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Original Article

Hearing loss, diet, and cognitive decline: interconnections for dementia prevention

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ABSTRACT

Background: Hearing loss poses a significant global public health concern associated with cognitive decline. Among the many risk factors associated with Alzheimer's disease and related dementia (ADRD), hearing loss is the most prevalent sensory impairment in older adults and has emerged as a significant, yet often overlooked, modifiable risk factor for dementia.

Objectives: To assess 1) the association between diet and risk of hearing loss in older adults and 2) the modifying effect of diet on the impact of hearing loss on cognitive decline in an aging population.

Design: Prospective cohort study

Setting: The Chicago Health and Aging Project, a community-based cohort study

Participants: A total of 5,145 older adults (62 % non-Hispanic Black, 63 % female).

Measurements: Self-reported hearing ability was assessed during each cycle of data collection. Diet was assessed by a 144-item Food Frequency Questionnaire. Diet quality was evaluated using a 144-item Food Frequency Questionnaire, focusing on adherence to dietary patterns such as Dietary Approaches to Stop Hypertension (DASH), Mediterranean, and Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND). Cognitive function assessment was conducted during the in-home visits at each cycle. Four cognitive tests, including the East Boston tests of immediate and delayed recall, the mini-mental State Examination, and the Symbol Digit Modalities test, were included. We used linear mixed effect models to examine 1) the association of hearing loss and cognitive decline and 2) the association of diet on cognitive decline through modifying risk hearing loss. Discrete-time survival analysis examined the association between dietary patterns and the time to hearing impairment.

Results: Among 5,145 participants included in the analyses, 747 (14.5 %) reported hearing loss, including 207 Black adults and 199 White adults. Each unit increase in the DASH, MedDiet, and MIND scores was associated with 19 % (95 % CI: 0.79, 0.94, $P < 0.001$), 11 % (95 % CI: 0.79, 1.00, $P = 0.05$), and 13 % (95 % CI: 0.87, 0.99, $P < 0.05$) lower risk for hearing loss, respectively. High adherence to the Western diet was associated with an earlier onset of hearing loss up to 14 months ($P < 0.05$). Participants had an increased rate of cognitive decline after reporting hearing loss. During follow-up, participants in the highest tertile of the DASH diet score who reported hearing loss experienced a 17 % faster cognitive decline ($\beta = -0.07 \pm 0.01$) compared to those without hearing loss ($\beta = -0.06 \pm 0.003$). However, this decline was significantly slower than that of participants observed in the lowest tertile of the DASH diet, who exhibited a 67 % faster cognitive decline ($\beta = -0.10 \pm 0.012$, $P = 0.05$).

Discussion: Healthy dietary patterns, particularly the DASH diet, was associated with a reduced risk of hearing loss and slower cognitive decline following hearing loss. Clinically, these findings underscore the importance of dietary quality in preserving cognitive health by potentially mitigating risk of hearing loss or delaying the onset of hearing loss in older adults.

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1. Background and objectives

The burden of Alzheimer's disease and related dementias (ADRD) is continuously growing in parallel with the aging population, presenting an urgent public health challenge [1]. Among the many risk factors associated with ADRD, hearing loss is the most prevalent sensory impairment in older adults and has emerged as a significant, yet often overlooked, modifiable risk factor for dementia [2–4]. Hearing loss is associated with accelerated cognitive decline and an increased risk of dementia. The 2024 Lancet Commission report cited that individuals with hearing loss have a 37 % increased risk of dementia [HR 1.37 %, 95 % CI 1:00–1:87] [3]. In the U.S., approximately 63 % of adults over age 70 are affected by hearing impairment, [5,6] underscores the substantial public health implications of addressing hearing loss as a potential target for dementia prevention.

Although there is robust evidence that diet rich in anti-inflammatory and antioxidant nutrients supports cardiovascular and brain health [7–11], hearing loss remains an understudied risk factor of dementia in the context of dietary prevention. Given that the cochlea, the sensory organ responsible for hearing, relies on a constant supply of oxygenated blood from the labyrinthine artery, a healthful diet that promotes vascular health may also help preserve cochlear function. This dietary approach could reduce hearing loss and, in turn, mitigate its negative effects on cognition. However, few studies have explored the potential of diet to prevent age-related hearing loss [12] and its associated cognitive impacts, leaving a significant knowledge gap.

In the present study, our overarching goal was to investigate the impact of diet on cognition by modifying the risk of hearing loss, an understudied risk factor. Specifically, we aimed to first examine whether healthful dietary patterns namely, the Mediterranean Diet (MedDiet), Dietary Approaches to Stop Hypertension (DASH) Diet, and Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) Diet - can lower the risk of hearing loss followed by an examination of their subsequent impact on cognitive function. Leveraging data from the Chicago Health and Aging Project, a longitudinal, bi-racial, population-based study, we investigated diet as a modifiable lifestyle factor that may modify hearing loss risk and its associated cognitive function in older adults. This work has the potential to highlight diet-based strategies for reducing sensory and cognitive deterioration, offering a non-invasive, accessible intervention for public health.

