Author(s): Välimaa, Maija; Koivunen, Kaisa; Viljanen, Anne; Rantanen, Taina; von Bonsdorff, Mikaela

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Cohort comparison of vision and hearing in 75- and 80-year-old men and women born 28 years apart

Maija Välimaa [a,*], Kaisa Koivunen [a], Anne Viljanen [a], Taina Rantanen [a], Mikaela von Bonsdorff [a,b]

[a] Faculty of Sport and Health Sciences, and Gerontology Research Center, University of Jyväskylä, PL 35, Jyväskylä 40014, Finland
[b] Folkhälsan Research Center, Helsinki, Finland

HIGHLIGHTS

- Currently older people have better visual acuity and a lower prevalence of visual impairment compared to their counterparts born 28 years earlier.
- Cohort differences in hearing were less pronounced, with only men of the later-born cohort showing improved hearing.
- The improvements are probably attributable to the more advantageous living conditions experienced by the later-born cohort.

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ABSTRACT

Purpose: We compared the vision and hearing of older men and women born 28 years apart. In addition, we explored factors explaining the possible cohort differences.
Methods: Two independent cohorts of 75- and 80-year-old men and women were assessed as a part of the Evergreen study in 1989–1990 (n = 500) and the Evergreen II study in 2017–2018 (n = 726). Studies were conducted with similar protocols, and differences between cohorts were compared for distance visual acuity and hearing acuity. We also studied whether educational level and health factors (i.e. total cholesterol, blood pressure, BMI, and smoking status) underlie the possible cohort differences. Independent samples t-test, Pearson chi-squared test, and linear regression analyses were used as statistical analyses.
Results: Across age and sex groups, the later-born cohort had better visual acuity and a lower prevalence of visual impairment compared to the earlier-born cohort. In hearing, 75-year-old men in the later-born cohort had better hearing acuity, with average hearing level at 32 dB compared to 36 dB in the earlier-born cohort, and 80-year-old men had a lower prevalence of moderate or worse hearing loss (74 % vs. 54 %) than men in the earlier-born cohort. Similar differences were not observed for women. The cohort differences in distance visual acuity and hearing acuity attenuated when adjusting for education level.
Conclusions: Today older adults retain better vision longer than before, but cohort differences in hearing are less obvious. Differences between cohorts may be partly due to advances in education.

1. Introduction

Vision and hearing impairments are common in older people (Killeen et al., 2023; Reed et al., 2023), and are among the most significant factors contributing to years lived with disability (GBD 2019 Ageing Collaborators, 2022). Several studies have shown that older people with vision or hearing impairments are more likely to have difficulties in activities of daily living (Chen et al., 2015; Crews & Campbell, 2004; Mikkola et al., 2015; Taipale et al., 2019), which often rely on visual and auditory cues. Moreover, poor vision and hearing have a profound influence on older people's everyday living that extends far beyond activities of daily living. Sensory impairments have been linked to mobility limitations (Mikkola et al., 2015; Kulmala et al., 2012; Tareque et al., 2019; Viljanen et al., 2009b), and cognitive difficulties (Chen et al., 2017; Lin et al., 2011; Lin et al., 2004), as well as increased risk of falls (Viljanen et al., 2009a; Kulmala et al., 2008; Gopinath et al., 2016), and mortality (Ehrlich et al., 2021; Genther et al., 2015; Feng et al., 2022). Moreover, when both vision and hearing impairment occur together the

* Corresponding author.
E-mail address: maija.mv.valimaa@jyu.fi (M. Välimaa).

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risk of functional decline might be further elevated (Bouscaren et al., 2019; Armstrong et al., 2022; Phillips et al., 2022). As such, losses in vision and hearing place a heavy burden on societies and individuals.

During the past few decades, several changes in education, occupational safety, health care, and medicine have shaped people's life course (Drewelies et al., 2019). These advances may also have reduced exposure to individual and environmental risk factors for sensory impairments, such as unhealthy lifestyles, chronic diseases, and environmental exposures, like UV radiation and noise exposure (Yang et al., 2023; Sacca et al., 2009). According to recent cohort comparisons, older people today have better physical, mental, and cognitive functioning than previously (Kekäläinen et al., 2023; Koivunen et al., 2021; Munukka et al., 2021), suggesting that longer life is accompanied by better age-specific functional ability. However, existing literature presents inconsistent findings regarding the cohort differences in vision and hearing among older people. Studies from Europe indicate that current older men and women have better vision than previously (Delcourt et al., 2018; Purola et al., 2024), whereas studies from the US and China did not find significant cohort differences or report even an increased prevalence of visual impairment (Ko et al., 2012; Luo et al., 2022). In terms of hearing, previous research from the US and Europe indicates that the hearing of current older men is better than previously (Hoff et al., 2018; Hoffman et al., 2012), while the findings for women are contrary (Göthberg et al., 2020; Homans et al., 2017).

These inconsistent findings underscore the need for future research on cohort differences in vision and hearing in older people. Moreover, the mechanisms underlying the cohort differences have been hardly studied. To address this gap, this study aims to explore the cohort differences in vision and hearing among older adults born almost three decades apart, while also examining factors explaining the possible cohort differences.

2. Methods

2.1. Study population and recruitment

This study uses data from two population-based research projects, Evergreen, and Evergreen II, conducted at the University of Jyväskylä, Finland. Evergreen data were collected in 1989–1990 (Heikkinen, 1998), and Evergreen II in 2017–2018 as part of the *Active Aging – Resilience and external support as modifiers of disablement outcome* (AGNES) study (Rantanen et al., 2018). Samples in both datasets were drawn from the Finnish Population register based on birth year and place of residence. All community-dwelling 75- and 80-year-old men and women living in the city of Jyväskylä formed the target population. Participants of the Evergreen cohort were born in 1910 and 1914 and of the Evergreen II cohort in 1938–1939 and 1942–1943 (Heikkinen, 1998; Rantanen et al., 2018).

