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Hearing loss and tinnitus: association with employment and income among young adults

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Introduction: Auditory difficulties (i.e., hearing loss, tinnitus, both) are correlated with unemployment, underemployment, and reduced income, particularly among minority populations, Although hearing loss is more common among Non-Hispanic White individuals, receipt of otologic and hearing healthcare is far less common among Non-Hispanic Black individuals with hearing loss and tinnitus. The objective of this study was to evaluate differences in employment and income among young adults with hearing loss, tinnitus, and both.

Methods: Data from Waves IV (2008) ($N = 15,701$) and V (2016–18) ($N = 11,955$) of the National Longitudinal Study of Adolescent to Adult Health (ADD Health) contained self-reported hearing loss for individuals aged 24–43. Logistic and ordinal dependent variable regression evaluated the likelihood of having paid employment and the level of income, respectively, between categories of hearing loss controlling for sample heterogeneity. Findings were validated using a two-part model with racial/ethnic interactions.

Results: Among respondents, 5.81%–8.87% reported tinnitus only, 0.82%–1.39% reported hearing loss only, and 0.54%–1.41% reported both. Regression analysis showed that Black individuals were less likely to have paid employment (OR = 0.72, CI = 0.58, 0.90) and earned lower income (OR = 0.85, CI = 0.82, 0.88) than White individuals. There were no differences in the likelihood of employment/income between those with tinnitus/both conditions and those with no difficulties, but those with hearing loss had lower likelihood of paid employment (OR = 0.88, CI = 0.85, 0.87) and income (OR = 0.95, CI = 0.94, 0.97). Black and Hispanic individuals with hearing loss were less likely to have paid employment (Black individuals OR = 0.02, CI = 0.00, 0.18; Hispanic individuals OR = 0.01, CI = 0.00, 0.15). Black individuals with hearing loss (OR = 0.79, CI = 0.64, 0.95), tinnitus (OR = 0.83, CI = 0.80, 0.88), and other respondents with both (OR = 0.72, CI = 0.68, 0.77) earned lower income.

Conclusion: Results suggest that hearing loss is associated with a reduced likelihood of employment and employment advancement particularly among young Black and Hispanic individuals.

KEYWORDS

hearing loss, tinnitus, employment, income, young adult

1 Introduction

The World Health Organization (2024) estimates that by 2050, approximately 2.5 billion people will have some degree of hearing loss. Higher rates of hearing loss have been reported among Non-Hispanic White Americans when compared to other racial-ethnic groups (DeAngelis et al., 2024). Currently there are over 28 million working age (20–69 years) Americans who experience some degree of hearing loss (HL) (Lin, 2012). Untreated hearing loss can result in reductions in health, quality of life, and life satisfaction (Kamil and Lin, 2015) by adversely affecting interpersonal relationships as well as relationships in the workplace (Cunningham and Tucci, 2017). Furthermore, hearing-impaired workers experience higher levels of stress, expend increased effort in listening at work, and tend to take more sick days as a result of stress-related complaints (Canlon et al., 2013).

Related to hearing loss is tinnitus or the "ringing or other noises" in one's ears (Biswas et al., 2022). Worldwide estimates suggest 14% of adults experience tinnitus (Jarach et al., 2022) and in the US, 11.2% of the population or ∼27 million people) experience tinnitus (Batts and Stankovic, 2024). Tinnitus is the auditory perception of a stimulus in the absence of a stimulus that is commonly associated with acoustic trauma, chronic hearing loss, emotional stressors, or spontaneous occurrence (Piccirillo et al., 2020). Tinnitus has also been associated with lower self-reported health, and higher levels of depression, anxiety, and stress (Stegeman et al., 2021). A reciprocal relationship with stress appears to exist as individuals with tinnitus frequently experience abnormal responses to stress and stress has also been identified as a probable cause of tinnitus (Patil et al., 2023). According to Dalrymple and colleagues (Dalrymple et al., 2021), most cases of tinnitus are benign and idiopathic. Additionally, a standard diagnostic workup emphasizing detailed history and physical examination can result in identifying causes that are treatable.

Racial disparities have been reported in the presence of hearing loss and tinnitus. Studies show that the odds of hearing loss are 91% higher in Non-Hispanic White older adults when compared to Non-Hispanic Black older adults even after adjusting for age, sex, household income, and educational levels (Deng et al., 2021). These same disparities persist among younger adults aged 45–64 (Madans et al., 2021). Similarly, Batts and Stankovic (2024) reported that tinnitus rates were significantly higher among non-Hispanic individuals vs. Hispanic White individuals, Black individuals, or other ethnicity. However, a different trend exists among adults with hearing loss and tinnitus in relationship to their hearing environments and hearing healthcare for their conditions. For example, a recent study utilizing national data demonstrated that Non-Hispanic White individuals reported a significantly better hearing health than other ethnicities (Nadler, 2023). Similarly, non-Hispanic White individuals have better access to hearing healthcare when compared to other racial-ethnic groups (Blazer et al., 2016). Finally, non-Hispanic Black individuals with tinnitus were less likely to receive tinnitus evaluations for tinnitus suggesting they are under-served in the treatment of the disorder (Batts and Stankovic, 2024).

In addition to racial disparities, the presence of hearing loss or tinnitus has significant economic implications. For example, hearing loss has been attributed to unemployment, underemployment, and reduced earnings (Emmett and Francis, 2015; Garcia Morales et al., 2022; Shan et al., 2020). Similarly, the presence of tinnitus has also been associated with higher rates of unemployment, underemployment, and lower income (Emmett and Francis, 2015). However, before considering the long-term economic implications of hearing loss and tinnitus, we must acknowledge that key human investment is made during the teens, twenties, and early thirties through the growth of knowledge, development of positive work habits, gathering of information, accrual of advancement opportunities, establishment of benchmark wages, and determination of one's market value (Quinones et al., 1995). During this time, the accrual of human capital through post-secondary education, early employment, and continuity in employment benefits young adults throughout their working lives (Staff and Mortimer, 2007). Studies show that differences in both the amount and timing of work experience, can explain a substantial portion of individual-level wage differentials (Light and Ureta, 1995).

Most studies of the economic impact of hearing loss and tinnitus have primarily focused on associations among older adults and few studies have included individuals with tinnitus (Haji et al., 2022). To our knowledge, no study has directly examined the longitudinal association between hearing loss, tinnitus, and earned income in a large, nationally representative sample. Benito et al. (2016). examined the "hearing earnings gaps" between individuals who were deaf or hard of hearing and those without a hearing disability, but their small, cross-sectional sample limited their ability to assess causality and account for educational and employment heterogeneity. Therefore, this study explored the relationship between hearing loss, employment, and income examining racial and ethnic differences in these relationships among a nationally representative sample of young adults. Given the importance of early career employment and earnings in subsequent wage growth and job tenure, the identification and explication of potential employment and income differentials is essential amidst the increasing prevalence of both hearing loss (Shargorodsky, 2010) and tinnitus (Mahboubi et al., 2013) among the youth and young adult population.

2 Methods

2.1 Data

Data for this study came from the National Longitudinal Study of Adolescent to Adult Health (ADD Health)—a longitudinal study following a nationally representative sample of adolescents who were in Grades 7–12 during the 1994–1995 school year (Harris and Udry, 2018). ADD Health combines longitudinal survey data on respondents' social, economic, psychological, and physical wellbeing with contextual data on family, neighborhood, community, school, friendships, peer groups, and romantic relationships. Participant responses from the ADD Health survey have been used to study the relationships between labor market outcomes and a variety of characteristics, including education (Rees and Sabia, 2014), health conditions (Norton and Han, 2008), and behaviors (Fletcher, 2009; Rees and Sabia, 2015). However, despite the inclusion of survey items concerning hearing loss few studies have focused on the implications thereof for this study population.