2. Methods

2.1. Study population

The Chicago Health and Aging Project (CHAP) is a longitudinal, population-based cohort that began enrollment in 1993 of older adults 65 years and older from four neighborhoods on the south side of Chicago [13]. The Rush University Medical Center Institutional Review Board approved the study. All participants provided informed consent. Completing the self-administered questionnaire was considered as providing informed consent as well.

2.2. Dietary assessment

Diet was assessed using a 144-item FFQ modified from the Harvard FFQ validated for use in older residents [14]. Details on the FFQ collection were published previously [14]. In brief, participants were asked to report how often, on average, they consumed specific foods or beverages with pre-specified portion sizes during the preceding year. We used the Harvard University food composition and USDA databases to calculate nutrient intake. The frequency of consumption of foods was multiplied by either the natural portion size (i.e., 1 apple) or serving sizes based on sex-specific mean portion sizes derived from a national survey for older adults. A trained research assistant conducted screening on the quality of the FFQs. Those with >50 % of pages left unanswered were

documented. We used the first available FFQ to calculate the dietary scores.

The MedDiet score, as previously described, [15] was based on 11 food groups, with a scoring range from 0 to 5 for each food item, with a total MedDiet score ranging from 0 to 55. The scoring of MedDiet for the CHAP population was previously published [16]. The higher scores corresponded to greater adherence to the MedDiet.

DASH diet score was based on ten food groups. Food items on the CHAP FFQ were assigned to 7 DASH food groups, and three components, the proportion of energy from total fat, saturated fat, and milligrams sodium per day, were computed using the Harvard nutrient database. The composite DASH diet accordance score (0 to 10) was calculated in previous publication [17]. The MIND diet score has 15 dietary components, including ten food groups (green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, poultry, olive oil, and wine) related to brain health and five unhealthy food groups (red meats, butter and stick margarine, cheese, pastries, and sweets, and fried/fast food) [10,11]. For all other diet score components except olive oil, a score of 0, 0.5, or 1 was assigned to the frequency of consumption of 1 portion of each food item.

The Western diet score was derived using principal component analysis as described previously [18]. In brief, two distinct diet patterns were identified using factor analysis with factor loading > 0.2. We labeled factor 1 as a healthy dietary pattern and factor 2 as the Western pattern characterized by a high intake of processed meat, red meat, butter, high-fat dairy products, eggs, and refined grains. The Western diet scores (0 to 19) were generated by ranking participants as per their adherence to this dietary pattern. A higher Western diet score was indicative of more consumption of unhealthy food. We standardized individual diet scores as z-scores by subtracting the baseline mean and dividing by the standard deviation.

2.3. Assessment of hearing loss

Self-reported hearing loss was determined based on the response to a questionnaire on hearing capacity through each data cycle. Our hearing question asked: "Can you usually hear and understand what a person says without seeing his face if that person talks in a normal voice to you in a quiet room", which provided a possible response of "Yes", "No", or no answer. Those who did not provide answers were considered missing data and were excluded from the analysis.

Participants who answered "No" to the first question were identified as individuals with hearing loss. Questionnaire-based self-reported hearing loss in large populations has been validated in previous studies and has demonstrated good sensitivity in detecting hearing loss [19–21]. In the Blue Mountains hearing study, a single question on hearing loss appeared sufficiently sensitive and specific to provide a reasonable estimate of hearing loss prevalence among older adults. The sensitivity of using a single question to detect mild hearing loss - defined as the better ear pure-tone average hearing thresholds at 0.5, 1, 2, 4 kHz ($BEPTA_{0.5,1,2,4\text{ kHz}} > 25\text{ dB HL}$) - was 84 % for older men and 75 % for women [19]. The sensitivity to detect moderate hearing loss ($BEPTA_{0.5,1,2,4\text{ kHz}} > 40\text{ dB HL}$) was 97 % for men and 95 % for women, and 100 % for detecting severe hearing loss ($BEPTA_{0.5,1,2,4\text{ kHz}} > 60\text{ dB HL}$) [19]. The specificity was 72 %, 65 %, and 64 % for women, and 58 %, 51 %, and 48 % for men. Findings from previous cohort studies showed that self-reported functional hearing ability provides an ecologically valid assessment of hearing in real-world settings [12,22].

2.4. Cognitive function assessment

Cognitive function assessment was conducted during the in-home visits at each cycle. Four cognitive tests, including the East Boston tests of immediate and delayed recall [23,24], the mini-mental State Examination [25], and the Symbol Digit Modalities test [26,27], were included. We transformed the raw scores to z scores for each test using

means and standard deviations taken from the CHAP baseline population. The average of z scores from each test was used as a global measure of cognitive function. With this approach, the cognitive score is scaled in standardized units with a positive score indicating better performance [28].

