

SUPPLEMENTARY TABLE 1. Domains of Depressive Symptom.

Depressive symptom domain	Item 1	Item 2	Item 3
Cognitive-affective domain	Feeling sad	Feeling depressed	Feeling lonely
Somatic domain	Everything was an effort	Restless sleep	Could not get going

SUPPLEMENTARY TABLE 2. Trajectory Definitions of Depressive Symptoms.

Depressive trajectory	Wave 4	Wave 5	Wave 6	Wave 7	Definition
Consistently low	-	-	-	-	No elevated symptoms at any time point
Consistently high	+	+	+	+	Elevated symptoms at all time points
Decreasing	+	-	-	- / =	Elevated symptoms at the initial time point(s) followed by a consistent decline;
	+	+	-	- / =	
Increasing	-	+	+	+ / =	No elevated symptoms initially but consistent elevation thereafter
	-	-	+	+ / =	
Fluctuating					All other cases where the above conditions are not met

SUPPLEMENTARY TABLE 3. Baseline Characteristics of Participants Stratified by Depression Severity in the NHANES.

Characteristic	Overall (n = 1736)	Non-depressed (n = 1274)	Mild depression (n = 309)	Moderate depression (n = 102)	Severe depression (n = 51)	p
Age, y, mean (SD)	66.3 (7.5)	66.4 (7.5)	66.5 (7.7)	66.3 (7.9)	63.6 (6.8)	0.077
Sex, n (%)						0.103
Male	827 (47.6)	627 (49.2)	128 (41.4)	47 (46.1)	25 (49.0)	
Female	909 (52.4)	647 (50.8)	181 (58.6)	55 (53.9)	26 (51.0)	
Race/ethnicity, n (%)						0.003
Mexican American	264 (15.2)	198 (15.5)	40 (12.9)	12 (11.8)	14 (27.5)	
Other hispanic	233 (13.4)	162 (12.7)	47 (15.2)	16 (15.7)	8 (15.7)	
Non-hispanic white	667 (38.4)	465 (36.5)	135 (43.7)	44 (43.1)	23 (45.1)	
Non-hispanic black	377 (21.7)	287 (22.5)	66 (21.4)	19 (18.6)	5 (9.8)	
Other race	195 (11.2)	162 (12.7)	21 (6.8)	11 (10.8)	1 (2.0)	
Educational attainment, n (%)						< 0.001
Below high school	203 (11.7)	136 (10.7)	41 (13.3)	15 (14.7)	11 (21.6)	
Completed high school	225 (13.0)	138 (10.8)	54 (17.5)	26 (25.5)	7 (13.7)	
College or above	1308 (75.3)	1000 (78.5)	214 (69.3)	61 (59.8)	33 (64.7)	
BMI, kg/m², mean (SD)	29.9 (6.6)	29.5 (6.4)	30.5 (6.7)	31.0 (7.7)	32.5 (7.7)	< 0.001
TyG, mean (SD)	8.7 (0.7)	8.7 (0.7)	8.8 (0.8)	9.0 (0.8)	8.6 (0.6)	< 0.001
PIR, mean (SD)	2.5 (1.6)	2.7 (1.6)	2.1 (1.4)	2.0 (1.4)	1.6 (1.1)	< 0.001
SIRI, mean (SD)	1.4 (1.0)	1.3 (1.0)	1.4 (0.9)	1.5 (0.9)	1.8 (1.8)	0.005
Smoking status, n (%)						< 0.001
Never	850 (49.0)	648 (50.9)	137 (44.3)	45 (44.1)	20 (39.2)	
Former	578 (33.3)	428 (33.6)	108 (35.0)	29 (28.4)	13 (25.5)	
Current	308 (17.7)	198 (15.5)	64 (20.7)	28 (27.5)	18 (35.3)	
Alcohol consumption, n (%)						0.228
Yes	174 (10.0)	133 (10.4)	33 (10.7)	5 (4.9)	3 (5.9)	
No	1562 (90.0)	1141 (89.6)	276 (89.3)	97 (95.1)	48 (94.1)	
Physical activity, n (%)						0.194
Inactive	1073 (61.8)	794 (62.3)	185 (59.9)	71 (69.6)	23 (45.1)	
Moderate	363 (20.9)	261 (20.5)	70 (22.7)	15 (14.7)	17 (33.3)	
Vigorous	50 (2.9)	38 (3.0)	7 (2.3)	4 (3.9)	1 (2.0)	
Both moderate and vigorous	250 (14.4)	181 (14.2)	47 (15.2)	12 (11.8)	10 (19.6)	
Comorbidities, n (%)						< 0.001
Yes	1044 (60.1)	712 (55.9)	208 (67.3)	81 (79.4)	43 (84.3)	
No	692 (39.9)	562 (44.1)	101 (32.7)	21 (20.6)	8 (15.7)	
Antidepressants use, n (%)						0.006
No	1697 (97.8)	1255 (98.5)	295 (95.5)	98 (96.1)	49 (96.1)	
Yes	39 (2.2)	19 (1.5)	14 (4.5)	4 (3.9)	2 (3.9)	
Memory problem, n (%)						
No	1545 (89.0)	1210 (95.0)	252 (81.6)	58 (56.9)	25 (49.0)	
Yes	191 (11.0)	64 (5.0)	57 (18.4)	44 (43.1)	26 (51.0)	
Occupation noise, n (%)						< 0.001
No	1101 (63.4)	844 (66.2)	171 (55.3)	61 (59.8)	25 (49.0)	
Yes	635 (36.6)	430 (33.8)	138 (44.7)	41 (40.2)	26 (51.0)	
Recreational noise, n (%)						< 0.001
No	1518 (87.4)	1137 (89.2)	262 (84.8)	82 (80.4)	37 (72.5)	
Yes	218 (12.6)	137 (10.8)	47 (15.2)	20 (19.6)	14 (27.5)	
Firearm noise, n (%)						0.991
No	1041 (60.0)	761 (59.7)	187 (60.5)	62 (60.8)	31 (60.8)	
Yes	695 (40.0)	513 (40.3)	122 (39.5)	40 (39.2)	20 (39.2)	
Low-frequency PTA, dB, mean (SD)	19.6 (12.0)	19.1 (11.7)	20.0 (11.9)	21.4 (14.0)	26.0 (13.4)	< 0.001
Speech-frequency PTA, dB, mean (SD)	23.9 (12.6)	23.4 (12.3)	24.2 (12.5)	25.8 (14.2)	30.7 (13.7)	< 0.001
High-frequency PTA, dB, mean (SD)	43.3 (18.7)	43.0 (18.9)	43.0 (18.1)	45.0 (17.8)	51.1 (17.7)	0.017
PHQ, mean (SD)	3.3 (4.2)	1.2 (1.4)	6.7 (1.4)	11.5 (1.4)	18.5 (3.0)	< 0.001

