Concept Paper Template 2018

Provisional Paper Title: Childhood hearing and life course health and environmental influences on hearing in mid-life

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Please describe your proposal in 2-3 pages with sufficient detail for helpful review.

Objective of the study:

Although it has been well documented that the cumulative prevalence of hearing impairment rises with age (Parving & Christensen, 1996; Russ, 2001; Russ et al., 2018), there is scarce evidence in the literature pertaining to longitudinal studies of hearing that have tracked the same individuals from childhood until adulthood.

Hearing ability is generally seen to be associated with ageing (Frisina, 2009; Howarth & Shone, 2006; Pronk et al., 2019), and so the majority of longitudinal studies focus on tracking individuals starting in young-mid adulthood and into their later years (Brant & Fozard, 1990; Cruickshanks et al., 2005; Davis, Ostri & Parving, 1991; Eisdorfer & Wilkie, 1972; Gates et al., 1990; Karlsmose et al., 2005; Lee et al., 2005).

For example, the Framingham Heart Study measured hearing thresholds of a cohort (n=1662) aged 57-89 years, and did follow up testing six years later (Gates et al., 1990), and the longitudinal study of presbyacusis (age-related hearing loss) in South Carolina measured 188 individuals aged between 60 and 81 years (Lee et al., 2005). Cohorts such as the one from the Baltimore Longitudinal Study (n=813) tracked individuals only as young as 20 years (and as old as 95 years), for a period of 20 years (Brant & Fozard, 1990); the Maastricht Aging Study cohort (n=1721) tracked individuals aged between 21-84 years across 12 years (Linssen et al., 2014); and one study from a rural Danish population tracked individuals aged between 31 and 50 years across 5 years (Karlsmose et al., 2005).

The onset of hearing loss is gradual and subtle, most commonly first affecting the detection of high-pitched sounds and with difficulty understanding speech in noisy but not in quiet environments (Davis et al., 2016). Acquired hearing impairment in adulthood is associated with numerous health issues, including depression, poorer balance, falls, hospitalizations, and early mortality, as well as social implications, such as social isolation, loss of autonomy, impaired driving ability, and financial decline (review, Davis et al. 2016). There is also evidence of associated increased rates of cognitive decline and risk of cognitive impairment (Lin et al., 2013), and there is some evidence that hearing treatments may ameliorate this decline (Acar et al., 2011; Maharani et al., 2018; Sarant et al., 2020). Increase in self-reported hearing handicap and communication difficulties (Dalton et al., 2003) are likely, in part, to be due to worsened speech-in-noise perception (Dubno et al., 1984). In a middle-aged cohort of 40-69 year olds (UK Biobank, n=164,770) a combined prevalence of significant hearing impairment and the (unpleasant, and sometimes debilitating) perception of tinnitus was 27.6% (Dawes et al., 2014), indicating that a deterioration in hearing ability and its consequences begin to emerge in mid-life rather than late-life.

In contrast to the literature around hearing and ageing, studies at other end of the age spectrum has focused on the longitudinal study of childhood ear health with its associated consequences through to adolescence, including hearing impairment (Bennett et al., 2001; Sorri et al., 1995), and auditory processing (Gravel et al., 1996; Klausen et al., 2000), behavioural (Bennett et al., 2001; Silva et al., 1986; Welch & Dawes, 2007), and educational (Bennett et al, 2001; Klausen et al., 2000; Schilder et al., 1993; Silva et al., 1986; Welch & Dawes, 2007; Williams & Jacobs, 2009) difficulties.

Only a handful of studies have made the link between childhood and adult hearing abilities within the same cohort, as these are usually considered and studied as separate issues (Russ et al., 2018). However, one example of an exceptional effort came from the HUNT Study, which measured the hearing of 32,786 children at primary school, and then again in the same individuals at ages ranging from 20-56 years (Aarhus et al., 2015). Hearing loss associated with recurrent ear disease in childhood showed subsequent negative associations with hearing ability in mid-adulthood (but not young adulthood), and marginally increased the risk of developing adult hearing loss - deterioration of 1.1dB per year in hearing thresholds, 95% CI 0.7-1.6, for chronic middle ear infections; and deterioration of 0.9 dB per year in hearing thresholds, 95% CI 0.2-1.7, for acute middle ear infections). Given this evidence, as well as the documented consequences of impaired hearing at both ends of the age-spectrum, our understanding of changes in hearing ability across the lifespan and the consequences of poor hearing will be enhanced by research that simultaneously considers age-, hearing-, lifestyle-, cognitive-, and psychosocial-related changes.

The Dunedin Study provides a unique opportunity to document the progression of ear health, hearing ability, and an array of life course factors from the same large number of individuals over 40 years. In line with the Life-Course Health Development model (Halfon & Forrest, 2017), we believe that the rich data set from the Dunedin Study provides a comprehensive array of relevant variables which, when included in the model (see figure below from Russ et al., 2018), will be able to shed light on the influences of protective and risky biological and environmental factors on trajectories of hearing health.