2.5. Assessment of covariates

During the participant's in-home interview, social and demographic characteristics, including age (y), sex (female/male), education (years in school), smoking status (never smoking, current or former smoker), and medical history were collected. Race and ethnicity were self-identified at baseline based on the 1990 US Census questionnaire. Weight (kg) and height (m) were measured during the in-home interview and used to compute BMI. Medical history of diabetes, hypertension, heart disease (self-reported history of myocardial infarction or digitalis use), stroke, and medication use were self-reported [29]. Lifetime socioeconomic status (SES) consisted of self-reported SES in childhood and adulthood.

2.6. Statistical analyses

2.6.1. Dietary patterns and risk of hearing loss

We used the Kaplan-Meier survival curve to estimate the survival function for the time until hearing impairment was reported. If participants never reported hearing impairment, their time was considered censored at their final visit. A log-rank test was then used to compare the survival distributions of diet scores categorized into tertiles, with higher tertiles indicating closer self-reported adherence to the dietary pattern. We used the first available FFQ to calculate scores for each dietary pattern.

We further examined the association between dietary patterns and the time to hearing impairment using discrete-time survival analysis, considering that hearing impairment was reported within three-year data collection intervals. This approach measured time as the number of data collection cycles until the first reported hearing impairment or censoring at the final data cycle. We analyzed dietary pattern scores as both continuous and categorical measures in tertiles. Three models were conducted. Model 1 was adjusted for age (years), sex (F/M), race, education (years), calorie (kcal), smoking status, baseline global cognition. Model 2 was Model 1 further adjusted for cardiovascular disease comorbidities (history of hypertension, diabetes, heart disease, and stroke). Model 3 was Model 2 further adjusted for BMI.

2.6.2. Modification of the effect of diet on hearing loss and cognitive decline

We used a linear mixed effects model to examine 1) the association of hearing loss and cognitive decline and 2) the impact of diet on cognitive function through modifying the risk of hearing loss. This model allowed for a change in slope beginning at the first report of hearing impairment and, therefore, provided estimates of the annual rate of cognitive decline separately for the periods before and after reporting hearing loss. To fit this model, we defined two-time variables. Overall time was defined as the years elapsed since the baseline interview. Cognitive decline after the self-reported hearing impairment was modeled by adding a second time variable that was zero until the time of hearing impairment and then counting the number of years following the self-report of hearing impairment. This second-time variable measured the additional effect of cognitive decline after the report of hearing loss. In our cohort, in the pre-hearing loss phase, the annual rate of decline for those without hearing loss was -0.0623 standard unit (SU), the slope for those with hearing loss was -0.0624 SU ($P = 0.97$). Because of the differences of -0.0001 SU was nearly identical to that of participants who never reported hearing impairment. Therefore, for improved visualization and interpretation, we combined data from these two groups in our modeling. This assumes that the cognitive decline before hearing impairment is equal to the overall rate of cognitive decline.

In the model examining the association of hearing loss and cognitive decline, we accounted for participants' age, sex, race, education, total calorie intake, cardiovascular disease comorbidities, time, and each variable's respective interaction term with time. We also included a variable of the time since the onset of hearing loss. In the model examining the dietary effects on cognition through modifying hearing loss risk, we further accounted for diet score and an interaction term of diet score and time after onset for those who reported hearing impairment. The dietary score was evaluated as a continuous variable, and the categorical variable was divided into tertiles. SAS version 9.4 (SAS Institute Inc.) was used for data analysis with a type 1 error rate for significance at 0.05, and all tests were 2-sided.

3. Results

3.1. Characteristics of the study sample

The mean age of participants was 73 years old (Table 1). During follow up, 747 participants reported hearing impairment and they were significantly older and had lower lifetime SES and global cognition scores than those with no hearing impairment. Individuals with hearing loss had marginally lower (worse) scores for the MIND, Mediterranean, and DASH diet scores and, in contrast, a slightly higher score for Western dietary patterns. A higher proportion of Black participants reported no hearing impairment during follow-up compared to White/Caucasian participants. Baseline characteristics based on tertile of each diet score was presented in **Supplementary Table 1**.

3.2. Association between diet and risk of hearing loss

Table 2 presents the association between diet and risk of hearing loss. The lowest tertile of each dietary pattern was considered the reference group. Higher MIND, MedDiet, and DASH scores were associated with a significantly lower risk of developing hearing loss (Fig. 1). The HR of developing hearing loss for individuals in the highest tertile of MIND, MedDiet, and DASH was 0.79 [95 % CI: 0.64, 0.97, $P = 0.03$], 0.80 [95 % CI: 0.64, 1.00, $P = 0.05$] and 0.72 [95 % CI: 0.59, 0.88, $P = 0.001$] (Table 2). One standardized unit increase in the MIND, MedDiet, and DASH scores was associated with 11 %, 8 %, and 13 % lower risk, respectively (Table 2). In contrast, individuals in the mid-tertile of the Western diet had a significantly higher risk (HR: 1.45, 95 % CI [1.16, 1.80], $P = 0.0009$). The association was marginal significant for those in the highest tertile Western diet ($P = 0.08$) Table 3.