The recruitment procedures of the Evergreen and Evergreen II studies were comparable, and are described in more detail in the study protocols (Heikkinen, 1998; Rantanen et al., 2018) and prior cohort comparisons (Kekäläinen et al., 2023; Koivunen et al., 2021; Munukka et al., 2021). Briefly, in the Evergreen study, all community-living 75- and 80-year-old adults received an information letter about the study suggesting a time for the at-home interview and an examination at the research center. Of the eligible ($n = 652$) participants, 77 % ($n = 500$) participated both in the at-home interview and the examination in the laboratory, and of whom 98 % had data on outcome measures, except for visual acuity (86 %). In the Evergreen II project, participants were sent an information letter about the study along with a scheduled phone interview. During the phone interview for those willing to participate, the at-home interview and physical examination were scheduled. A postal questionnaire assessing lifestyle, physical activity, functional status, and quality of life was sent with the information letter. Of the eligible ($n = 1835$) participants 40 % ($n = 726$) participated both in the at-home interview and an examination at the laboratory, with 99 % of whom had data available on outcome measures. Due to the differences in the participation rates, the non-participants were compared between the cohorts to ensure their comparability. The non-participants in both cohorts were similar in terms of self-rated health and the reasons for non-participation (Koivunen et al., 2021). Reasons for non-participation were poor health (Evergreen 23 % ($n = 35$); Evergreen II 17 % ($n = 192$)), lack of interest (Evergreen 40% ($n = 60$); Evergreen II 48 % ($n = 527$)) and other unknown reasons (Evergreen 38 % ($n = 57$); Evergreen II 35 % ($n = 390$)). The results did not differ when analyses were carried out separately for sex and age groups (Koivunen et al., 2021).

2.2. Variables

2.2.1. Vision

The vision testing included a distance visual acuity measurement at the research center assessed with the Illuminated Landolt ring decimal chart (Oculus 4512) at a 5-m distance with current visual correction. Row-by-row scoring was used, and all values were presented in Snellen decimal equivalents ranging from 0.125 to 2.0 (Kulmala et al., 2008; Rantanen et al., 2018), where a higher value indicates better visual acuity. In the Evergreen cohort, visual acuity was measured separately for the left and right eye, and the better eye visual acuity was used. In the Evergreen II cohort, visual acuity was measured simultaneously for both eyes. For the analyses, presenting visual acuity was classified according to WHO's recommendations as: Normal vision (VA ≥ 0.5), Mild vision loss (VA < 0.5 to ≥ 0.3), and Moderate or worse vision loss (VA < 0.3) (World Health Organization, 2019). During the home interview, the near vision was assessed by a self-rated question evaluating whether the participant could read a normal newspaper with current visual correction. The answers were categorized as 1. Without difficulty, 2. With some difficulty, and 3. With a great deal of difficulty or not at all.

2.2.2. Hearing

The hearing protocol consisted of pure-tone air conduction testing for each ear separately at frequencies of 0.125, 0.25, 0.5, 1, 2, 4, and 8 kHz. In the Evergreen study, hearing acuity was measured with a clinical audiometer (Madsen OB 822 with TDH 39 headphones) with a maximum intensity of 120 dB in the sound-proof chamber by an audiologist or trained research assistant at the research center. Before testing, the audiometer was calibrated according to the ISO 389 standard (Hietanen et al., 2004). In the Evergreen II study, hearing was measured with a screening audiometer (Oscilla USB-330, Inmedico A/S, Denmark with Peltor H7A headphones) with a maximum intensity of 95 dB in a quiet office room by a trained research assistant (Rantanen et al., 2018). The Hughson-Westlake protocol was used in the measurements. If the pure-tone threshold could not be heard at a given frequency, a value of 130 dB was given, as recommended by the British Society of Audiology (British Society of Audiology, 2018). Since the maximum test values differed between cohorts, all values above 95 dB were coded to 130 dB in both cohorts to make data comparable, resulting in 13.5 % ($n = 66$) of the Evergreen cohort and 15.1 % ($n = 109$) of the Evergreen II cohort having at least one value coded as 130 dB in the better or worse ear.

For the cohort comparisons, the better ear (BE) and worse ear (WE) hearing thresholds were determined by the pure-tone average over frequencies of 0.5–4 kHz ($PTA_{0.5\text{–}4\ kHz}$), where a higher value indicates worse hearing. Hearing acuity was defined as BE $PTA_{0.5\text{–}4\ kHz}$ and used to classify hearing impairment according to the WHO's recommendation as: Normal hearing (< 20 dB HL), Mild hearing loss (≥ 20 to < 35 dB HL), and Moderate or worse hearing loss (≥ 35 dB HL) (World Health Organization, 2021). In the at-home interview, hearing was assessed by asking whether the participant could hear a normal conversation with three or more persons with or without hearing aids. The responses were categorized as 1. Without difficulty, 2. With some difficulty, and 3. With a great deal of difficulty or not at all.

2.2.3. Dual sensory loss

Dual sensory loss was defined based on the WHO's recommendations for vision and hearing impairment and the classification used previously (Phillips et al., 2022). For analyses, the dual sensory variable was categorized as three-level: 1. No sensory loss, 2. Singel sensory loss, if the participant had either vision or hearing loss, and 3. Dual sensory loss, if the participant had both vision and hearing loss. Visual impairment was defined as presenting VA <0.5 and hearing impairment as better ear $PTA_{0.5–4\ kHz} \geq 20$ dB HL.

2.2.4. Covariates

To study the potential factors underlying the cohort differences, we chose covariates that theoretically can be part of the mechanism leading to differences between the cohorts. Educational level is associated with sensory functions (Killeen et al., 2023; Reed et al., 2023) and self-reported years of full-time education assessed in the home interview were used as a covariate. Health factors such as high total cholesterol, blood pressure, body mass index (BMI), and smoking status are also associated with vision and hearing loss and were used as covariates (Yang et al., 2023; Sacca et al., 2009). During the health examination in the laboratory total cholesterol was drawn from blood samples, systolic and diastolic blood pressure values were obtained from the resting phase of an orthostatic test, and BMI was calculated from participants' weight and height (kg/m^2) (Heikkinen, 1998; Rantanen et al., 2018). In the analyses, total cholesterol, blood pressure, and BMI were used as continuous variables. Smoking status was assessed by self-report during the home interview in the Evergreen study and in the postal questionnaire prior to the home interview in the Evergreen II study. For analyses, smoking status was categorized as 0. Never smoked and, 1. Current or former smoker.