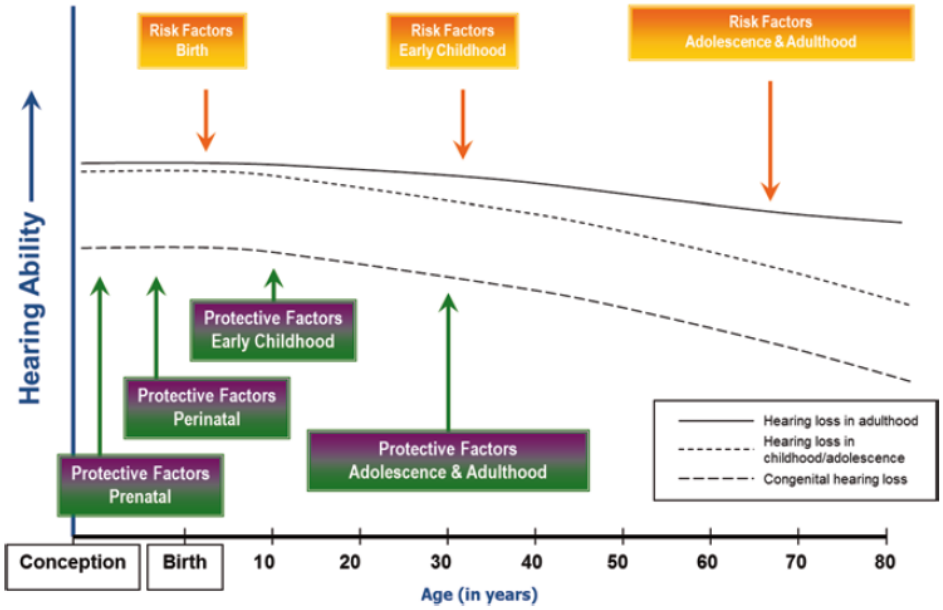

Fig. 1 Hearing loss trajectories

This paper will aim to address the following objectives:

Objective 1: use childhood data (ages 3, 5, 7, 9, 11, 13 and 15) on - pure-tone hearing thresholds, otological status (presence of otitis media), and speech processing in noise - to form derived measures of "childhood hearing" variables.

Objective 2: explore the association between childhood hearing variables and hearing ability at age 45. Most data/studies are concerned with "clinical" hearing loss, whereas we would like to focus our question on hearing ability which may still sit within the normal range in mid-life, but could potentially branch off into different trajectories of age-related hearing impairment as the cohort gets older. Investigating this would indicate the proportional influence of early hearing status on hearing in later life.

Objective 3: explore the effects of life course factors (health indices and environmental influences) on the association between childhood and mid-life hearing ability, and would be the precursor to future data collection phases and papers defining the trajectory of age-related hearing loss and its consequences.

Data analysis methods:

Objective 1:

a) Obtain/create derived variables of "childhood hearing" – pure-tone audiometry, otological status, and speech-in-noise processing.
b) Obtain/create derived variables of adulthood lifestyle factors – metabolic syndrome, and occupational noise exposure.

Objective 2:

a) Conduct multivariate regression analyses to investigate associations between childhood hearing variables and age 45 hearing ability.

Objective 3:

a) Add additional life course factors (health indices and environmental influences) to the multivariate regression model to investigate whether the influences of other biological and environmental factors change the significant associations identified in Objective 2.

Variables needed at which ages:

- Sex
- Pure-tone audiometric thresholds (both ears) at low-mid frequencies 0.5, 1, 2, and 4 kHz – P5, 7, 9, 11, 45; and at high frequencies 8 and 12.5 kHz – P45
- Otological status (Bennett et al., 2001; Welch & Dawes, 2007)
- Tympanometric data (both ears) for curve type, pressure, and middle ear compliance – P45
- Ipsilateral acoustic reflexes (both ears) for 1 kHz – P45
- Speech-in-noise (SPIN) results – P11 and P13
- Digits triplets in noise (UCAST) thresholds – P45
- Listening in spatialized noise sentences test scores– P45
- Subjective hearing questionnaire self-ratings – P45
- Perinatal complication score
- Childhood BMI (pre-derived)
- Childhood systolic and diastolic blood pressure (pre-derived)
- Childhood SES (pre-derived)
- Childhood IQ (pre-derived)
- Adult Metabolic Syndrome criteria – P38 and P45

- Adult SES – P45
- Adult IQ – P45
- Highest education attainment – P38, 45
- Cumulative lifetime smoking – pre-derived up to P45
- Use/discharge of firearms – P21
- Occupational codes – P45
- Exposure to loud noise at work question – P45

References that guided our request for variables include: Dawes et al., 2014; Helzner et al., 2005; Howarth & Shone, 2006; Linssen et al., 2019; Russ et al., 2018; Thorne et al., 2011; Yamasoba et al., 2013

Significance of the Study (for theory, research methods or clinical practice):

The goal is to gain a better understanding of hearing ability trajectories, and what early-life ear health and life course factors can influence its development. The Dunedin dataset is one of few, if not the only, that documents hearing data from the same individuals over a 40-year period.

This knowledge may lead to the potential derivation of a sensory-based (auditory, vision, balance) measure of the quantification of ageing, similar to the biological one derived by Belsky and colleagues (2015). The aim would be to apply the "formula" to predict ageing trajectories, identify sensory risk factors, and use this information to advocate for corrective interventions as early as possible.

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