The initial ADD Health cohort consisted of children and adolescents who were followed into young adulthood through five in-home interviews (Waves I–V) occurring in 1994–5, 1996, 2001–02, 2008–09, and 2016–18 when respondents were 12–17, 13–18, 18–26, 24–32, and 33–43 years old, respectively. ADD Health used a school-based design with the primary sampling frame derived from the Quality Education Database (QED) comprised of 26,666 U. S. High Schools. From this frame, a stratified sample of high schools was selected with the probability of selection proportional to school size. Schools were stratified by region, urbanicity, school type (public, private, parochial), ethnic mix, and size. For each high school selected, one of its feeder schools was identified and recruited with probability proportional to its student contribution to the high school. Adolescents were selected with unequal probability from the 1994–1995 enrollment rosters for the schools and those not on rosters that completed the in-school questionnaire. A core sample was derived from this administration by stratifying students in each school by grade and sex and then randomly choosing students from each stratum. For additional information on the ADD Health sampling process, attrition, and data collection, see http://www.cpc.unc.edu/projects/addhealth/design. In Wave I, a parent of each ADD Health respondent was interviewed to gather social, behavioral, and health information. To reflect the changing lives as the respondents age from adolescence to adults, ADD Health changes survey questionnaires with each successive Wave. In Waves III and IV, survey items regarding hearing ability and tinnitus, respectively, were included in the survey for the first time. Therefore, this study utilized Waves IV and V collected when respondents were aged 24–32 and 33–43, respectively, to evaluate the association between income and hearing loss/tinnitus.

2.2 Inclusion and identification criteria

The study sample was limited to individuals who responded to questions related to hearing loss and tinnitus in either Wave IV or V. The first question asked, "Which statement best describes your hearing without a hearing aid or other assistive devices? [Excellent, Good, Fair/A Little Trouble, Poor/Moderate Trouble, Very Poor/A Lot of Trouble, Deaf]." The second question asked, "In the past 12 months have you been bothered by ringing, roaring, or buzzing in your ears or head (tinnitus) that lasts for 5 min or more? [Yes, No]." These criteria resulted in 15,701 respondents in Wave IV (345 excluded) and 11,955 respondents in Wave V (2 excluded).

2.3 Hearing loss/tinnitus identification

Most (Wave IV 15,701, Wave V 11,955) respondents provided valid responses to hearing-related survey items in each wave making them eligible for inclusion in the panel. Given the difficulty in the interpreting results from multinomial models, we collapsed the responses into two groups containing the top three and bottom three categories in each wave (Table 1). In this study, these categories are labeled as hearing loss and no hearing loss. In the panel, 128 (0.82%), 913 (5.81%), and 85 (0.54%%) reported having hearing loss only, tinnitus only, and both conditions in Wave IV while 166 (1.39%), 1,061 (8.87%), and 168 (1.41%) reported these conditions in Wave V. The 14,575 (92.83%) and 10,560 (88.33%) in Waves IV and V, respectively, reported neither difficulty.

2.4 Individual characteristics

Demographic, parental, and health-related attributes were included in the analysis (Biswas et al., 2022; Stegeman et al., 2021). Demographic covariates included age, sex, race/ethnicity, region of residence, employment status, and educational attainment. To create a consistent measure of educational attainment across waves, education was coded into three categories: (1) less than a high school degree; (2) high school degree or equivalent, some college, vocational or technical degree; and (3) college degree and beyond. Region included four geographic regions—Northeast, Midwest, South, and West. Respondents were employed if they reported working at least 10 h per week for pay. Both sex (male, female) and race/ethnicity (non-Hispanic White individuals, non-Hispanic Black individuals, Hispanic individuals, non-Hispanic Asian/Pacific Islander individuals, non-Hispanic American Indian/Native American non-Hispanic Other, or Multiracial individuals) were self-identified. Respondents who reported being non-Hispanic Asian/Pacific Islander, non-Hispanic American Indian/Native American non-Hispanic Other, or Multiracial individuals were combined due to small sample sizes.

Since access to resources, education, and care during childhood is associated with individual-level educational attainment, income, and health status later in life (Maness et al., 2016), we included an indicator for Wave I parental income over $60,000 annually—the upper 50% of the distribution. To account for differences in health care access between respondents, an indicator was created for having health insurance. Respondents also reported their general health status as excellent (5), very good (4), good (3), fair (2), or poor (1). Consistent with other studies using ADD Health data (Maness et al., 2016; Hoke and Boen, 2021), responses were collapsed into two groups—excellent/very good/good and fair/poor.

2.5 Employment and income

Respondents indicated whether not they were working for pay. Those working for pay were also asked about their income. Income was reported as the total received from personal earnings before taxes including, wages or salaries, including tips, bonuses, and overtime pay, and income from self-employment. In Wave IV, earned income was reported as one of 12 categories ranging from "less than $5,000" to "$150,000 or more." In Wave V, earned income was reported as one of 13 income categories ranging from "<$5,000" to "$200,000 or more." Therefore, to create a consistent series across waves, the values provided in Waves V were coded into the 12 categories used in Wave IV. The categorical translation is shown in Table 2. Respondents with no earned income who indicated that they were not working, were assigned an income

TABLE 1 Sample characteristics and tests of differences by type of hearing loss.

Variable	Wave IV									
	No hearing loss (*N* = 14,575, 92.83%)		Tinnitus (*N* = 913, 5.81%)		Hearing loss (*N* = 128 0.82%)		Both (*N* = 85, 0.54%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	*t*-Stat	*p*-Value
Age (24–34)	28.50	1.79	28.60	1.77	28.80	1.86	28.84	1.68	2.54	0.011
	N	PCT	N	PCT	N	PCT	N	PCT	χ2	*p*-Value
	Working Status								15.7698	0.0013
No paid employment	5,056	34.69	363	39.80	58	45.31	30	35.29		
Paid employment	9,517	65.31	549	60.20	70	54.69	55	64.71		
	Income								122.8458	<.0001
No income	964	6.61	55	6.02	16	12.5	4	4.71		
less than $5,000	367	2.52	48	5.26	10	7.81	5	5.88		
$5,000 to $9,999	302	2.07	40	4.38	3	2.34	3	3.53		
$10,000 to $14,999	429	2.94	41	4.49	4	3.13	3	3.53		
$15,000 to $19,999	461	3.16	31	3.4	6	4.69	3	3.53		
$20,000 to $24,999	644	4.42	49	5.37	3	2.34	3	3.53		
$25,000 to $29,999	683	4.69	45	4.93	6	4.69	13	15.29		
$30,000 to $39,999	1475	10.12	95	10.41	12	9.38	6	7.06		
$40,000 to $49,999	1,649	11.31	95	10.41	13	10.16	10	11.76		
$50,000 to $74,999	3,319	22.77	204	22.34	24	18.75	20	23.53		
$75,000 to $99,999	2,084	14.3	109	11.94	16	12.5	10	11.76		
$100,000 to $149,999	1,476	10.13	75	8.21	10	7.81	2	2.35		
$150,000 or more	722	4.95	26	2.85	5	3.91	3	3.53		