2.3. Statistical analyses

To compare the current and earlier cohorts, we used *t*-tests for continuous and Pearson chi-squared tests for categorical variables. Differences in the median BE and WE hearing thresholds were estimated with the Mann-Whitney *U* test. We tested whether the cohort difference varied according to age and sex by examining cohort-by-age and cohort-by-sex interaction terms in linear regression analysis comprising all participants.

We further tested factors explaining the potential cohort differences in a set of linear regression models. In the first model, visual acuity was placed as a dependent variable and the birth cohort as an independent variable in the model. Then several models were completed adding covariates one at a time, to study whether they attenuated the potential cohort differences. The final model included all covariates. The same procedure was performed for hearing acuity. In all regression analyses, the Evergreen cohort was used as a reference category. To increase the power, we also performed the hierarchical linear regression analysis in a similar manner with age groups combined and age included as a

Table 1

Descriptive statistics and cohort differences of 75- and 80-year-old men and women from the Evergreen and the Evergreen II cohorts.

	75-year-old					80-year-old				
	n	Evergreen 1989–1990	n	Evergreen II 2017–2018	*p*[a]	n	Evergreen 1989–1990	n	Evergreen II 2017–2018	*p*[a]
Men										
Years of education, m (sd)	102	6.2 (3.5)	182	12.2 (4.4)	**<0.001**	59	5.9 (4.1)	130	11.9 (4.4)	**<0.001**
Total cholesterol, m (sd)	104	6.0 (1.2)	183	4.9 (1.0)	**<0.001**	60	5.6 (1.0)	132	4.5 (1.1)	**<0.001**
Systolic blood pressure, m (sd)	103	154.7 (18.3)	183	146.1 (18.3)	**<0.001**	59	161.2 (28.6)	131	143 (17.3)	**<0.001**
Diastolic blood pressure, m (sd)	103	85.7 (9.3)	183	78.4 (6.8)	**<0.001**	59	82.2 (12.1)	131	76.2 (9.7)	**<0.001**
Body mass index, m (sd)	104	25.8 (3.6)	183	27.0 (4.3)	**0.021**	60	26.3 (3.8)	131	27.0 (4.1)	0.268
Current or former smoker, f (%)	97	64 (66.0)	182	95 (52.2)	**0.027**	57	38 (66.7)	128	56 (43.8)	**0.004**
Use of spectacles, f (%)	102		179			59		128		
No spectacles		3 (2.9)		5 (2.8)	**<0.001**		4 (6.8)		7 (5.5)	**<0.001**
Spectacles for nearsightedness		15 (14.7)		11 (6.1)			11 (18.6)		1 (0.8)	
Spectacles for farsightedness		0 (0.0)		51 (28.5)			2 (3.4)		38 (29.7)	
Both		84 (82.4)		112 (62.6)			42 (71.2)		82 (64.1)	
Uses hearing aid, f (%)	102	9 (8.8)	181	28 (11.5)	0.111	60	9 (15.0)	127	31 (24.4)	0.143
Women										
Years of education, m (sd)	189	6.1 (3.3)	249	12.1 (4.1)	**<0.001**	141	5.7 (3.2)	159	11.8 (6.2)	**<0.001**
Total cholesterol, m (sd)	188	6.9 (1.4)	250	5.4 (1.1)	**<0.001**	140	6.1 (1.0)	158	5.2 (1.1)	**<0.001**
Systolic blood pressure, m (sd)	191	160.1 (21.5)	249	151.0 (19.9)	**<0.001**	144	169.7 (29.5)	159	153.8 (20.3)	**<0.001**
Diastolic blood pressure, m (sd)	191	85.2 (9.8)	249	79.2 (8.8)	**<0.001**	144	85.5 (13.0)	159	78.8(10.5)	**<0.001**
Body mass index, m (sd)	191	27.8 (4.7)	251	28.0 (4.8)	0.757	145	26.7 (4.0)	159	27.9 (4.9)	**0.018**
Current or former smoker, f (%)	185	18 (9.7)	250	49 (19.6)	**0.005**	143	10 (7.0)	158	22 (13.9)	0.051
Use of spectacles, f (%)	183		246			145		157		
No spectacles,		3 (1.6)		3 (1.2)	**<0.001**		2 (1.4)		4 (2.5)	**<0.001**
Spectacles for nearsightedness		29 (15.8)		8 (3.3)			21 (14.5)		1 (0.6)	
Spectacles for farsightedness		6 (3.3)		45 (18.3)			7 (4.8)		35 (22.3)	
Both		145 (79.2)		190 (77.2)			115 (79.3)		117 (74.5)	
Uses hearing aid, f (%)	185	9 (4.9)	246	18 (7.3)	0.298	144	14 (9.7)	159	20 (12.6)	0.431

Notes: *m*=Mean; sd= Standard Deviation; *f*=Frequency

[a] = *t*-test for continuous variables and Pearson chi-squared test for categorical variables; Bolded p-value indicates statistically significant difference between cohorts

covariate in the model. These results are presented in the supplementary materials. All analyses were conducted with IBM SPSS Statistic version 28.0.11.

3. Results

Descriptive statistics are shown in Table 1. Men and women in the later-born cohort had higher educational levels, lower blood pressure, and lower total cholesterol levels compared to the earlier-born cohort. In the later-born cohort, men were less frequent, and women were more frequently current or former smokers than their counterparts in the earlier-born cohort. The increased use of spectacles in the later-born cohort was mainly driven by the more frequent use of spectacles for farsightedness, e.g. reading glasses.

3.1. Vision

Cohort comparisons of visual acuity, visual impairment, and difficulties in self-reported near vision are shown in Table 2. In regression analysis including all participants, the cohort-by-age interaction term for visual acuity was statistically significant ($p < 0.001$) while the cohort-by-sex interaction was not ($p = 0.084$), suggesting that in the later-born cohort, visual acuity improved more in the 75-year-olds than in the older age group, while the sex differences remained similar between cohorts. In terms of relative differences, the later-born cohort had better visual acuity across sex and age groups compared to the earlier-born cohort, with mean differences ranging from 0.2 to 0.5 decimals. The later-born cohort also had a smaller prevalence of mild and moderate or worse visual loss than the earlier-born cohort, except for 80-year-old men. The prevalence of moderate or worse visual loss decreased in 75-year-olds, from 19 % to 2 % in men and from 22 % to 2 % in women. For 80-year-old women, the prevalence of moderate or worse visual loss decreased from 12 % to 3 %. Additionally, a smaller proportion of the later-born cohort perceived difficulties in near vision compared to the earlier-born cohort.