3.3. Association between hearing loss and cognitive decline

In line with previous findings, self-reported hearing loss in older adults was associated with faster cognitive decline. Compared to individuals reporting no hearing loss during follow-up, those with hearing loss experienced faster cognitive decline ($\beta = -0.0241 \pm 0.0057$, $P = 0.0001$) (Supplementary Fig 1).

3.4. Association between diet, hearing loss risk and cognition

Subsequently, we examined the effect of diet modification on cognitive function by mitigating the risk of hearing loss (Fig. 2). During follow-up, participants in the highest tertile of the DASH diet score who reported hearing loss experienced a 17 % faster cognitive decline ($\beta = -0.07 \pm 0.01$) compared to those without hearing loss ($\beta = -0.06 \pm 0.003$, $P < 0.0001$). However, this decline was significantly slower than observed in participants in the lowest (worst) tertile, who exhibited a 67 % faster cognitive decline ($\beta = -0.10 \pm 0.012$, $P = 0.05$ Fig. 2).

Table 1
Baseline participants' characteristics.

Variable	Overall N = 5145*	No hearing loss N = 4398*	Developed hearing loss N = 747*
Age (yr)	73.4 (5.9)	72.9 (5.6)	76.0 (7.1)
Education (yr)	12.6 (3.5)	12.7 (3.5)	12.0 (3.6)
Calories (Kcal)	1715 (628)	1714 (633)	1724 (596)
MedDiet score	28.4 (4.8)	28.4 (4.8)	28.1 (4.8)
MIND score	7.0 (1.7)	7.0 (1.7)	6.8 (1.6)
DASH score	3.6 (1.3)	3.6 (1.3)	3.5 (1.3)
Western diet score	3.8 (1.9)	3.8 (1.9)	3.9 (1.8)
Global cognition	0.30 (0.69)	0.33 (0.66)	0.15 (0.80)
Lifetime SES	0.20 (0.76)	0.21 (0.77)	0.09 (0.75)
BMI	27.8 (5.8)	27.9 (5.8)	27.0 (5.7)
Male	1892 (37 %)	1625 (37 %)	267 (36 %)
Black	3224 (63 %)	2823 (64 %)	401 (54 %)
Current smoker	676 (13 %)	598 (14 %)	78 (10 %)
Former smoker	2054 (40 %)	1755 (40 %)	299 (40 %)
Hypertension	2729 (53 %)	2370 (54 %)	359 (48 %)
Diabetes	955 (19 %)	835 (19 %)	120 (16 %)
Heart disease	678 (13 %)	578 (13 %)	100 (13 %)
Stroke	413 (8.0 %)	350 (8 %)	63 (8.4 %)

* Mean (SD); n (%).

Table 2
Association of different dietary patterns (in tertiles) and HR of hearing loss among CHAP participants (n = 683).

	T1	T2	T3	Per 1 score increase	P value	
Cases (n)	269	234	180			
Median	5.5	7.0	8.5			
MIND	Model 1	Ref	0.91 (0.76, 1.10)	0.81 (0.66, 0.99)*	0.90 (0.83, 0.98)	0.01
	Model 2	Ref	0.91 (0.75, 1.09)	0.80 (0.65, 0.98)*	0.89 (0.82, 0.97)	0.01
	Model 3	Ref	0.89 (0.73, 1.08)	0.79 (0.64, 0.97)*	0.89 (0.82, 0.98)	0.01
Cases (n)	213	231	239			
Median	23	28	33			
MedDiet	Model 1	Ref	0.98 (0.81, 1.20)	0.83 (0.67, 1.03)	0.92 (0.84, 1.00)	0.08
	Model 2	Ref	0.98 (0.80, 1.19)	0.83 (0.67, 1.02)	0.92 (0.84, 1.01)	0.08
	Model 3	Ref	0.96 (0.78, 1.19)	0.80 (0.64, 1.00)	0.92 (0.84, 1.00)	0.08
Cases (n)	226	224	233			
Median	2	3	4.5			
DASH	Model 1	Ref	0.90 (0.74, 1.10)	0.75 (0.62, 0.91)*	0.89 (0.82, 0.97)	0.003
	Model 2	Ref	0.90 (0.74, 1.09)	0.74 (0.60, 0.90)*	0.88 (0.81, 0.96)	0.004
	Model 3	Ref	0.91 (0.74, 1.11)	0.72 (0.59, 0.88)*	0.87 (0.80, 0.95)	0.002
Cases (n)	197	270	216			
Median	2	3.5	5.6			
Western	Model 1	Ref	1.46 (1.18, 1.80)*	1.32 (1.00, 1.74)*	1.13 (0.98, 1.27)	0.07
	Model 2	Ref	1.46 (1.19, 1.81)*	1.35 (1.02, 1.79)*	1.13 (0.99, 1.29)	0.07
	Model 3	Ref	1.45 (1.16, 1.80)*	1.30 (0.96, 1.74)	1.10 (0.96, 1.27)	0.16

* $P < 0.05$.