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TABLE 1 (Continued)

Variable	Wave IV									
	No hearing loss (N = 14,575, 92.83%)		Tinnitus (N = 913, 5.81%)		Hearing loss (N = 128 0.82%)		Both (N = 85, 0.54%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	t-Stat	p-Value
	Sex								15.0873	0.0017
Male	6,763	46.4	471	51.59	65	50.78	50	58.82		
Female	7,812	53.6	442	48.41	63	49.22	35	41.18		
	Race/Ethnicity								61.9781	<.0001
White individuals	7,903	54.33	568	62.42	94	73.44	65	76.47		
Black individuals	3,257	22.39	172	18.9	18	14.06	11	12.94		
Other individuals	1,039	7.14	37	4.07	4	3.13	2	2.35		
Hispanic individuals	2,346	16.13	133	14.62	12	9.38	7	8.24		
	Region								17.8487	0.037
Northeast	1,797	12.33	92	10.08	14	10.94	50	58.82		
Midwest	3,330	22.86	202	22.12	43	33.59	35	41.18		
South	5,952	40.85	398	43.59	45	35.16	50	58.82		
West	3,491	23.96	221	24.21	26	20.31	35	41.18		
	Education								18.0092	0.0004
Less than high school degree	1,118	7.67	112	12.27	13	10.16	13	15.29		
High school, some college	8,756	60.08	582	63.75	95	74.22	59	69.41		
College or above	4,701	32.25	219	23.99	20	15.63	13	15.29		
	Health Insurance								27.8252	<.0001
Uninsured	3,760	26.24	287	32.36	49	40.5	23	27.38		
Insured	10,569	73.76	600	67.64	72	59.5	61	72.62		
	Regular Health Facility								8.2393	0.0613
No regular health clinic	6,212	42.62	417	45.67	66	51.56	41	48.24		

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TABLE 1 (Continued)

Variable	Wave IV									
	No hearing loss (*N* = 14,575, 92.83%)		Tinnitus (*N* = 913, 5.81%)		Hearing loss (*N* = 128 0.82%)		Both (*N* = 85, 0.54%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	t-Stat	*p*-Value
Regular health clinic	8,363	57.38	496	54.33	62	48.44	44	51.76		
	Self-Reported Health Status								103.5969	<.0001
Excellent, Very Good, Good	13,260	90.98	748	81.93	105	82.03	67	78.82		
Fair, Poor	1,315	9.02	165	18.07	23	17.97	18	21.18		
	Parental Income								6.7357	0.0808
Parent not high income	9,556	65.56	634	69.44	79	61.72	57	67.06		
Parent high income	5,019	34.44	279	30.56	49	38.28	28	32.94		
	Wave V									
	No Hearing loss (*N* = 10,560, 88.33%)		Tinnitus (*N* = 1,061, 8.87%)		Hearing loss (*N* = 166, 1.39%)		Both (*N* = 168, 1.41%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	*t*-Stat	*p*-Value
Age (33–43)	37.53	1.89	38.71	1.85	37.78	1.90	37.72	1.92	3.14	0.0017
	N	PCT	N	PCT	N	PCT	N	PCT	$\chi 2$	*p*-Value
	Working Status								37.6047	<.0001
No paid employment	1,625	15.43	209	19.75	38	23.17	47	27.98		
Paid employment	8,908	84.57	849	80.25	126	76.83	121	72.02		
	Income								76.3742	<.0001
No income	172	1.63	10	0.94	7	4.22	2	1.19		
less than $5,000	1000	9.47	110	10.37	24	14.46	19	11.31		
$5,000 to $9,999	401	3.8	58	5.47	11	6.63	7	4.17		
$10,000 to $14,999	411	3.89	35	3.3	10	6.02	13	7.74		

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TABLE 1 (Continued)

Variable	Wave IV									
	No hearing loss (*N* = 14,575, 92.83%)		Tinnitus (*N* = 913, 5.81%)		Hearing loss (*N* = 128 0.82%)		Both (*N* = 85, 0.54%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	t-Stat	*p*-Value
$15,000 to $19,999	378	3.58	51	4.81	8	4.82	12	7.14		
$20,000 to $24,999	554	5.25	65	6.13	13	7.83	11	6.55		
$25,000 to $29,999	542	5.13	51	4.81	4	2.41	6	3.57		
$30,000 to $39,999	1174	11.12	113	10.65	17	10.24	14	8.33		
$40,000 to $49,999	1238	11.72	113	10.65	17	10.24	14	8.33		
$50,000 to $74,999	2148	20.34	210	19.79	24	14.46	29	17.26		
$75,000 to $99,999	1125	10.65	117	11.03	17	10.24	18	10.71		
$100,000 to $149,999	882	8.35	101	9.52	9	5.42	14	8.33		
$150,000 or more	535	5.07	27	2.54	5	3.01	9	5.36		
	Sex								66.6789	<.0001
Male	4,444	42.08	543	51.18	80	48.19	109	64.88		
Female	6,116	57.92	518	48.82	86	51.81	59	35.12		
	Race/Ethnicity								66.0026	<.0001
White individuals	6,028	57.21	683	64.37	124	74.7	126	75		
Black individuals	2,153	20.43	166	15.65	15	9.04	18	10.71		
Other individuals	785	7.45	61	5.75	5	3.01	7	4.17		
Hispanic individuals	1,571	14.91	151	14.23	22	13.25	17	10.12		

(Continued)

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TABLE 1 (Continued)

Variable	Wave IV									
	No hearing loss (N = 14,575, 92.83%)		Tinnitus (N = 913, 5.81%)		Hearing loss (N = 128 0.82%)		Both (N = 85, 0.54%)			
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	t-Stat	p-Value
	Region								14.6906	0.0998
Northeast	1,255	12.66	105	10.56	18	11.76	16	10.74		
Midwest	2,290	23.1	235	23.64	51	33.33	36	24.16		
South	3,961	39.96	421	42.35	50	32.68	58	38.93		
West	2,407	24.28	233	23.44	34	22.22	39	26.17		
	Education								33.2682	<.0001
Less than high school degree	708	6.7	76	7.16	17	10.24	14	8.33		
High school degree	5,708	54.05	617	58.15	109	65.66	109	64.88		
College	4,144	39.26	368	34.68	40	24.1	45	26.79		
	Health Insurance								5.027	0.1698
Uninsured	834	7.9	94	8.86	20	12.05	15	8.93		
Insured	9,726	92.1	967	91.14	146	87.95	153	91.07		
	Regular Health Facility								1.4985	0.6826
No regular health clinic	4,729	44.78	478	45.05	76	45.78	83	49.4		
Regular health clinic	5,831	55.22	583	54.95	90	54.22	85	50.6		
	Self-Reported Health Status								269.835	<.0001
Excellent, Very Good, Good	9,319	88.25	817	77	114	68.67	98	58.33		
Fair, Poor	1,241	11.75	244	23	52	31.33	70	41.67		
	Parental Income								4.2783	0.2329
Parent not high income	6,688	63.33	687	64.75	103	62.05	118	70.24		
Parent high income	3,872	36.67	374	35.25	63	37.95	50	29.76		

Std Dev, Standard deviation. ***Indicates*** statistically significant at 95% confidence level. Estimates were weighted to reflect a nationally representative sample.

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TABLE 2 Likelihood of working- multilevel logistic estimation.