NHANES, National Health and Nutrition Examination Survey; SD, standard deviation; BMI, body mass index; TyG, triglyceride-glucose index; PIR, poverty-income ratio; SIRI, systemic inflammation response index, PTA, pure-tone average.

SUPPLEMENTARY TABLE 4. Model Diagnostics for Multivariable Linear Regression in NHANES.

Frequency	Shapiro-Wilk p-value	Levene's p
Low-frequency PTA	< 0.001	< 0.001
Speech-frequency PTA	< 0.001	< 0.001
High-frequency PTA	< 0.001	< 0.001

NHANES, National Health and Nutrition Examination Survey; PTA, pure-tone average.

SUPPLEMENTARY TABLE 5. Quantile Regression Validation in NHANES.

Frequency range	Depression level	β (95% CI)	p -value
Low-frequency PTA	No	Ref	
	Mild	0.59 (-2.06, 3.24)	0.650
	Moderate	0.23 (-3.83, 4.30)	0.897
	Severe	6.61 (0.69, 12.52)	0.029
Speech-frequency PTA	No	Ref	
	Mild	1.07 (-1.24, 3.38)	0.364
	Moderate	0.83 (-4.03, 5.69)	0.738
	Severe	8.51 (1.46, 15.56)	0.018
High-frequency PTA	No	Ref	
	Mild	0.97 (-0.88, 2.81)	0.303
	Moderate	0.82 (-3.03, 4.68)	0.677
	Severe	8.70 (1.20, 16.19)	0.023

NHANES, National Health and Nutrition Examination Survey; PTA, pure-tone average; CI, confidence interval.