In the linear regression models, none of the selected factors fully explained the cohort differences (Table 3). However, higher educational levels attenuated cohort differences the most, reducing the difference by about 15 %, except for 80-year-old men. The influence of health factors on the cohort differences was smaller. When all variables were included the cohort difference attenuated 15 % in 75-year-old men, 13 % in 75-year-old women, and 12 % in 80-year-old women. In Supplementary Table S1 (Table S1) when age groups were combined, the results remained similar. Visual acuity in the later-born cohort was 0.3 decimal better for men and 0.4 decimal for women. Higher educational levels attenuated the cohort differences the most, 10 % in men and 13 % in women.

3.2. Hearing

Fig. 1 illustrates the cohort differences in the median hearing thresholds for both BE and WE across measured frequencies. In the later-born cohort, 75-year-old men showed 5 dB lower (better) hearing thresholds at higher frequencies in both BE and WE compared to the earlier-born cohort. For 80-year-old men, the later-born cohort had a 5 dB lower hearing threshold in the BE only at 0.5 kHz. Conversely, the earlier-born cohort had median thresholds 5–10 dB lower at 0.25 kHz across both age groups. In women, the earlier-born cohort had approximately 5 dB lower hearing thresholds at 0.125, 0.25, and 2 kHz in BE in both age groups. At higher frequencies and in the WE, the thresholds overlapped between the cohorts. In 75-year-old women, the distribution of the hearing threshold at 0.125 kHz was slightly shifted toward lower decibels in the earlier-born cohort compared to the later-born cohort (mean rank 195.0 vs. 236.3, $p < 0.001$) explaining the significant cohort difference, even though the medians are same.

For hearing acuity, the cohort-by-age interaction-term was non-significant ($p = 0.736$), while the cohort-by-sex interaction showed significant interaction ($p = 0.005$) indicating that hearing improvement was pronounced in men compared to women. In Table 2, when analyzing the differences in hearing acuity, hearing impairment, and self-reported hearing difficulties, men in the later-born cohort had lower (better) hearing acuities compared to the earlier-born cohort. However, the difference was significant only in 75-year-old men, with mean difference of −3.9 dB. Additionally, 80-year-old men in the later-born cohort had a lower prevalence of hearing impairment than the earlier-born cohort, with moderate or worse hearing loss decreasing from 74 % to 54 %. Furthermore, a smaller proportion of the 80-year-old men in the later-born cohort reported hearing difficulties compared to the earlier-born cohort. Similar differences were not observed in women.

In the linear regression models for hearing acuity, the cohort differences became non-significant after including higher educational level and all covariates into the model (Table 4). Higher educational level explained 99 % and all covariates together explained 78 % of the observed cohort difference. When the age groups were combined, men in the later-born cohort had −3.7 dB lower hearing acuity than the earlier-born cohort, and similarly, including educational level and all covariates into the model the cohort differences became non-significant, decreasing by 71 % and 68 % (Supplementary Table S2).

3.3. Dual sensory loss

The later-born cohort had a smaller proportion of dual sensory impairments compared to the earlier-born cohort, except for 80-year-old men (Table 2). In 75-year-olds, the prevalence of dual sensory impairment decreased from 29 % to 6 % in men and from 40 % to 15 % in women. For 80-year-old women, the corresponding decrease in prevalence was from 32 % to 12 %. The majority of men and women in both cohorts still had at least one sensory impairment.

4. Discussion

Based on our results the vision of older men and women is better compared to same-aged individuals born 28 years earlier. The later-born cohort had better visual acuity and less visual impairments compared to the earlier-born cohort. In addition, a smaller proportion of the later-born cohort reported difficulties in near vision than the earlier-born cohort. For hearing, the cohort differences were less pronounced, and differences were observed only in men. In addition, the later-born cohort had fewer dual sensory impairments than the earlier-born cohort, likely due to improved vision in the later-born cohort. These changes may have important implications for other aspects of functioning, quality of life, and healthy aging.

Our findings are consistent with previous studies conducted in Europe (Purola et al., 2024; Delcourt et al., 2018) showing that besides reduced visual impairments, overall visual acuity has also improved in the later-born cohorts. Purola et al. (2024) measured distance and near visual acuities with current correction in Finland between 2000 and 2017, and while observing a decrease in the prevalence of impaired vision (VA<0.25) from 30 % to 7 %, they also reported that the prevalence of good vision (VA>1.0) increased from 6 % to 36 % among people aged 85 and older. Furthermore, fewer participants in the later-born cohort had near vision impairments than in the earlier-born cohort (Purola et al., 2024). In their meta-analysis, Delcourt et al. (2018) concluded that in people older than 55 years the prevalence of non-refractive visual impairment (VA<0.5) decreased from 2 % in 1991–2006 to 1 % in 2007–2012 in Europe. However, in the US the prevalence of nonrefractive visual impairment (VA<0.5) in people older than 60 years remained stable between 1999–2002 to 2005–2008 (Ko et al., 2012), and in China increased from 6 % in 1998 to 11 % in 2018 (Luo et al., 2022). The differences in findings across studies may stem from the different time intervals between cohorts, age groups studied, comparability of the cohorts, and ways of measuring visual acuity, but

Table 2
Cohort difference in vision and hearing of 75- and 80-year-old men and women from the Evergreen cohort and the Evergreen II cohort.