Variable	Odds Ratio			
	Estimate	95% CI		*p*-Value
Intercept	0.05	0.04	0.07	0.00
Age	1.09	1.08	1.10	0.00
Female vs Male	0.62	0.57	0.68	0.00
Black vs White individuals	0.91	0.81	0.95	0.01
Hispanic vs White individuals	0.89	0.38	0.93	0.02
Other vs White individuals	0.96	0.78	1.18	0.70
Midwest vs Northeast	1.03	0.89	1.19	0.68
South vs Northeast	1.01	0.89	1.16	0.85
West vs Northeast	0.89	0.76	1.03	0.11
High School vs < High School	1.41	1.21	1.64	0.00
College vs < High School	1.81	1.54	2.13	0.00
No Insurance vs Insured	0.71	0.54	0.90	0.00
No Health facility vs Has Regular Facility	0.99	0.91	1.08	0.78
Tinnitus vs No Difficulty	0.91	0.75	1.09	0.30
Hearing loss vs No Difficulty	1.07	0.70	1.62	0.76
Both Difficulties vs No Difficulty	0.84	0.54	1.31	0.45
Health Fair/Poor vs Excellent/very good/good	0.81	0.63	0.93	0.00
Parent High Income vs Income < 50th percentile)	1.02	0.94	1.12	0.60
Tinnitus*Black individuals	0.85	0.57	1.29	0.45
Tinnitus*Hispanic individuals	0.89	0.57	1.38	0.60
Tinnitus*Other individuals	1.27	0.63	2.55	0.51
Hearing loss*Black individuals	0.28	0.09	0.87	0.03
Hearing loss*Hispanic individuals	3.21	1.11	9.31	0.20
Hearing loss*Other individuals	1.11	0.12	10.27	0.93
Both Difficulties*Black individuals	0.28	0.63	0.86	0.75
Both Difficulties*Hispanic individuals	0.20	0.05	0.77	0.02
Both Difficulties*Other individuals	12.73	1.80	90.18	0.10
Dependent Variable: Working (0,1)				
Estimates reflect the likelihood of working				

Reference group: Sex (male), Race/ethnicity (non-Hispanic White individuals), Region (Northeast), Education (Less than high school), Hearing (No difficulties), Insurance (insured), Health facility (Has a regular facility for care), Health (Excellent/very good/good), Parental income (income < 50th percentile). **Indicates** statistically significant at 95% confidence level. Std Err, Standard Error; Pr, Probability; CI, Confidence Interval; Estimates were weighted to reflect a nationally representative sample. $N = 25{,}644$.

value of zero. Respondents who indicated that they were working but did not report a valid income (Wave IV $N = 1{,}039$, Wave V $N = 2{,}216$) were not included in the regression analysis.

2.6 Statistical analysis

First, using Wave IV and V longitudinal weights, descriptive statistics for all covariates were calculated for respondents with hearing loss (HL) only, tinnitus (TN) only, both difficulties, and no hearing difficulties. Between group differences in continuous and categorical covariates were tested using t- and chi-square tests, respectively. To adjust for the complex clustered sampling frame of ADD Health and ensure that the results were nationally representative, survey commands and sampling weights were used for all calculations. Statistical analyses accounted for clustering and stratification of the ADD Health sampling design.

Second, multivariable logistic regression analyzed the relationships between covariates and the relative likelihood of paid employment adjusting for age, sex, race/ethnicity, region of residence, education, health insurance, having a regular care facility, hearing loss, health status, and parental income level. Interaction terms between race/ethnicity and hearing loss were included to assess subgroup differences. Since some respondents were present in both Waves IV and V, their responses would be correlated over time. To account for this type of correlation as well as the school-level clustering and regional stratification of the ADD Health sampling design, regression models included random individual-time intercepts that adjusted for the compounded structure of their covariance using multilevel models with time-invariant fixed effects. Significance levels were set at $p < 0.05$. Adjusted odds ratios (ORs) were calculated for all covariates and interaction effects. The model specification accounted for the repeated individual-level observations in the panel data.

Third, since income was reported as categorical values in Waves IV and V, rather than a discrete or continuous value, the distribution and distributional parameters of income were examined to determine the appropriate distributional specification. Due to the ordered categorical nature of the outcome, an ordinal logistic regression model was specified. The ordinal logistic regression assumes a non-normal distribution in the error term of an integer-based dependent variable and can be employed without any special corrections. Given the proportional odds assumption which was tested and validated using the Brant-Wald test, the coefficients represent the difference in the log odds of a given level and the reference. Odds ratios and associated 95% confidence intervals were also calculated to reflect the magnitude of the expected change in income levels. The model specification accounted for repeated individual-level structure and cross-wave covariance of the panel data through the log of individual-level time exposure.

Although this study utilizes data from Waves IV and V of the National Longitudinal Study of Adolescent to Adult Health (Add Health), it is not a fully longitudinal analysis in the strictest sense, as not all respondents were present in both waves. Therefore, the analytic sample includes both longitudinal respondents (those observed in both waves) and cross-sectional respondents (those observed in either Wave IV or Wave V). While the longitudinal design of Add Health informs the structure and strengths of the dataset, the current analysis is treated as a pooled cross-sectional study. All models account for missingness under the assumption that data are missing at random (MAR), but the primary research question does not rely on within-person changes over time. This design choice reflects the study's goal of estimating population-averaged associations between income and auditory health outcomes, rather than examining within-individual trajectories. Since some Wave IV respondents were not present or had missing response values in Wave V, the missing at random (MAR) assumption was tested by regressing a binary indicator of Wave V missingness on the model covariates. The lack of significance in any covariates suggested that sample attrition did not significantly bias results.

2.7 Sensitivity analysis

To ensure that the inclusion of an interaction term between hearing loss and race enhanced the model fit, a likelihood ratio test was conducted to compare the model with and without the inclusion of these interactions (improvement in model fit at $\alpha = 0.05$ was larger than critical value 3.84). Finally, we conducted a sensitivity analysis to examine the robustness of findings. A two-part selection regression model was used to validate the findings related to differential earnings likelihoods and levels between respondents with HL only, tinnitus only, both conditions, and no hearing loss. Two-part selection models mitigate any potential selection bias by separating the selection process (i.e., whether a respondent earns income) from the primary relationship of interest (i.e., the association between income level and hearing loss). Since respondents who are not working or are not in the labor force, have no income, they were coded as missing.

Missing data is a common challenge in analyzing longitudinal survey data. If the data are missing at random (MAR), and the parameters governing the missing data process and the model for the outcome are disjoint, then the missing data are ignorable. Most statistical methods used in longitudinal data analysis rely on the MAR assumption and violation of the assumption can result in biased estimates. In a two-part model, the relationship between the risk of the variable being missing and its unseen value is fit for the probability of observing a positive-vs.-non-positive outcome. Then, conditional on a positive outcome, a regression model is fit for the positive outcome. The analysis herein models the risk of a respondent having a missing or non-missing income, then, conditional on having non-missing income, models the association between income level and the covariates. The model specification accounted for repeated individual-level structure of the panel data and cross-wave covariance through the log of individual-time exposure. To ensure that sample attrition did not bias results, the model was also estimated to include those with missing observation in Wave V within the stage 1 analysis sample.