Model 1 was adjusted for age (years), sex (F/M), race, education (years), calorie (kcal), smoking status, baseline global cognition.

Model 2 was Model 1 further adjusted for cardiovascular disease comorbidities (history of hypertension, diabetes, heart disease, and stroke).

Model 3 was Model 2 further adjusted for BMI.

3.5. Diet modifying time to the first reported hearing loss

Interestingly, when we analyzed the time to the first reported hearing loss, we found a significant effect of diet (Fig. 3). Participants in the high tertile of the Western experienced significantly earlier onset of hearing impairment, up to 14 months sooner, compared to those in the lowest tertile ($P < 0.05$, Fig. 3). Those in the highest tertile of the MedDiet had a significantly delayed onset of hearing loss ($P < 0.05$, Fig. 3) than those in the lowest tertile of the MedDiet.

4. Discussion

We found that better dietary quality, as indicated by higher scores on the Mediterranean (MedDiet), DASH, and MIND diets, and lower scores on the Western diet were associated with a lower risk and delaying onset of hearing loss. Additionally, adherence healthy dietary

patterns appeared to mitigate cognitive decline by attenuating the risk of hearing loss. While previous studies have examined the independent associations between specific nutrients and cognition and hearing loss risk, to our knowledge, this is one of the first studies to examine the impact of overall diet on global cognition by modifying hearing loss risk.

Epidemiological evidence suggests a protective role of specific nutrients in preventing hearing loss [30–32]. Intake of antioxidant nutrients, including vitamins C and E, beta-carotene [33], and magnesium [34], has been associated with a reduced risk of hearing loss. It is proposed that these antioxidants may neutralize reactive oxygen species (ROS) that cause cochlear damage, thereby preserving auditory cells and potentially mitigating age-related hearing loss [35,36]. However, nutrients are not consumed in isolation but as components of foods within various dietary patterns where their interaction may result in additive or synergistic effects over time.

