Sociodemographic Variation in Life Expectancy with Hearing Impairment in the U.S.

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Short Abstract

Hearing impairment is an important public health problem, as its prevalence is expected to increase, and it is associated with negative consequences including depression, cognitive impairment, and poor physical functioning. However, little is known about social disparities in onset or transitions into and out of hearing impairment. Gender and race/ethnicity are associated with hearing impairment, but it is not known how long individuals can expect to live with or without hearing impairment. Occupational and environmental exposure to noise can cause hearing impairment, and have both been shown to vary by region of the U.S. However, research has not explored to what extent region matters to hearing impairment, or whether region of birth or current region of residence matters more. This study uses extended Bayesian multistate life table methods on a sample from the Health and Retirement Study to examine differences in hearing-impaired life expectancy by gender, race/ethnicity, and region.

Extended Abstract

Introduction

Hearing impairment is an important and growing public health problem (Ciorba et al. 2012; Looi et al. 2015). By 2025, it is expected to have a prevalence rate twice that of diabetes (Cederroth, Canlon and Langguth 2013), with 23% of adults aged 20 and older experiencing hearing impairment by 2060 (Goman, Reed and Lin 2017). This increase is due, in part, to an aging population (Wallhagen et al. 1997), increasing use of personal listening devices (Daniel 2007; Morata 2007), and noise-induced hearing injury and blast-related comorbidities from military service (Helfer et al. 2011). The consequences of hearing impairment are substantial. Hearing impairment is associated with depression (West 2017), dementia (Lin et al. 2011b), cognitive impairment (Lin et al. 2011a), increased falls (Lin and Ferrucci 2012; Viljanen et al. 2009), and poorer physical functioning (Chen et al. 2015; Dalton et al. 2003).

Yet despite the ubiquity of hearing loss and its known consequences, little is known about social disparities in onset nor the extent to which individuals transition into and out of hearing impairment either due to the use of special equipment or recovery from temporary traumas. In fact, only one study to date has calculated expected years lived with hearing impairment. This study, based on an Australian sample, used multistate Markov models to calculate sensory life expectancies, or how long individuals could be expected to live with hearing impairment, vision impairment, or dual sensory impairment. The authors found that men aged 65 could expect to live 10.4 years with a hearing impairment while women could expect to live 12.9 years with a hearing impairment (Kiely et al. 2016).

Several demographic covariates may be important to consider in understanding sensory-impaired life expectancy. For example, gender and racial/ethnic differences in hearing impairment may play a role. Hearing loss prevalence varies across gender and racial/ethnic, with males and whites experiencing a disproportionate burden of hearing loss (Agrawal, Platz and Niparko 2008). Another demographic variable that may influence hearing impairment is region of residence. Poor living conditions and inadequate access to medical treatment are associated with the development of ear infections, which can cause hearing impairment if untreated (Acuin 2004). Research finds regional variation in these factors such that people living in the south are less likely to access medical care (Lanska and Kryscio 1994) or have health insurance (Barnett and Vornovitsky 2016) compared to people living in other regions of the U.S.

The current study aims to expand research regarding sensory life expectancy by using longitudinal, nationally representative data from the U.S. Specifically, the study will use the Health and Retirement Study to estimate: 1) hearing impairment free life expectancy versus years expected to be lived with hearing impairment in the U.S., and 2) how demographic variables including gender, race/ethnicity, and region of residence influence hearing-impaired life expectancy.

Background

Gender and Racial/Ethnic Variation in Hearing

Gender and race/ethnicity may play important roles in hearing-impaired life expectancy. The prevalence of hearing impairment is higher among men than women, with some studies reporting that men have twice the prevalence of hearing impairment compared to women (Agrawal et al. 2008; Hoffman et al. 2017). Mechanisms that explain this association include that men are more likely to work in occupations that entail excessive noise exposure, including construction or manufacturing. Additionally, men are more likely to engage in recreational activities that expose them to loud noises, including using power tools, shooting firearms, and motorcycle riding (Lie et al. 2016). While this relationship is well-established, it is not known how long males and females can expect to live with or without hearing impairment.