3 Results

Table 1 provides descriptive statistics for all covariates for respondents with no hearing loss, hearing loss, and tinnitus. Chi-square and t-statistics tested for statistically significant differences across groups. Only a small portion of respondents reported tinnitus only (Wave IV 5.81%; Wave V 8.87%), HL only (Wave IV 0.82%; Wave V 1.39%), or both conditions (Wave IV 0.54%; Wave V 1.41%). Most respondents reported no hearing loss (Wave IV 92.83%; Wave V 88.33%). Over half (Wave IV 53.6%; 57.92% Wave V) of those with no hearing loss were female. However, females comprised less than half of those with tinnitus (Wave IV 48.41%; Wave V 48.82%), HL (Wave IV 49.22%; Wave V 51.81%), and both conditions (Wave IV 41.18%; Wave V 35.12%)—a statistically significant difference (Wave IV $\chi^2 = 15.09$, $p = 0.0017$; Wave V $\chi^2 = 66.68$, $p < 0.0001$). Most respondents were White individuals (tinnitus only Wave IV 62.42%; Wave V 64.37%; HL only Wave IV 73.44%; Wave V 74.70%, both conditions Wave IV 76.47%; Wave V 75%). Only a small portion of those with these difficulties were Black and Hispanic individuals. Respondents were distributed throughout the US with the largest representation in the South (Wave IV: TN only 43.59%; HL only 35.16%; 58.82%; Wave V: TN only 42.35%; HL only 32.68%; both conditions 38.93%), but these differences were not statistically significant (Wave IV $\chi^2 = 17.85$, $p = 0.087$; Wave V $\chi^2 = 14.69$, $p = 0.10$).

Significantly differences in educational attainment (Wave IV $\chi^2 = 18.01$, $p = 0.0004$; Wave V $\chi^2 = 33.27$, $p < 0.0001$) were found between the auditory groups with college graduation among those hearing loss only (Wave IV 15.63%; Wave V 24.1%), tinnitus only (Wave IV 23.99%; Wave V 34.68%), and both conditions (Wave IV 15.29%; Wave V 26.79%) lower compared to those with no hearing loss (Wave IV 32.25%; Wave V 39.26%). Between 80 and 90% of all groups had health insurance (Wave IV $\chi^2 = 27.83$, $p < 0.0001$; Wave V $\chi^2 = 5.03$, $p = 0.17$) and over half had a regular facility where they received healthcare (Wave IV $\chi^2 = 8.24$, $p = 0.06$; Wave IV $\chi^2 = 1.50$, $p = 0.68$). However, roughly 91% and 88% of those with no hearing loss in Waves IV and V reported being in good, very good, or excellent health. Only 82%, 82%, and 79% in Wave IV and 77%, 68.67%, and 58.33% in Wave V of those with tinnitus only, HL only, and both difficulties (Wave IV $\chi^2 = 103.60$, $p < 0.0001$; Wave V $\chi^2 = 269.84$, $p < 0.0001$) reported good health. Between 30 and 40% of respondents had parents in the top half of the income distribution in Waves IV (No difficulty 34.44%; Tinnitus only 30.56%; HL only 38.28%; Both 32.94) and V (No difficulty 36.67%; Tinnitus only 35.25%; HL only 37.95%; Both 29.76%) and there was no statistically significant difference between groups (Wave IV $\chi^2 = 6.74$, $p = 0.08$; Wave V $\chi^2 = 4.28$, $p = 0.23$).

Figure 1 shows the percent of each auditory group at each income level in Waves IV and V. As indicated in the figures, there were significant differences in the income distribution (Wave IV $\chi^2 = 122.85$, $p < 0.0001$; Wave V $\chi^2 = 76.37$, $p < 0.0001$) with respondents with no difficulty clustered in the upper income ranges and respondents with hearing loss concentrated in the left tail of the distribution. However, the groups also showed significant sex, racial/ethnic, educational, and self-reported health differences. To determine if the association between hearing loss and income level were robust to differences in these characteristics, we performed three regression analyses.

Multilevel logistic regression (Table 2) estimated the association between the likelihood of engaging in work and age, sex, race/ethnicity, region of residence, education, insurance, regular health facility, parental income, auditory group, and auditory group-race interactions. Results showed that the likelihood of working increased with age (OR = 1.09, CI = 1.08, 1.10). Given the longitudinal nature of the data, this may also suggest that the likelihood increased over the time frame of the panel. Those with a high school (OR = 1.41, CI = 1.21, 1.64) or college (OR = 1.81, CI = 1.54, 2.13) education were also more likely to work compared to the reference group. Compared to males, White respondents, and those in good health, females (OR = 0.62, CI = 0.57, 0.68), Black individuals (OR = 0.91, CI = 0.81, 0.95), Hispanic individuals (OR = 0.89, CI = 0.38, 0.93), and those in poor health (OR = 0.81, CI = 0.63, 0.93) had a lower likelihood of working. Compared to their counterparts without any hearing loss, Black individuals with hearing difficulties (OR = 0.28, CI = 0.09, 0.87) and Black and Hispanic individuals with both difficulties (Black individuals OR = 0.28, CI = 0.63, 0.86; Hispanic individuals OR = 0.20, CI = 0.05, 0.77) had a lower likelihood of working.

Multilevel logistic regression (Table 3) estimated the longitudinal association between the likelihood of being paid for work (a binary variable) and the individual-level covariates, auditory groups, and auditory group-race interactions. Results showed that the likelihood of being paid for work increased with age (OR = 1.14, CI = 1.11, 1.16). All else held constant, respondents in the Midwest (OR = 1.43, CI = 1.11, 1.85) and South (OR = 1.40, CI = 1.10, 1.77) were more likely to be paid for work relative to those in the Northeast. Compared to respondents without a degree, those with a high school diploma (OR = 1.52, CI = 1.18, 1.95) and college degrees (OR = 2.72, CI = 1.97, 3.75) were significantly more likely to be paid for work. However, being uninsured (OR = 0.63, CI = 0.34, 0.99), not having a regular facility for healthcare (OR = 0.35, CI = 0.12, 0.64), and rating individual health as fair or poor (OR = 0.52, CI = 0.180.96) was associated with a lower likelihood of being paid for work. Black individuals (OR = 0.72, CI = 0.58, 0.90), Hispanic individuals (OR = 0.64, CI = 0.43, 0.95), and respondents of Other racial groups (OR = 0.75, CI = 0.56, 1.00) were less likely to be paid for work compared to White individuals. Compared to respondents without any hearing loss, those with HL (OR = 0.88, CI = 0.85, 0.87) were significantly less likely to be paid for work. Relative to their counterparts with no HL, Black individuals (OR = 0.02, CI = 0.00, 0.18) and Hispanic individuals (OR = 0.01, CI = 0.00, 0.15) respondents with HL were less likely to be paid for work.