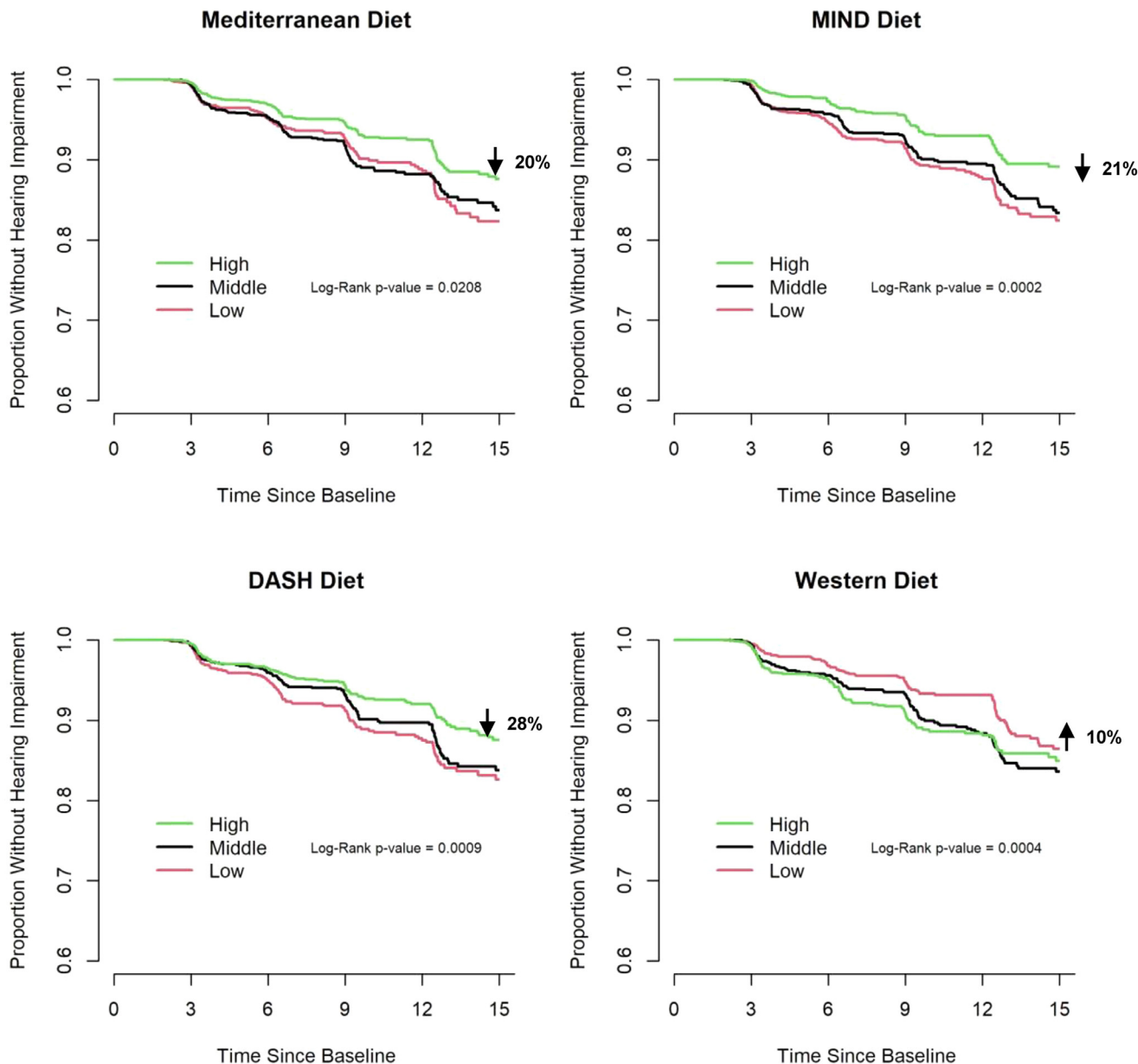


Fig. 1. Kaplan-Meier survival curve comparing dietary patterns (in tertiles) and risk of developing hearing loss ($n = 5145$). Model was adjusted for age (years), sex (F/M), race, education (years), calorie (kcal), smoking status, cardiovascular disease comorbidities, baseline global cognition, BMI. Green, black, and red line represents represent the highest, middle, and lowest tertile of Mediterranean, MIND, DASH and Western diet score, respectively.

Dietary patterns such as the MedDiet, MIND, and DASH recommend higher intakes of plant-based foods such as fruits, vegetables, whole grains, and nuts and reducing the consumption of red meat and processed meat. Previous observational studies and randomized controlled trials have shown that MedDiet and DASH diet lower blood pressure [37,38] and preserve vascular function [39]. Specifically, the DASH diet has been effective in improving endothelial function, lowering blood pressure [40] while the MedDiet, rich in polyphenols [41] from extra virgin olive oil, nuts, fruits, and vegetables, exhibits potent antioxidant properties.

One of the proposed mechanisms linking hearing loss and dementia involves shared vascular pathology where poor vascular health may affect cochlear and hair cell blood supply, causing hearing loss to lead to dementia [42]. We hypothesized that adherence to a healthful diet pattern would have an observable impact on hearing loss due to its po-

tential to enhance nitric oxide availability, thereby improving endothelial function and maintaining vascular health of cochlear capillaries, which may attenuate hearing loss. Indeed, we observed that participants with high Western diet scores experienced an early onset of hearing loss - up to 14 months earlier compared to those with low scores on the Western diet. The Western diet characterized by high intakes of red meat and saturated fats, sugary drinks, and fast and processed food is strongly associated with increased risk of cardiovascular disease (CVD) [43] and hypertension [44]. These associated chronic condition could further contribute to the damage of cochlear vascular health, thus accelerating hearing loss.

Lifestyle factors, such as physical activity, also influence hearing loss risk and cognitive decline. Studies have shown that higher physical activity levels were associated with lower hearing loss risk in women [45], whereas lower levels of physical activity were correlated with worse