SUPPLEMENTARY TABLE 6. Restricted Cubic Spline Analysis for Covariate Non-Linearity in Hearing Threshold Associations.

Variable	χ² (linear)	p value (linear)	χ² (non-linear)	p value (non-linear)	Interpretation
Age	241.25	< 0.0001	23.99	< 0.0001	Significant non-linearity
BMI	15.19	0.0017	3.40	0.1825	Linear significant; non-linear not significant
PIR	3.76	0.2885	3.37	0.1859	Neither linear nor non-linear significant
TyG	4.22	0.2383	0.02	0.9898	Neither linear nor non-linear significant
SIRI	8.95	0.0028	1.28	0.2586	Linear significant; non-linear not significant

BMI, body mass index; PIR, poverty-income ratio; TyG, triglyceride-glucose index; SIRI, systemic inflammation response index.

SUPPLEMENTARY TABLE 7. Interaction Effects Between Covariates and Depression Severity on Hearing Thresholds (p < 0.05).

Variable	Depression level	Interaction term	β (95% CI)	p value
Age	Mild depression	Age	0.33 (0.08, 0.58)	0.010
Race	Severe depression	Other Race	26.62 (14.74, 38.51)	< 0.001
Firearm noise	Mild depression	Firearm noise exposure	-6.70 (-10.98, -2.41)	0.002
Firearm noise	Severe depression	Firearm noise exposure	-16.91 (-26.89, -6.93)	0.001
Physical activity	Severe depression	Moderate activity	-13.88 (-25.61, -2.14)	0.021
Physical activity	Severe depression	Vigorous activity	-19.59 (-30.78, -8.41)	0.001
Physical activity	Severe depression	Both activity types	10.15 (3.12, 17.19)	0.005
Memory	Severe depression	Memory impairment	-19.16 (-33.39, -4.94)	0.008
SIRI	Mild depression	SIRI	2.67 (0.15, 5.19)	0.037
SIRI	Moderate depression	SIRI	7.13 (2.93, 11.33)	0.001

SIRI, systemic inflammation response index; CI, confidence interval.

SUPPLEMENTARY TABLE 8. Associations Between Depressive Symptom Scores and Risk of Hearing Loss.

Variable	Unadjusted HR (95% CI)	p	FDR q	Adjusted HR (95% CI) ^a	p	FDR q	E-value
Total depressive symptoms score							
Per SD increase	1.07 (1.05-1.10)	< 0.001	0.002	1.10 (1.07-1.13)	< 0.001	0.002	1.43
Cognitive-affective depressive symptoms score							
Per SD increase	1.07 (1.01-1.14)	0.027	0.027	1.09 (1.03-1.17)	0.007	0.027	1.40
Somatic depressive symptoms score							
Per SD increase	1.17 (1.11-1.23)	< 0.001	0.002	1.22 (1.16-1.29)	< 0.001	0.002	1.74

^aAdjusting for age, sex, education attainment, cognition function, marital status, tobacco and alcohol use, diabetes and hypertension.

HR, hazard ratio; FDR, false discovery rate; SD, standard deviation; CI, confidence interval.

SUPPLEMENTARY TABLE 9. Somatic Depressive Symptom Domain in Relation to Incident Hearing Loss.

Variable	Unadjusted HR (95% CI)	p	FDR q	Adjusted HR (95% CI) ^a	p	FDR q	E-value
Everything was an effort							
No	Ref			Ref			
Yes	1.39 (1.28-1.51)	< 0.001	< 0.001	1.32 (1.21-1.45)	< 0.001	< 0.001	2.10
Restless sleep							
No	Ref			Ref			
Yes	1.23 (1.14-1.32)	< 0.001	< 0.001	1.22 (1.14-1.32)	< 0.001	< 0.001	1.76
Could not get going							
No	Ref			Ref			
Yes	1.31 (1.20-1.43)	< 0.001	< 0.001	1.31 (1.20-1.44)	< 0.001	< 0.001	2.03

^aAdjusting for age, sex, education attainment, cognition function, marital status, tobacco and alcohol use, diabetes and hypertension.

HR, hazard ratio; FDR, false discovery rate; CI, confidence interval.