	Men						Women					
	75-year-old			80-year-old			75-year-old			80-year-old		
	Evergreen 1989–1990	Evergreen II 2017–2018	*p*[a]	Evergreen 1989–1990	Evergreen II 2017–2018	*p*[a]	Evergreen 1989–1990	Evergreen II 2017–2018	*p*[a]	Evergreen 1989–1990	Evergreen II 2017–2018	*p*[a]
Visual acuity, m (se)	0.6 (0.03)	1.0 (0.03)	**<0.001**	0.8 (0.05)	1.0 (0.03)	**0.003**	0.5 (0.02)	1.0 (0.02)	**<0.001**	0.6 (0.03)	0.9 (0.03)	**<0.001**
Visual impairment, f (%)												
Normal vision	56 (70.0)	171 (94.5)	**<0.001**	48 (85.7)	118 (89.4)	0.790	79 (55.2)	234 (93.2)	**<0.001**	99 (73.3)	140 (88.1)	**0.001**
Mild vision loss	9 (11.3)	6 (3.3)		6 (10.7)	10 (7.6)		32 (22.4)	13 (5.2)		20 (14.8)	15 (9.4)	
Moderate or worse vision loss	15 (18.8)	4 (2.2)		2 (3.6)	4 (3.0)		32 (22.4)	4 (1.6)		16 (11.9)	4 (2.5)	
Self-rated near vision, f (%)												
No difficulties	78 (75.0)	163 (90.1)	**0.002**	41 (68.3)	110 (85.3)	**0.016**	137 (71.7)	219 (89.0)	**<0.001**	93 (64.6)	137 (85.6)	**<0.001**
Some difficulties	17 (16.3)	14 (7.7)		16 (26.7)	18 (14.0)		43 (22.5)	25 (10.2)		29 (20.1)	18 (11.3)	
Severe difficulties	9 (8.7)	4 (2.2)		3 (5.0)	1 (0.8)		11 (5.8)	2 (0.8)		22 (15.3)	5 (3.1)	
Hearing acuity, m (se)	35.9 (1.4)	32.0 (0.9)	**0.007**	42.4 (1.9)	38.9 (1.4)	0.159	28.9 (0.9)	30.5 (0.7)	0.155	34.8 (1.1)	36.0 (1.0)	0.436
Hearing impairment, f (%)												
Normal hearing	7 (7.1)	25 (13.8)	0.184	1 (1.8)	5 (3.8)	**0.035**	36 (19.1)	32 (12.9)	0.196	14 (9.7)	11 (7.0)	0.286
Mild hearing loss	45 (45.9)	85 (47.0)		14 (24.6)	56 (42.2)		98 (52.1)	138 (55.4)		63 (43.4)	59 (37.3)	
Moderate or worse hearing loss	46 (46.9)	71 (39.2)		42 (73.7)	71 (53.8)		54 (28.7)	79 (31.7)		68 (46.9)	88 (55.7)	
Self-rated hearing, f (%)												
No difficulties	61 (59.8)	119 (65.7)	0.314	25 (41.7)	59 (45.7)	**0.028**	121 (64.4)	179 (72.2)	0.198	76 (52.8)	104 (65.0)	0.059
Some difficulties	39 (38.2)	55 (30.4)		23 (38.3)	61 (47.3)		59 (31.4)	59 (23.8)		58 (40.3)	51 (31.9)	
Severe difficulties	2 (2.0)	9 (7.0)		12 (20.0)	9 (7.0)		8 (4.3)	10 (4.0)		10 (6.9)	5 (3.1)	
Dual sensory impairment, f (%)												
No sensory loss	5 (6.5)	25 (14.0)	**<0.001**	1 (1.9)	4 (3.0)	0.731	16 (11.4)	30 (12.0)	**<0.001**	10 (7.4)	11 (7.0)	**<0.001**
Single sensory loss	50 (64.9)	144 (80.4)		46 (85.2)	115 (87.1)		68 (48.6)	204 (81.9)		93 (68.9)	127 (80.9)	
Dual sensory loss	22 (28.6)	10 (5.6)		7 (13.0)	13 (9.8)		56 (40.0)	15 (6.0)		32 (23.7)	19 (12.1)	

Notes: *m*=Mean; se=Standard Error; *f*=Frequency; Presenting visual acuity expressed in Snellen decimal equivalents where a higher value indicates better acuity; Visual impairment categorized as Normal vision (VA ≥ 0.5), Mild vision loss (VA < 0.5 to ≥ 0.3), and Moderate or worse vision loss (VA < 0.3) based on the presenting visual acuity; Hearing acuity measured as the better ear $PTA_{0.5–4\ kHz}$ where a higher value indicates worse hearing; Hearing impairment categorized according to the better ear $PTA_{0.5–4\ kHz}$ as Normal hearing (< 20 dB HL), Mild hearing loss (≥ 20 to < 35 dB HL), Moderate or worse hearing loss (≥ 35 dB HL).

[a] =Students' *t*-test for continues variables and Pearson chi-squared test for categorical variables; Bolded p-value indicates statistically significant difference between cohorts.

Table 3
Linear regression of the association between birth cohort and visual acuity.

	Men						Women					
	75-year-old			80-year-old			75-year-old			80-year-old		
	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2
Birth Cohort	0.432 (0.047)	**<0.001**	0.240	0.181 (0.061)	**0.003**	0.041	0.522 (0.034)	**<0.001**	0.375	0.261 (0.038)	**<0.001**	0.136
+ **Education**	0.364 (0.057)	**<0.001**	0.253	0.198 (0.071)	**0.006**	0.040	0.452 (0.044)	**<0.001**	0.385	0.220 (0.045)	**<0.001**	0.136
+ **Total cholesterol**	0.453 (0.053)	**<0.001**	0.240	0.213 (0.067)	**0.002**	0.042	0.520 (0.039)	**<0.001**	0.372	0.269 (0.042)	**<0.001**	0.134
+ **Blood pressure**	0.416 (0.051)	**<0.001**	0.241	0.168 (0.065)	**0.011**	0.042	0.527 (0.036)	**<0.001**	0.376	0.277 (0.040)	**<0.001**	0.151
+ **BMI**	0.437 (0.048)	**<0.001**	0.239	0.181 (0.061)	**0.003**	0.040	0.522 (0.034)	**<0.001**	0.374	0.257 (0.039)	**<0.001**	0.133
+ **Smoking**	0.436 (0.048)	**<0.001**	0.237	0.204 (0.064)	**0.002**	0.046	0.532 (0.035)	**<0.001**	0.377	0.258 (0.039)	**<0.001**	0.129
+ **All**	0.368 (0.068)	**<0.001**	0.244	0.233 (0.085)	**0.009**	0.052	0.454 (0.050)	**<0.001**	0.384	0.231 (0.051)	**<0.001**	0.128

Notes: β=Unstandardized beta indicates mean cohort differences (Evergreen cohort as a references group); SE=Standard Error; Adj R^2=Model Adjusted R; Each covariate was added in the model one at a time and all together in the final "All" model; Presenting visual acuity expressed in Snellen decimal equivalents where a higher value indicates better acuity.

they may also indicate that trends in vision vary between countries.