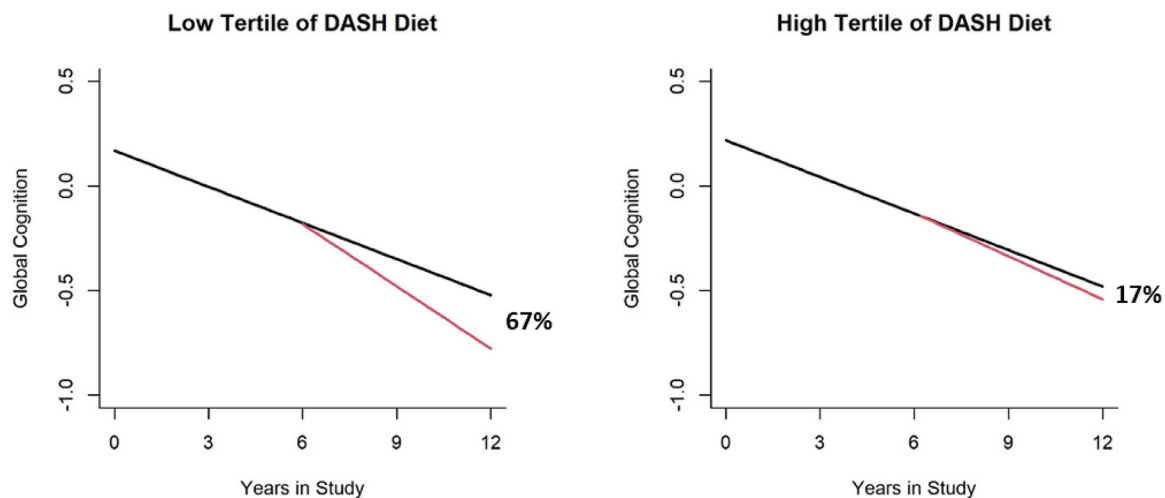
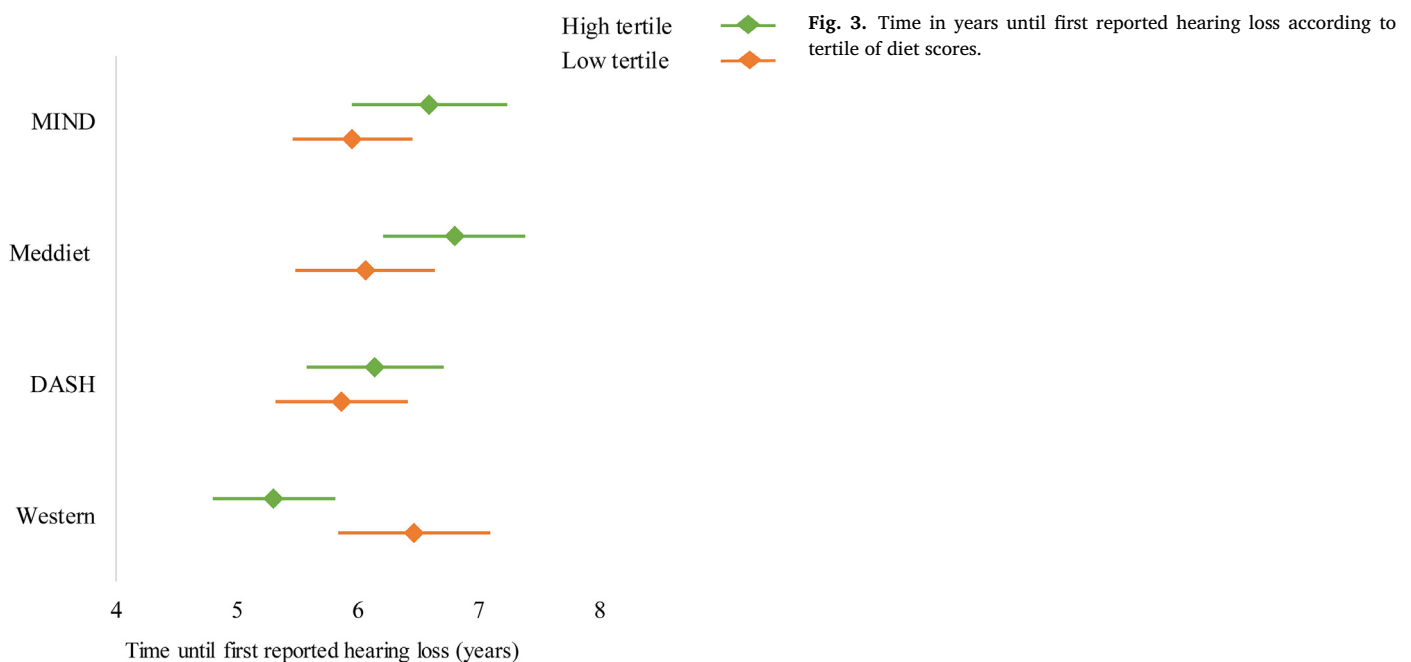


Fig. 2. Global cognition of participants never report hearing loss versus those reported hearing loss according to DASH diet score. Model was adjusted for age (years), sex (F/M), race, education (years), smoking, total calorie intakes (kcal), baseline global cognition, cardiovascular disease comorbidities, time, each variable's respective interaction term with time, diet score (in tertiles), and an interaction term of diet score and time after onset for those who reported hearing impairment. Black line represents rate of cognitive decline of individuals who never reported hearing loss during follow up. Red line represents rate of cognitive decline of those who reported hearing loss. In the pre-hearing loss phase, the annual rate of decline for those without hearing loss was -0.0623 standard unit (SU), the slope for those with hearing loss was -0.0624 SU ($P = 0.97$). Because of the differences of -0.0001 SU was nearly identical to that of participants who never reported hearing impairment. Thus, we modeled the two groups of participants combined.



hearing [46] which may affect cognitive performance [47]. Furthermore, a recent randomized controlled trial suggested a hearing interventions could potentially lower risk of cognitive decline in a high risk population [48]. In our study, adherence to the DASH diet attenuated cognitive decline among participants with hearing loss. Additionally, a higher MedDiet score was associated with a delay in the onset of hearing loss. In contrast, a poorer dietary pattern increases the risk of hearing loss and its onset. These results suggest that the potential mechanisms by which diet may preserve cognition include 1) reducing the risk of hearing loss and 2) delaying the onset of hearing loss. Although the MIND diet also emphasized some of the same dietary components of the MedDiet and DASH diet, we did not observe a significant association between the MIND diet and hearing loss related cognitive decline, despite its known cognitive benefits. This discrepancy may stem from

differences in underlying mechanisms. While the MIND diet is designed to mitigate neurodegenerative processes, it may have less direct impact on vascular or auditory pathways compared to other diets.