SUPPLEMENTARY TABLE 10. Kaplan-Meier Analysis Parameters for Incident Hearing Loss.

Trajectory group	n	Events (n)	Censored (n) ^a	Median follow-up (years)	Mean follow-up (years)	Event rate
Consistently low	3,304	885	2,419	18.0	16.2	26.8%
Decreasing	110	34	76	18.0	15.6	30.9%
Fluctuating	1,364	441	923	18.0	15.9	32.3%
Increasing	103	40	63	18.0	15.4	38.8%
Consistently high	149	53	96	18.0	15.7	35.6%

^aParticipants without hearing loss at end of follow-up.

SUPPLEMENTARY TABLE 11. Post-Hoc Power Analysis for Trajectory Group Comparisons vs. Consistently Low Group

Depressive symptom trajectory	Sample size (case/control)	Minimum detectable effect size (Cohen's d) [*]	Statistical power for observed effect	Power to detect medium effect (d = 0.5)
Consistently high	156 / 3612	0.30	92%	> 99%
Increasing	113 / 3612	0.35	85%	98%
Decreasing	117 / 3612	0.34	54%	98%

^{*}Minimum detectable effect size represents the smallest Cohen's d detectable with 80% power at α = 0.05 (two-tailed).

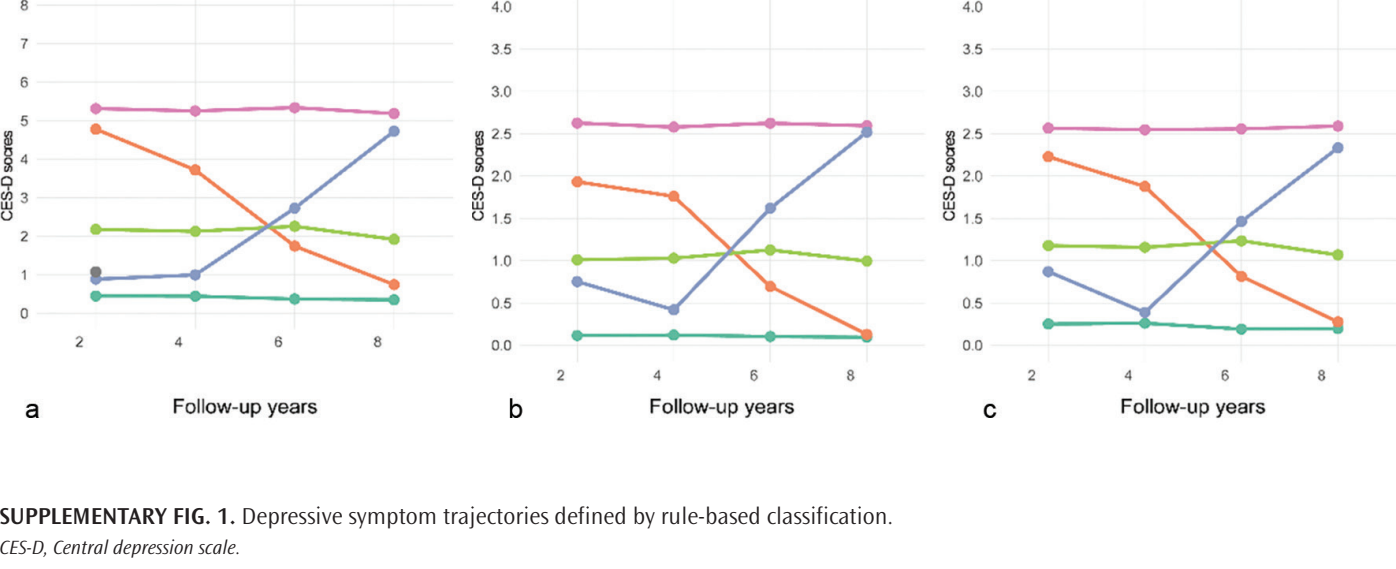
SUPPLEMENTARY TABLE 12. Covariate-Specific Proportional Hazards Testing in Depressive Trajectory Cox Models.