In terms of race/ethnicity, epidemiologic studies have consistently reported that hearing loss prevalence varies by sub-group, with whites experiencing a disproportionate burden (Agrawal et al. 2008). Blacks experience lower rates of hearing impairment compared to whites, with the odds of hearing impairment ranging from 40-60% lower in blacks (Cooper 1994; Helzner et al. 2005; Lin et al. 2011d). More recent research reports that blacks are more likely to have their hearing tested while whites are more likely to wear hearing aids (Nieman et al. 2015), and other studies show that this is not reflective of differential socioeconomic status, but rather to some protective effect of black race (Lin et al. 2011c). One study examined whether skin color served as the mechanism between race and hearing and found that darker-skinned Hispanics had better hearing than lighter-skinned Hispanics, but that associations between darker skin and better hearing were not statistically significant in either blacks or whites (Lin et al. 2012).

Although blacks report better hearing, they are disproportionately exposed to factors that may harm their hearing. For example, blacks are more likely to work in jobs with the highest levels of workplace injury and disability, which places them at increased risk for noise-induced hearing loss (Seabury, Terp and Boden 2017). Specifically, blacks are more likely to be employed in more hazardous occupations (Murray 2003), such as laborers, fabricators, and machine operators, while non-Hispanic whites are more likely to be employed in professional or managerial occupations (Seabury et al. 2017). Moreover, recent research reveals disparities in environmental exposure to noise such that urban block groups comprised primarily of blacks or residents living in poverty are disproportionately exposed to noise pollution (Casey et al. 2017). Taken altogether, blacks experience numerous risk factors for developing hearing impairment, but research finds that they are less likely to have hearing impairment. Calculating hearing-impaired life expectancies by race/ethnicity may be important for understanding this discrepancy.

Regional Variation in Hearing

Hearing-impaired life expectancy could also vary by birth or current region. First, poor living conditions, including overcrowding, poor sanitation, poor housing, poor nutrition, and inadequate access to medical treatment, are associated with the development of otitis media (ear infections), which, if not treated, can cause hearing impairment (Acuin 2004). These factors vary by region, with those living in the south being less likely to access medical care (Lanska and Kryscio 1994) or have health insurance (Barnett and Vornovitsky 2016). While poor living conditions can influence health outcomes at any age, they may be more consequential at younger ages. Other components of an individual's region of birth that may influence the development of hearing impairment pertain to noise exposure. For example, among young people, the prevalence of hearing impairment is predicted to rise in part due to noise-damage caused by increasing use of personal listening devices (Daniel 2007; Morata 2007).

Second, current region of residence may be important because prolonged exposure to loud noises in an occupational setting is one cause of hearing loss among working-age adults. One study found that, compared to office workers, workers who were exposed to high levels of personal noise had significantly higher mean values of systolic blood pressure after a nine-year follow up (Chang et al. 2011). Noise-induced hearing injury and blast-related comorbidities from military service are cited as a major driver of the increasing prevalence of hearing impairment (Helfer et al. 2011). Military service varies by region, as individuals from the south are more likely to enlist in the military compared to other regions of the U.S., comprising 36.9% of enlistees in 2015 (Quester and Shuford 2017).

In addition to occupational noise, research has increasingly found that environmental noise is problematic for health. Studies of road and aircraft traffic noise reveal that median noise levels exhibit spatial patterns that disproportionately affect certain groups. Specifically, regions that are predominantly occupied by minorities or low-income individuals tend to experience the most noise exposure, while young people (less than 18) and older people (65+) are less subject to high noise exposure (Carrier, Apparicio and Séguin 2016; Casey et al. 2017; Nega et al. 2013). However, the low prevalence of children in high-noise block groups may be related to the fact that white residents with children may have the resources to avoid living in neighborhoods exposed to high traffic noise compared to minority residents with children (Nega et al. 2013).