Multilevel ordinal logistics regression (Table 4) estimated longitudinal covariate associations with income level among respondents who reported earned income. Since ordinal logistics coefficient values do not have an intuitive interpretation, results were also expressed as odds ratios (ORs). Results indicated that, compared to males, females had significantly lower income levels (OR = 0.53, CI = 0.50, 0.56) levels lower. Income was also lower among older respondents (OR = 0.95, CI = 0.94, 0.96) compared to those at younger ages. Residents of the South (OR = 0.87, CI = 0.79, 0.97) and Midwest (OR = 0.80, CI = 0.72, 0.89) earned comparatively lower income than Northeastern residents. Compared to those with lower educational attainment, respondents with a high school (OR = 1.51, CI = 1.30, 1.75) or college (OR = 3.75, CI = 3.19, 4.42) degree had higher relative earnings. Uninsured respondents (OR = 0.53, CI = 0.48, 0.58) and those without a regularly facility for health care (OR = 0.60, CI = 0.56, 0.65) earned less than their counterparts. Relative to those without hearing loss, respondents with hearing loss (OR = 0.67, CI = 0.45, 0.99) and both HL and tinnitus (RO = 0.82, CI = 0.71, 0.95) had significantly lower earnings. Relative to White individuals, Black individuals (OR = 0.52, CI = 0.48, 0.57) had lower income, but respondents of other races (OR = 1.32, CI = 1.12, 1.57) had comparatively higher income. However, Black individuals with HL (OR = 0.35, CI = 0.19, 0.47) or tinnitus (OR = 0.84, CI = 0.75, 0.97) had lower income than their unimpaired counterparts.

3.1 Sensitivity analysis

While the direction and statistical significance of key covariates remained consistent across both the original and two-part models, the magnitude of several coefficients—particularly for variables such as parental income and health status—was reduced in the two-part model. This attenuation suggests that unobserved selection processes, such as the non-random likelihood of depression may have influenced part of the original associations. The two-part model addresses this by jointly modeling the probability of employment and income, providing more conservative and potentially more accurate effect estimates. Thus, while the original

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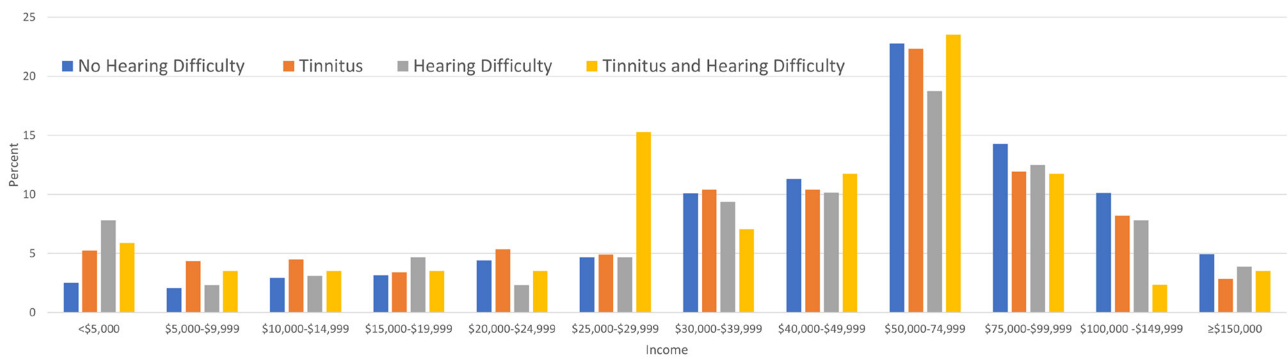

FIGURE 1
Reported income level by auditory difficulty wave IV.

models highlight robust associations, the two-part model adds value by strengthening causal inference and clarifying the extent to which selection bias may influence observed relationships. The coefficient values and magnitudes vary between the two frameworks as a result of the variations in empirical procedures, but the consistency in coefficient significance confirmed the robustness of the logit and ordinal regression estimates showing differences in the likelihood of earning income as well as the income levels of respondents with hearing loss and show differential earnings associations among racial and ethnic minority groups with hearing loss (Table 5).

4 Discussion

In those cohort of young adults (ages 22–43) who were initially identified when they were in grades 7–12, this study showed that hearing loss has a detrimental effect on income. Additionally, young adults from minoritized backgrounds with hearing loss earn substantially less than their White counterparts. These findings suggest hearing-related issues have a negative effect on earning beginning in young adulthood. The study also showed that, despite being more prevalent among young adults, the presence of tinnitus was not associated with differential employment likelihood or potential earnings. Reviews of the literature report a high economic cost associated with tinnitus (Daoud et al., 2022), yet a negative impact among young adults in this study did not emerge.

According to the Hearing Health Foundation (Hearing Health Foundation, 2024), individuals with hearing loss typically earn about 25% less than their counterparts without hearing loss. More importantly, individuals with hearing loss are more likely to be unemployed or underemployed, have lower income, and less likely to have access the hearing care (Malcolm et al., 2022). Further, adults with hearing loss frequently retire earlier than adults without hearing loss which translates into greater financial strain long term (Helvik et al., 2013). Garcia Morales et al. (2022) found that individuals with moderate-severe hearing loss were more likely to not be engaged in the labor force. Frequent transitions in and out of the labor market may force individuals to work well-past usual retirement ages to manage later life expenses (Adhikari et al., 2011). However, it is possible that individuals with hearing loss face unexplained barriers to entering and continuously being employed that are not specific to their hearing loss (e.g., poor general health, employment type, etc.) (Garcia Morales et al., 2022).

A second concerning issue is the implication for lifetime earnings. According to Infurna and Wiest (2018) disabilities impact the trajectories of wellbeing. Life satisfaction declines in adults who become disabled in the years following disability. Given evidence that the effects of early work force participation are felt and often exacerbated throughout the course of employment (Helbling et al., 2016), it is tenable that hearing loss among young adults could potentially operate in the same fashion by negatively impacting employment and income over time—analogous to individuals with disabilities (Svinndal et al., 2020).

Workforce participation issues and subsequently lifetime earnings are further complicated by racial-ethnic difficulties that are common among hearing workers. This study showed that compared with White individuals with hearing loss, Black individuals with the same difficulty had lower earnings. Lower earning among individuals with hearing-related issues has been previously reported however the longer-term impact is less clear. Emmett and Francis (2015) found that individuals with hearing loss demonstrated 1.5 times higher odds of having a low income than individuals with normal hearing. Black and Hispanic individuals with hearing loss earned 68% and 75% the income of White individuals with hearing loss highlighting the potential additive effect of hearing loss among Black individuals who traditionally earn less than White individuals (Wilson and Darity, 2022).

Finally, the issues of racial differences in earnings may not be isolated but linked to early decisions about care for individuals with hearing loss and tinnitus. Batts and Stankovic (2024) found that Non-Hispanic Black individuals were less likely to discuss hearing loss and tinnitus with their healthcare providers. Additionally, those Non-Hispanic Black individuals that did discuss their conditions were less likely to be subsequently evaluated for hearing loss or tinnitus. These early hearing healthcare interactions that lack the necessary discussion about hearing loss and tinnitus may contribute to observed otologic healthcare disparities.

The lack of difference between the income of young adults with tinnitus and those without hearing loss may suggest that tinnitus has little impact on employment/income of young adults or that the impact is more likely to occur later in life.

TABLE 3 Likelihood of being paid for work-multilevel logistic estimation.