In terms of hearing, our results showed that 75-year-old men in the later-born cohort had about 5 dB lower hearing thresholds at higher frequencies and 3 dB lower hearing acuity, while 80-year-old men had a lower prevalence of hearing impairment. Although the older age group had similar differences in hearing thresholds and hearing acuity, the observed cohort differences did not reach statistical significance, which may be due to the small sample size. Overall our results suggest that current older men tend to have better hearing than earlier, and similar results have been obtained by Göthberg et al. (2020) and Homans et al. (2017). Comparing Swedish birth cohorts of 80-year-old people, Göthberg et al. (2020) found that men from the cohort born in 1930 had 5–10 dB better median thresholds compared to the cohort born in 1901–1902, and the prevalence of disabling hearing loss decreased from 67 % to 43 %. For women, the hearing thresholds, and the prevalence of disabling hearing loss (47 % vs. 45 %) did not differ. Similarly, Homans et al. (2017) compared the hearing thresholds at the frequency of 4 kHz in people older than 55 years and reported that only men had better hearing thresholds in the later-born cohort compared to cohorts born two to three decades earlier. In contrast, Hoff et al. (2018) examined Swedish birth cohorts of 70-year-olds and reported that men and women in the cohort born in 1930 had 5–20 dB better median hearing thresholds in several frequencies compared to the cohort born in 1901–1907. The prevalence of hearing impairment (PTA>25 dB HL) also decreased from 53 % to 28 % in men and from 37 % to 22 % in women (Hoff et al., 2018). In addition, Engdahl et al. (2020) report that the adult population in Norway in 2017 had better hearing thresholds at frequencies 0.5–8 kHz compared to same-aged individuals in 1996. They also found a decreased prevalence of disabling hearing loss (>35 dB HL) in men (32 % vs. 22 %) and women (19 % vs. 14 %) in the later-born cohort. Overall, studies suggest that men of the later-born cohorts have better hearing compared to the earlier-born cohorts, but in women the cohort differences are less obvious.

Several explanations can underlie the observed cohort differences. The Evergreen cohort was born when Finland was mainly an undeveloped and agricultural country. The earlier-born cohort lived through the Civil War in 1918 and as young adults, served in the Winter War (1939–1940), the Continuation War (1941–1944), and the Lapland War (1944–1945). The Evergreen II cohort probably had less exposure to deleterious risk factors as they were born towards the end of the wars and grew up during the period of reconstruction when Finland rapidly modernized.

Our results indicate that higher educational level mainly attenuated the cohort differences in vision and hearing. After the wars, access to education improved, especially in secondary and tertiary education (Breen et al., 2010), which is in line with the doubling of the years of education in our findings. In general, higher education is associated with a higher standard of living and better resources to take care of oneself coupled with healthy living habits. Higher education is also associated with white-collar jobs reflecting changes in the occupational structure, which might partly explain the cohort differences in hearing among men. When the earlier-born Evergreen cohort entered work life the main occupations in Finland were agriculture and manufacturing, where noise-induced hearing loss is common (Natarajan et al., 2023). During the period of modernization, the occupational structure changed focusing more on service professions with less noise exposure. In addition, the Occupational Health and Safety Act was implemented in 1930 and updated in 1958, and the use of hearing protection in noisy working environments was widespread between 1970–1980 (Toppila et al., 2005). Engdahl et al. (2021) also reported that lower noise exposure explained a greater proportion of the improved hearing among men than in women. Since hearing loss in men is more often characterized as noise-induced (Reavis et al., 2023; Dubno et al., 2013), the reduced occupational noise exposure has mainly benefited men and potentially accounts for the observed sex differences in hearing. For women, the risk of hearing loss is emphasized by different factors, such as cardiovascular health (Reavis et al., 2023; Dubno et al., 2013), and changes in the risk factors may have occurred to a lesser extent. Additionally, twin and family studies suggest that the heritability of age-related hearing loss is relatively high, around 35–75 % (Yang et al., 2023; Viljanen et al., 2007), and genetic susceptibility might have a more significant role in the deterioration of women's hearing.

In addition, during the reconstruction of Finland, more attention was paid to the health of the population. Health and healthy lifestyles were promoted through nutrition recommendations and national health promotion interventions such as the North Karelia project in the early 1970-century and the Public Health Act in 1972 (Prättälä, 2003). Enhanced health and healthier lifestyles might have positively influenced vision and hearing in older age as few of the health factors slightly attenuated the cohort differences. Some health factors, particularly total cholesterol, tended to increase the cohort differences, which may suggest a negative confounding (Mehio-Sibai et al., 2005). Furthermore, during the past decades, several reforms were also implemented in the healthcare system, enhancing access to care and advances in medical treatments, which may explain the observed cohort differences in vision, in particular. For instance, the Health Insurance Act of 1963 provided medical coverage for citizens, while the 2005 legislation of National Guaranteed Access to Healthcare ensured that medical procedures, like cataract surgeries, were carried out within six months from diagnosis. These changes may partly explain the increased number of cataract surgeries since the early 2000s in Finland (Purola et al., 2022a). Besides, the prevalence of several age-related eye diseases, such as macular degeneration and glaucoma, has decreased or at least the age of onset has postponed during the last four decades in Finland (Purola et al., 2023; Purola et al., 2022b; Vaajanen et al., 2022). We also observed more frequent use of spectacles in the later-born cohort, which may indicate better awareness of eye health and better access to vision services.