Overall, there is evidence to suggest that there may be regional variation in hearing impairment. However, it is unclear to what extent region matters to hearing impairment, as well as whether region of birth or current region of residence plays a stronger role. The current study aims to address these questions by examining hearing-impaired life expectancy by both regional variables.

Methods

Sample

This study uses data from the Health and Retirement Study (HRS), a longitudinal, nationally representative survey of U.S. adults over the age of 50 and their spouses. The original core sample design of the HRS is a multi-stage area probability sample of households that has been conducted every two years since 1992. The HRS monitors changes in cognitive, physical, and functional health that are associated with aging. The core survey is asked of every participant in each survey wave and includes questions about income/wealth, family structure, health, employment, and retirement.

The core HRS is comprised of 37,495 individuals. The analytic sample for this study is restricted to individuals aged 50 and older and who were interviewed in the 1998 wave or were members of subsequent cohorts added after 1998. Only one individual per household is included in the sample. Individuals are also excluded from analysis if they were dropped by the HRS in any later wave or were missing on the key measures of interests.

Measures

Since auditory tests require expensive equipment, trained technicians, and strict controls on background noise (Bagai, Thavendiranathan and Detsky 2006), they are not usually feasible for assessing hearing impairment in community-based samples. Instead, the HRS employed two self-report questions to assess participants hearing impairment. First, participants were asked to report their use of a hearing aid (no=0, yes=1). Second, all participants were asked to rate their hearing (while wearing a hearing aid as usual) on a five-point scale from excellent (0) to poor (4). For this analysis, the variable is dichotomized into two states: no hearing impairment (excellent, very good, or good hearing) versus hearing impairment (fair or poor hearing). Previous research comparing self-rated measures of hearing impairment to pure tone audiometric testing reports good sensitivity and specificity between the two, indicating that self-rated hearing is a valid measure for estimating hearing impairment in population settings (Reuben et al. 1998; Sindhusake et al. 2001).

We include several covariates that capture demographic and socioeconomic status (SES) characteristics. Demographic variables include age (in years), sex (male/female), race/ethnicity (non-Hispanic white; non-Hispanic black; non-Hispanic other race; Hispanic), region (at both birth and time of interview: dummy variables for northeast, midwest, and west), and educational attainment. Finally, a dichotomous measure of hearing aid usage (1=use hearing aids) is included since hearing aid use can improve quality of life and reduce psychological distress (Corna et al. 2009; Mener et al. 2013).

Analytic Strategy

We generate multistate life tables to examine sociodemographic differences in remaining life to be spent with vs. without hearing impairment. Traditional multistate methods require population level data on transition rates between states. However, such data are often—as here—not available, and the traditional approach is limited in its ability to produce multistate life table estimates for subpopulations. Thus, we use a Bayesian method first developed by Lynch and Brown (2005) to handle two living states (plus death) but recently extended to handle multiple living states and unlimited numbers of covariates (Zang and Lynch 2018). The method involves (1) estimating a discrete time multinomial logit model with fixed and time-varying covariates, X (including age), and transitions between states over time intervals as the outcomes; (2) applying the parameter estimates to a desired covariate profile with a sequence of ages to obtain estimated age-specific transition probabilities; (3) assembling these transition probabilities into a sequence of transition probability matrices for multistate life table calculations; (4) producing multistate life tables using standard demographic methods.

In this paper, our states include (1) hearing unimpaired (H), (2) hearing impaired (I), and (3) dead (D), so that our multinomial logit model is five dimensional, with transition HH as the reference against which HI, HD, IH, IU, and ID transitions are compared. Figure 1 shows the state space for our study, along with the possible transitions. Age, sex, race/ethnicity, region of birth, current region, and education are the covariates predicting these. The parameter estimates are obtained via Gibbs sampling; after a run of the Gibbs sampler, we have *G=1000* sets of parameters. For each, we construct a sequence of age (x) specific 3-by-3 transition probability matrices, $\boldsymbol{P_x}$, by applying the inverse logit transformation to model predicted scores obtained by applying the parameter estimates to values to each covariate and incrementing age from 50-110.