Variable	Odds ratio			
	Estimate	95% CI		*p*-Value
Intercept	−2.60	−6.85	0.00	1.85
Age	1.14	1.11	1.16	0.15
Female vs Male	0.93	0.77	1.11	0.10
Black vs White individuals	0.72	0.58	0.90	0.10
Hispanic vs White individuals	0.64	0.43	0.95	0.05
Other vs White individuals	0.75	0.56	1.00	0.00
Midwest vs Northeast	1.92	1.43	2.58	0.95
South vs Northeast	1.43	1.11	1.85	0.62
West vs Northeast	1.36	0.99	1.86	0.62
High School vs < High School	1.52	1.18	1.95	0.67
College vs < High School	2.72	1.97	3.75	1.32
No Insurance vs Insured	0.63	0.34	0.99	0.29
No Health facility vs Has Regular Facility	0.35	0.12	0.64	0.11
Tinnitus vs No Difficulty	1.25	0.76	2.06	0.72
Hearing loss vs No Difficulty	0.88	0.85	0.87	0.16
Both Difficulties vs No Difficulty	2.75	0.69	11.01	2.40
Health Fair/Poor vs Excellent/very good/good	0.52	0.18	0.96	0.16
Parent High Income vs Income < 50th percentile)	1.18	0.95	1.45	0.37
Tinnitus∗Black individuals	1.08	0.44	2.68	0.99
Tinnitus∗Hispanic individuals	43.66	5.42	351.47	5.86
Tinnitus∗Other individuals	1.49	0.51	4.33	1.47
Hearing loss∗Black individuals	0.02	0.00	0.18	1.74
Hearing loss∗Hispanic individuals	0.01	0.00	0.15	1.88
Hearing loss∗Other individuals	0.10	0.01	1.15	0.14
Both Difficulties∗Black individuals	2.17	0.16	28.59	3.35
Both Difficulties∗Hispanic individuals	2.59	0.34	19.69	0.44
Both Difficulties∗Other individuals	0.35	0.03	4.65	1.54
Dependent Variable: Earning income from paid employment (0,1)				
Estimates reflect the likelihood of earning income				

Reference group: Sex (male), Race/ethnicity (non-Hispanic White individuals), Region (Northeast), Education (Less than high school), Hearing (No difficulties), Insurance (insured), Health facility (Has a regular facility for care), Health (Excellent/very good/good), Parental income (income < 50th percentile). ***Indicates*** statistically significant at 95% confidence level. Std Err, Standard Error; Pr, Probability; CI, Confidence Interval. Estimates were weighted to reflect a nationally representative sample. $N = 25{,}644$.

Age is a primary risk factor tinnitus even though the specific mechanism that cause tinnitus are less clear (Reisinger et al., 2023). Similarly, it is possible that tinnitus in young adulthood does not impact workforce participations and subsequently income. Studies suggest that young adults with tinnitus are less likely to seek professional services to reduce the debilitating effects (Bhatt, 2018). Young adults are also less likely to have chronic diseases commonly associated with tinnitus which increases their likelihood of continuing to work and earn income (Bhatt, 2018). Research suggests that tinnitus may worsen over time among those exposed to noise in their work environment (Engdahl et al., 2012), but the likelihood of exacerbation varies by nature of the condition (Ralli et al., 2017) suggesting a potential interactions between age, duration of tinnitus, symptomatology, and environment that may influence employment disruption and income. Finally, the impact of disabling conditions such as hearing loss and tinnitus is dynamic and unfolds over time (Shuey and Willson, 2019). Minimally, disabilities are associated with economic insecurity particularly as individuals approach retirement (Shuey and Willson, 2019). Disabilities also have negative implications for income by increasing the likelihood that income is derived from lower paying sources (Ranaldi, 2022)—such as government benefits or pensions which are lower than wages or salaries (Pu and Syu, 2023).

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TABLE 4 Relative level of earnings-multilevel ordinal logistic estimation.

Variable	OR	95% CI		*p*-Value
Age	0.95	0.94	0.96	0.00
Female vs Male	0.53	0.50	0.56	0.00
Black vs White individuals	0.52	0.48	0.57	0.00
Hispanic vs White individuals	1.32	1.12	1.57	0.00
Other vs White individuals	1.10	0.99	1.22	0.09
Midwest vs Northeast	0.80	0.72	0.89	0.00
South vs Northeast	0.87	0.79	0.97	0.01
West vs Northeast	1.00	0.89	1.13	0.95
High School vs < High School	1.51	1.30	1.75	0.00
College vs < High School	3.75	3.19	4.42	0.00
No Insurance vs Insured	0.53	0.48	0.58	0.00
No Health facility vs Has Regular Facility	0.60	0.56	0.65	0.00
Tinnitus vs No Difficulty	0.82	0.71	0.95	0.01
Hearing loss vs No Difficulty	0.67	0.45	0.99	0.04
Both Difficulties vs No Difficulty	0.81	0.56	1.17	0.27
Health Fair/Poor vs Excellent/very good/good	2.10	1.88	2.34	0.00
Parent High Income vs Income < 50th percentile)	1.36	1.26	1.46	0.00
Tinnitus*Black individuals	0.84	0.75	0.97	0.0474
Tinnitus*Other individuals	1.41	0.68	2.91	0.35
Tinnitus*Hispanic individuals	1.35	0.96	1.89	0.08
Hearing loss*Black individuals	0.35	0.19	0.47	0.13
Hearing loss*Other individuals	0.82	0.25	2.75	0.75
Hearing loss*Hispanic individuals	1.59	0.13	19.67	0.72
Both Difficulties*Black individuals	0.87	0.39	1.94	0.74
Both Difficulties*Other individuals	0.89	0.29	2.71	0.84
Both Difficulties*Hispanic individuals	0.42	0.13	1.33	0.14
Intercept1	−2.95	−3.24	−2.66	
Intercept2	−2.46	−2.75	−2.18	
Intercept3	−2.05	−2.33	−1.76	
Intercept4	−1.74	−2.02	−1.45	
Intercept5	−1.36	−1.65	−1.07	
Intercept6	−1.02	−1.31	−0.73	
Intercept7	−0.43	−0.72	−0.14	
Intercept8	0.13	−0.16	0.42	
Intercept9	1.24	0.96	1.53	
Intercept10	2.16	1.87	2.44	
Intercept11	3.41	3.11	3.71	
Dependent Variable: Income Level (1–12)				

Reference group: Sex (male), Race/ethnicity (non-Hispanic White individuals), Region (Northeast), Education (Less than high school), Hearing (No difficulties), Insurance (insured), Health facility (Has a regular facility for care), Health (Excellent/very good/good), Parental income (income < 50th percentile). ***Indicates*** statistically significant at 95% confidence level. OR, Odds ratio; Std Err, Standard Error; CI, Confidence Interval. Estimates were weighted to reflect a nationally representative sample. Model offset by the log of exposure. $N = 24{,}617$.

TABLE 5 Sensitivity analysis-two-part sample selection estimation.