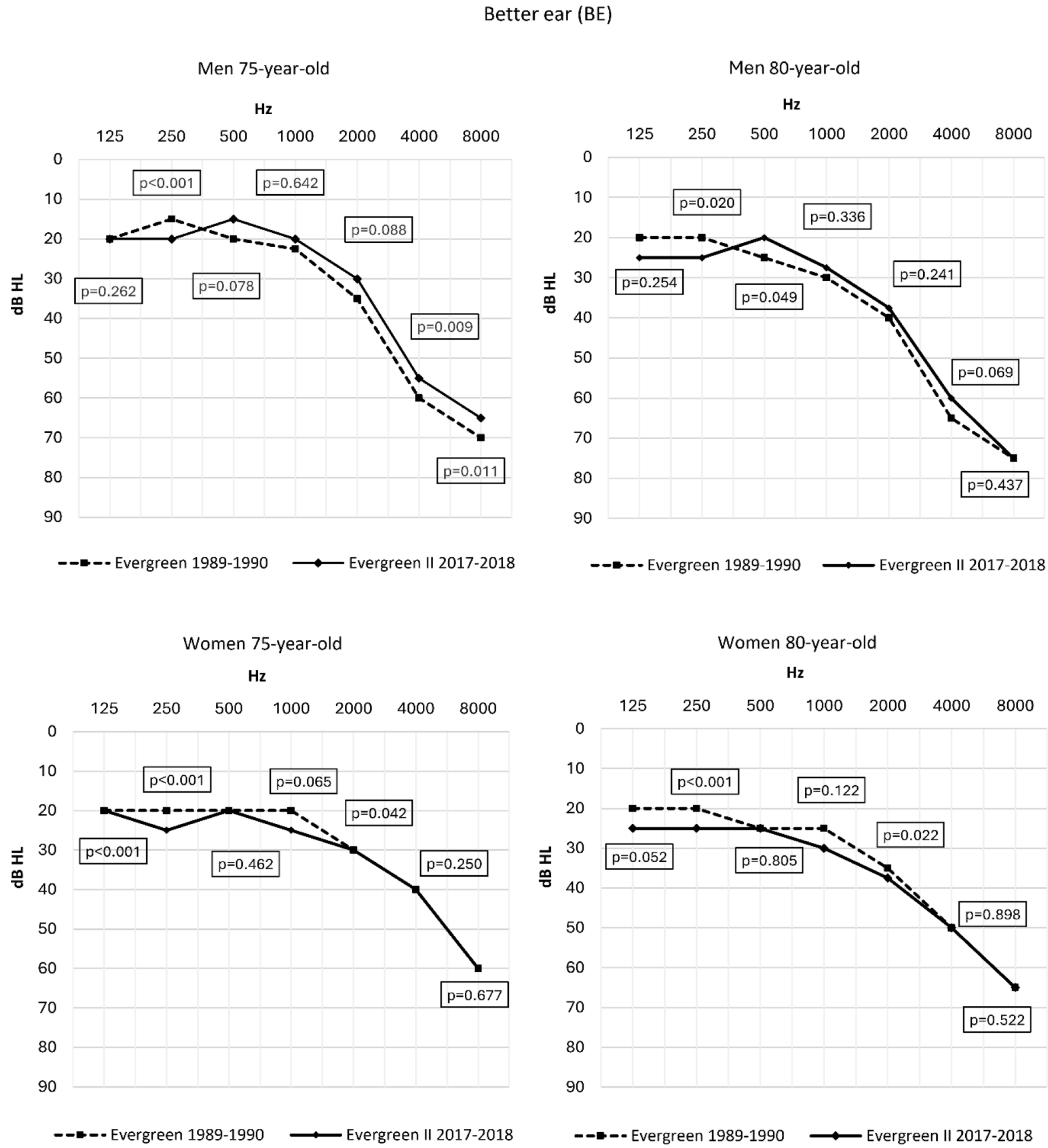

Fig. 1. Median hearing thresholds of 75-and 80-year-old men and women in the better and worse ear for measured frequencies. Birth cohort differences in median hearing thresholds were analyzed with the Mann-Whitney *U* test; p-values are shown for each frequency.

The strength of this study relies on the comparable population-based cohorts born 28 years apart. The recruitment procedures were identical and non-participants did not differ between cohorts according to self-rated health or reasons of non-participation (Koivunen et al., 2021). However, due to the smaller participation rate in the later-born cohort it is still possible that this cohort is a more selected and potentially healthier group. We cannot therefore completely rule out the possibility that selection bias explains some of the results. Another strength of this study is that besides sensory impairments we also studied cohort differences in visual and hearing acuity to understand the vision and hearing trends more comprehensively. Examining these variations can reveal how more subtle changes in vision and hearing, even in the absence of clinical impairment, might influence functioning and healthy aging. Furthermore, we also analyzed factors underlying the cohort differences which provides new insight into the existing literature. However, some limitations should be considered. In the earlier-born cohort, visual acuity was measured monocularly, and better eye visual acuity was used in the analyses. In the later-born cohort, acuity was measured binocularly. Previous studies comparing community-living older people show a high correlation between monocular and binocular acuities ($r = 0.93, p < 0.001$) (Schneck et al., 2010). In addition, the studies report that a higher proportion had equivalent acuities between monocular and binocular measurements, and only 15–20 % of participants showed better or worse binocular vision compared to better eye monocular vision. Although binocular acuity might be slightly advantageous to better eye monocular acuity, binocular summation, a condition where binocular acuity is better compared to monocular acuity, decreases with age (Rubin et al., 2000; Schneck et al., 2010; Azen et al.,