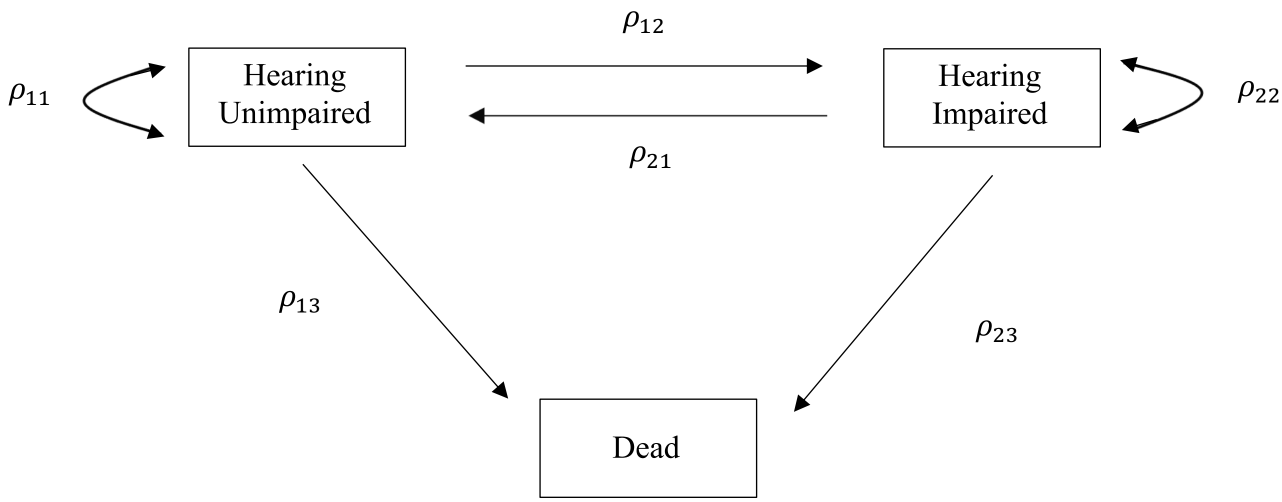
For computing the life tables, we establish a 1-by-2 radix vector, $\boldsymbol{l_0}$, of persons in hearing unimpaired and impaired states at age 50 and compute the life table using standard calculations (see Lynch and Brown 2005; Schoen 1988): (1) $\boldsymbol{l_{x+1} = l_x P_x}$, (2) $\boldsymbol{L_x = .5(l_x + l_{x+1})}$, (3) $\boldsymbol{T_x = \Sigma L_x}$, (3) $\boldsymbol{e_x = T_x / \Sigma l_x}$. Here, $\boldsymbol{l_x}$ is the vector of persons in each state at exact age x, $\boldsymbol{L_x}$ is the vector for persons years lived each state in the [x,x+1) age interval, $\boldsymbol{T_x}$ is the sum of all person years to be lived in each state at age x onward, $\boldsymbol{\Sigma l_x}$ is the total number of persons alive at x, regardless of state, and $\boldsymbol{e_x}$ is a vector of years to be lived in each state at age x.

We repeat this process for each of the G sets of parameters, thus obtaining 1,000 life tables for a given covariate profile (e.g., white men with 12 years of schooling who were born in the south and currently live in the west). State expectancy estimates are then sorted to produce empirical interval estimates for them. We repeat this entire process for other values of the covariates so that comparisons can be made across demographic subpopulations.

Results

Results for this paper are forthcoming as we are still finalizing the results from the extended Bayesian multistate life table methods. We will have full results within the next few weeks and a complete paper to follow.

Figure 1. State space used in multistate life table modeling.



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