Trajectory type	Model	Variables	Chi-square	df	p
Total	Crude	Depressive trajectory	7.21	4	0.130
		GLOBAL	7.21	4	0.130
Total	Adjusted	Depressive trajectory	6.03738	4	0.196
		Education	2.73708	3	0.434
		Marital status	0.00061	1	0.980
		Household income	0.40053	2	0.819
		Smoking status	0.34237	1	0.558
		Drinking status	3.89914	1	0.048
		Hypertension	2.13014	1	0.144
		Diabetes	0.04756	1	0.827
		Cognition	0.15459	1	0.694
		GLOBAL	17.19988	15	0.307
Cognitive	Crude	Depressive trajectory	4.17	4	0.380
		GLOBAL	4.17	4	0.380
Cognitive	Adjusted	Depressive trajectory	10.00	4	0.040
		Education	2.75991	3	0.432
		Marital status	0.00222	1	0.988
		Household income	0.36327	2	0.834
		Smoking status	0.40003	1	0.527
		Drinking status	3.65304	1	0.056
		Hypertension	2.24446	1	0.134
		Diabetes	0.05876	1	0.808
		Cognition	0.14466	1	0.704
		GLOBAL	16.16588	15	0.371

df, degrees of freedom.

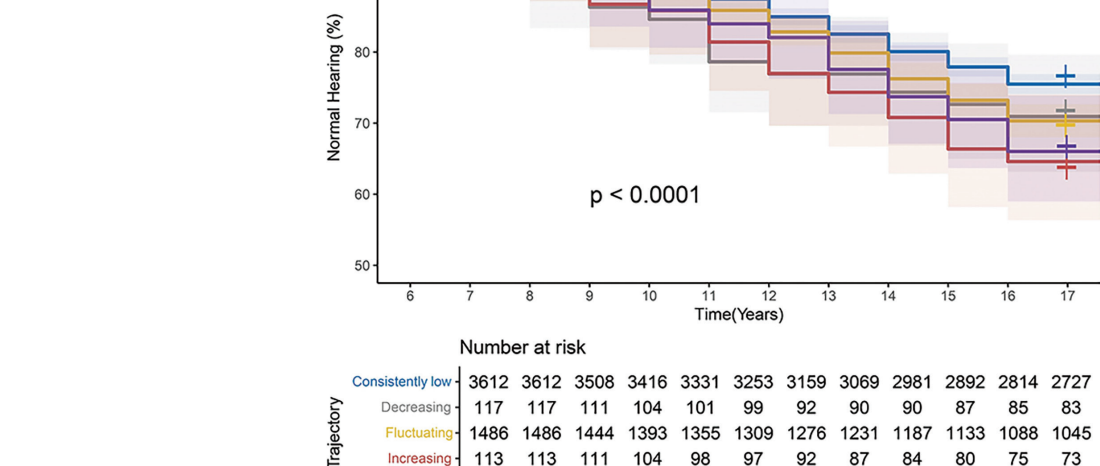
SUPPLEMENTARY TABLE 13. Critical Methodological Gaps in Longitudinal Evidence on Depressive Symptomatology as a Precursor to Hearing Impairment.

Author	Year	Country	Type	Diagnostic criteria (HL)	Diagnostic criteria (depression)	Sample	Limitations
Kim et al. ¹	2020	Korea	CS	PTA	MD	325,230	1. Population representativeness: exclusively East Asian cohort 2. Dynamic exposure: depression trajectories not analyzed
Liu et al. ²	2022	China	CS	SR	DDS	13,690	1. HL subtype focus: limited to sudden SNHL 2. Population: east Asian cohort only 3. Temporal dynamics: no longitudinal depression assessment
Wu ³	2021	China	C-C	SR	DDS (CESD-10)	8,339	1. Population: restricted to East Asians 2. Exposure variability: static depression measurement 3. Confounding: inadequate control for noise exposure/comorbidities
Lin et al. ⁴	2016	Taiwan	CS	HIS	MD	55,094	1. Generalizability: East Asian-specific findings 2. Mechanistic insight: no depression progression analysis



SUPPLEMENTARY FIG. 1. Depressive symptom trajectories defined by rule-based classification.

CES-D, Central depression scale.



SUPPLEMENTARY FIG. 2. Kaplan-Meier curves of cumulative hearing loss incidence in groups with different depressive symptom trajectories.

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