Part 2: Level of Income						
Variable		Std Err	95% CI		Chi-Square	Pr > ChiSq
Intercept	−0.74	0.17	−4.25	0.00	−1.08	0.40
Age	**−0.02**	0.00	−10.33	0.00	−0.02	0.02
Female	−0.35	0.02	−17.77	0.00	−0.39	0.31
Black individuals	−0.35	0.03	−12.83	0.00	−0.40	0.30
Hispanic	0.03	0.03	1.01	0.31	−0.03	0.10
Other	0.13	0.05	2.79	0.01	0.04	0.22
Midwest	**−0.09**	0.03	−2.85	0.00	−0.16	0.03
South	**−0.06**	0.03	−1.85	0.06	−0.12	0.00
West	0.00	0.03	−0.01	0.99	−0.07	0.07
Highschool	0.19	0.04	4.40	0.00	0.10	0.27
College	0.69	0.04	15.52	0.00	0.60	0.78
No Insurance	−0.39	0.03	−15.18	0.00	−0.44	0.34
No Health facility	−0.29	0.02	−14.30	0.00	−0.33	0.25
Tinnitus	**−0.10**	0.04	−2.31	0.02	−0.18	0.01
Hearing loss	**−0.14**	0.11	−1.29	0.20	−0.34	0.05
Both Difficulties	−0.08	0.11	−0.78	0.44	−0.29	0.12
Health Fair/Poor	**0.43**	0.03	13.46	0.00	0.37	0.49
Parent High Income	**0.18**	0.02	8.65	0.00	0.14	0.22
Tinnitus*Black individuals	0.13	0.09	1.49	0.14	−0.04	0.31
Tinnitus*Hispanic individuals	0.28	0.22	1.28	0.20	−0.15	0.70
Tinnitus*Other individuals	0.19	0.10	1.81	0.07	−0.02	0.39
Hearing loss*Black individuals	**−1.02**	0.28	−3.72	0.00	−1.56	0.05
Hearing loss*Hispanic individuals	0.21	0.70	0.29	0.77	−1.17	1.59
Hearing loss*Other individuals	−0.79	0.47	−1.68	0.09	−1.71	0.13
Both Difficulties*Black individuals	−0.05	0.23	−0.21	0.83	−0.50	0.40
Both Difficulties*Hispanic individuals	**−0.48**	0.32	−1.48	0.14	−1.11	0.02
Both Difficulties*Other individuals	0.03	0.30	0.10	0.92	−0.55	0.61
Part 1: Likelihood of Paid Employment						
		Std Err	95% CI		Chi-Square	Pr > ChiSq
Intercept						
Age	0.07	0.00	14.72	0.00	0.06	0.08
Female	−0.13	0.04	−3.18	0.00	−0.21	0.05
Black individuals	−0.17	0.05	−3.37	0.00	−0.27	0.07
Hispanic	−0.16	0.06	−2.51	0.01	−0.28	0.04

(Continued)

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TABLE 5 (Continued)

Part 2: Level of Income						
Variable		Std Err	95% CI		Chi-Square	Pr > ChiSq
Other	−0.16	0.09	−1.70	0.09	−0.34	0.02
Midwest	0.22	0.07	3.41	0.00	0.10	0.35
South	0.12	0.06	2.18	0.03	0.01	0.23
West	0.22	0.07	2.97	0.00	0.07	0.36
Highschool	0.06	0.06	1.00	0.32	−0.06	0.17
College	0.48	0.08	6.32	0.00	0.33	0.63
No Insurance	−0.18	0.05	−4.02	0.00	−0.27	0.09
No Health facility	−0.13	0.04	−2.97	0.00	−0.21	0.04
Tinnitus	0.09	0.10	0.86	0.39	−0.11	0.29
Hearing loss	0.49	0.29	1.74	0.08	−0.06	1.05
Both Difficulties	0.32	0.27	1.18	0.24	−0.21	0.85
Health Fair/Poor	0.27	0.06	4.67	0.00	0.16	0.38
Parent High Income	0.16	0.05	3.27	0.00	0.06	0.25
Tinnitus∗Black individuals	0.27	0.22	1.26	0.21	−0.15	0.69
Tinnitus∗Hispanic individuals	0.02	0.20	0.10	0.92	−0.37	0.41
Tinnitus∗Other individuals	1.53	0.46	3.34	0.00	0.63	2.42
Hearing loss∗Black individuals	−1.62	0.47	−3.44	0.00	−2.54	0.69
Hearing loss∗Hispanic individuals	−0.96	0.67	−1.44	0.15	−2.27	0.35
Hearing loss∗Other individuals	−2.20	0.62	−3.53	0.00	−3.42	0.98
Both Difficulties∗Black individuals	0.42	0.51	0.84	0.40	−0.57	1.42
Both Difficulties∗Hispanic individuals	−0.49	0.50	−0.98	0.33	−1.48	0.50
Both Difficulties∗Other individuals	0.00	0.91	0.03	0.84	0.95	1.26
Intercept1	−1.86	0.09	−19.73	0.00	−2.04	1.67
Intercept2	−1.65	0.09	−17.93	0.00	−1.83	1.47
Intercept3	−1.46	0.09	−16.01	0.00	−1.64	1.28
Intercept4	−1.31	0.09	−14.46	0.00	−1.48	1.13
Intercept5	−1.11	0.09	−12.39	0.00	−1.29	0.94
Intercept6	−0.94	0.09	−10.46	0.00	−1.11	0.76
Intercept7	−0.61	0.09	−6.86	0.00	−0.78	0.44
Intercept8	−0.29	0.09	−3.30	0.00	−0.46	0.12
Intercept9	0.36	0.09	4.07	0.00	0.18	0.53
Intercept10	0.87	0.09	10.00	0.00	0.70	1.03
Intercept11	1.50	0.09	17.16	0.00	1.33	1.67
Dependent Variable: Part 1: Paid employment (0,1); Part 2: Income Level (1–12)						

Reference group: Sex (male), Race/ethnicity (non–Hispanic White individuals), Region (Northeast), Education (Less than high school), Hearing (No difficulties), Insurance (insured), Health facility (Has a regular facility for care), Health (Excellent/very good/good), Parental income (income < 50th percentile). ***Indicates*** statistically significant at 95% confidence level. Std Err, Standard Error; CI, Confidence Interval. Estimates were weighted to reflect a nationally representative sample. Model offset by the log of exposure. $N = 25{,}664$. Bold represents statistically significant values.

4.1 Limitations

Despite the robustness of these findings, they must be interpreted in the context of the following limitations. First, all data was self-reported and cannot be otherwise verified, validated, or confirmed. Despite self-reported, survey data, is known to suffer from several biases including favorability bias, recall bias, acquiescence bias, and demand bias. Second, we are unable to account for any treatment, care, or mitigation efforts to absolve their hearing loss or tinnitus. While they may have previously or contemporaneously received amelioratory services, this information was not collected. Third, slightly lower percentages of the sample reported hearing loss and tinnitus than is seen in the general population. This likely reflects the difference between self-reported and clinically validated data use. Fourth, we do not account for differences in the severity, frequency, or chronic nature of either hearing loss or tinnitus which was not available in the data but could influence results. The data also does not confirm whether the reported hearing loss was congenital or acquired. Fifth, due to small cell sizes we combined non-Hispanic Asian/Pacific Islander, non-Hispanic American Indian/Native American, non-Hispanic Other, and Multiracial individuals into a single category. This decision, however, obscured the distinct heterogeneity of these groups illustrating the necessity of future studies with larger and more diverse samples. Finally, it is not possible to control for all sources of individual heterogeneity in these data for reasons such as availability within the ADD Health survey, confounding of statistical robustness, and unobservability.

5 Conclusions

Young adults with hearing loss are less likely to earn the same level of income to those absent of hearing loss and performing the same job even after controlling for relevant covariates. These observations are magnified when young adults from racial-ethnic minoritized backgrounds have hearing related issues. Future work is needed to determine the long-term impact for all individuals with hearing loss and to develop policy strategies to ensure equitable workforce participation and subsequently income.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://researchdata.unc.edu/.

Ethics statement

The studies involving humans were approved by the University of Florida Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

MJ: Methodology, Supervision, Visualization, Investigation, Data curation, Formal analysis, Software, Conceptualization, Funding acquisition, Validation, Resources, Writing – original draft, Writing – review & editing, Project administration. ET: Resources, Writing – original draft, Writing – review & editing, Conceptualization, Methodology. CE: Writing – original draft, Project administration, Visualization, Resources, Conceptualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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