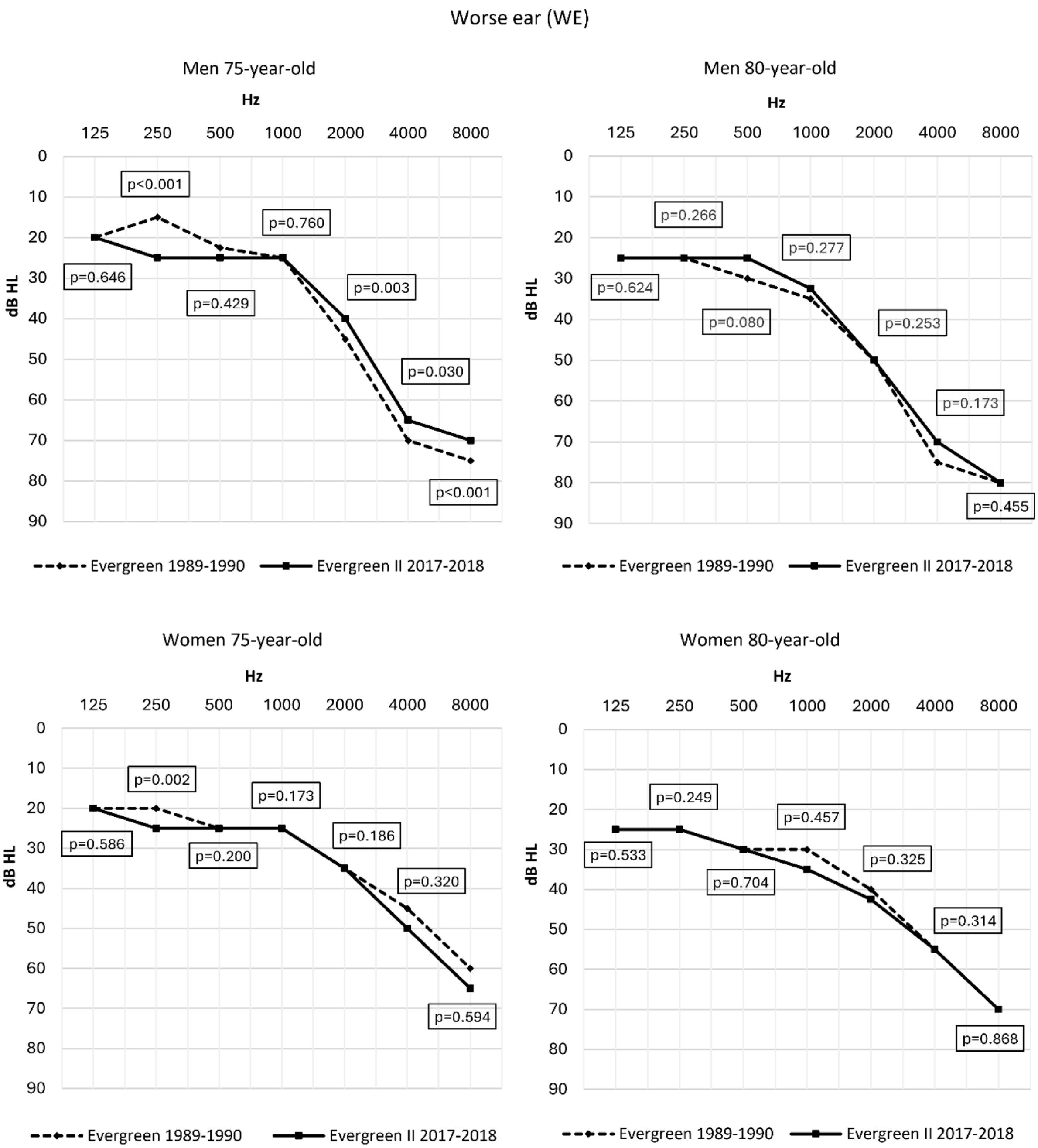

Fig. 1. (*continued*).

Table 4
Linear regression of the association between birth cohort and hearing acuity.

	Men						Women					
	75-year-old			80-year-old			75-year-old			80-year-old		
	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2	β (SE)	*p*	Adj R^2
Birth Cohort	−3.907 (1.578)	**0.014**	0.018	−3.448 (2.441)	0.159	0.005	1.609 (1.131)	0.155	0.002	1.160 (1.486)	0.436	−0.001
+ **Education**	−0.046 (1.872)	0.980	0.045	−2.421 (2.886)	0.403	0.003	2.510 (1.422)	0.078	0.003	2.949 (1.745)	0.092	0.007
+ **Total cholesterol**	−4.801 (1.785)	**0.008**	0.019	−1.485 (2.676)	0.580	0.016	1.515 (1.321)	0.252	0.000	0.905 (1.644)	0.582	−0.004
+ **Blood pressure**	−4.348 (1.712)	**0.012**	0.021	−4.265 (2.613)	0.104	0.004	1.567 (1.188)	0.188	−0.001	0.809 (1.581)	0.609	−0.003
+ **BMI**	−3.965 (1.601)	**0.014**	0.015	−3.462 (2.465)	0.162	0.000	1.589 (1.130)	0.160	0.004	1.118 (1.504)	0.458	−0.005
+ **Smoking**	−3.511 (1.625)	**0.032**	0.030	−3.779 (2.574)	0.144	0.002	1.254 (1.148)	0.275	0.008	1.129 (1.494)	0.450	−0.005
+ **All**	−0.856 (2.217)	0.700	0.059	−1.857 (3.428)	0.589	0.005	2.440 (1.617)	0.132	0.003	1.947 (1.995)	0.330	−0.002

Notes: β=Unstandardized beta indicates mean cohort differences (Evergreen cohort as a references group); SE=Standard Error; Adj R^2=Model Adjusted R; Each covariate was added in the model one at a time and all together in the final “All” model; Hearing acuity measured as the better ear $PTA_{0.5–4\ kHz}$ where a higher value indicates worse hearing acuity;.

2002), suggesting that the results are generally comparable between the two methods. There were slight differences also in the audiometry measurements. In the Evergreen cohort, hearing was measured manually in a sound booth chamber, and in the Evergreen II cohort, in a quiet office room with an automated test. Although automated pure-tone audiometry shows good agreement with manual audiometry, with automated thresholds falling within typical variability observed in manual thresholds (Mahomed et al., 2013; Hoff et al., 2023), it is possible that background noise during the hearing measurement may have led to worse hearing thresholds in the later-born cohort, especially at lower frequencies. The ambient noise might explain why the later-born cohort systematically had higher thresholds at 0.25 kHz (Storey et al., 2014; Maclennan-Smith et al., 2013). Unfortunately, comparable data on eye diseases was not available due to differences between cohorts in reporting diseases.

In conclusion, this study provides evidence that currently older people are living longer with better sensory functions, especially vision. For hearing, the results are less obvious, and only men of the later-born cohort had better hearing compared to their counterparts born almost three decades earlier. With improved sensory functions, older people may potentially have reduced risk of disability and future research should examine the extent to which generational improvements in sensory functions have influenced the meaning of vision and hearing in determining functioning and overall health in later life. Moreover, given the numerous changes over the past decades, further research should also examine how environmental factors, such as exposure to noise and UV radiation, have contributed to cohort differences in order to enhance strategies for promoting vision and hearing.

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Ethical approval

The Evergreen study received ethical approval from the ethical committee of the University of Jyväskylä and the Evergreen study was approved by the ethical committee of the Central Finland Health Care District. The principles of the Declaration of Helsinki were implemented in both study projects.

CRediT authorship contribution statement

Maija Välimaa: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Kaisa Koivunen:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Anne Viljanen:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Taina Rantanen:** Writing – review & editing, Data curation, Conceptualization. **Mikaela von Bonsdorff:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2024.105653.

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