it was unknown if individuals identified with “poor hearing” on the basis of Digit Triplet test performance were eligible for a hearing aid based on standard audiometric criteria. However, the Digit Triplet test correlates highly with audiometric thresholds at population level ($r^2 = 0.77$, Smits et al. 2004) and is therefore a reliable indicator of poor hearing.

**CONCLUSIONS**

Individuals with self-reported hearing difficulties and individuals who lived with others were more likely to use a hearing aid. Interventions to promote hearing aid use may need to focus on the reasons for not recognizing hearing difficulties, and whether it would be possible to promote hearing aid use by addressing this lack of recognition. To address the communication needs of those least likely to use hearing aids, interventions to promote hearing aid use need to target younger individuals, those who live alone and those from an ethnic minority background.
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