Hearing loss also relates to social isolation and reduced social engagement, which have strong implications for cognitive health and overall quality of life in older adults [49]. Reducing hearing loss risk may enhance social functioning thus prevent cognitive decline. These potential synergetic effects of diet and other lifestyle factors emphasize the importance of multifactorial lifestyle interventions to prevent or mitigate hearing loss and preventing cognitive decline in older adults.

Strengths of the present study include its prospective design and the inclusion of a biracial community cohort. The present study systematically evaluated the modifying effects of different dietary patterns on cognition, particularly in the context of hearing loss. This approach sug-

Table 3

Rate of global cognitive decline among participants with or without hearing loss across tertiles of dietary scores.

MedDiet	No hearing loss		After first reported hearing loss	
	Estimate	SD	Estimate	SD
MedDiet				
T1	-0.071	0.004	-0.083	0.0124
T2	-0.064	0.004	-0.056	-0.079
T3	-0.056	0.004	-0.079	0.011
DASH				
T1	-0.06	0.004	-0.101	0.012
T2	-0.067	0.004	-0.083	0.012
T3	-0.06	0.004	-0.071*	0.011
MIND				
T1	-0.068	0.004	-0.096	0.011
T2	-0.061	0.004	-0.094	0.011
T3	-0.057	0.004	-0.059	0.012
Western				
T1	-0.060	0.004	-0.082	0.013
T2	-0.063	0.004	-0.077	0.011
T3	-0.065	0.004	-0.093	0.011

* $P < 0.05$ compared to DASH T1 after first reported hearing loss.

Model was adjusted for age, sex, race, education, total calorie intakes, cardiovascular disease comorbidities, time, each variable's respective interaction term with time, diet score (in tertiles), and an interaction term of diet score and time after onset for those who reported hearing impairment.

gests multiple potential mechanistic pathways through which diet may influence cognitive function. To our knowledge, this is one of the first studies to explore these relationships. Our study has several limitations. Dietary information was self-reported using FFQs, which could be prone to recall errors and misclassification. This may have resulted in an underestimation of the association of interest. Nevertheless, self-reported FFQs have been validated in older adults using objective biochemical markers [50,51]. We used the first available FFQ in the analysis, which did not account for longitudinal dietary changes, although dietary patterns in this population have generally been consistent. In the present study, hearing loss was assessed based on self-report. We acknowledge that pure-tone audiometry (PTA) is the gold-standard measure for evaluating hearing loss, self-reported hearing loss has been validated in previous population-based studies with reasonable high sensitivity among older adults [19]; however, the severity of hearing loss and the progression of hearing loss could not be considered in the present study. Future studies should incorporate audiometric testing to refine our findings further. Although we carefully adjusted for many potential confounders, residual confounding may have influenced the results. Given the observational nature of the study, we must caution against a causal interpretation of findings. While we observed strong associations between dietary patterns, risk of hearing loss, and cognition, and accounted for multiple confounders, these relationships may still be influenced by unmeasured variables such as lifestyle factors or co-existing health conditions. Despite these limitations, the consistency of our findings with prior research and the biological plausibility of the proposed mechanisms lend support to the hypothesis. Future research should include experimental validate these findings and explore causal pathway. Our study demographic primarily represents older adults from the south side of Chicago, which may limit the generalization of our findings to populations from different regions. Therefore, further research in additional populations is warranted.

The findings of this study suggest that healthful dietary patterns, such as the Mediterranean, DASH, and MIND diets, may play a significant role in reducing the risk of hearing loss and delaying its onset—an understudied but significant risk factor for cognitive function in older adults. Public health strategies should emphasize healthful dietary patterns as part of broader efforts to preserve auditory health and cognitive health in older adults. Integrating hearing health screenings with dietary counseling in preventive care and conducting clinical trials on diet and lifestyle factors can help address the linked challenges of hearing loss and cognitive decline in aging populations.

In summary, healthful dietary patterns are critical in preventing or delaying the onset of hearing loss. These dietary patterns help preserve cognitive function by reducing the risk of hearing impairment. Preventing hearing loss through dietary intervention could be an effective way to maintain cognitive function in older adults. Diet intervention may serve as a strategy for preventing hearing loss, dementia, and hearing loss-associated dementias simultaneously.

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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.

CRediT authorship contribution statement

Xiaoran Liu: Writing – original draft, Formal analysis, Conceptualization. **Uzma S. Akhtar:** Conceptualization, Writing – review & editing. **Todd Beck:** Formal analysis. **Kyle Dennis:** Formal analysis. **Denis A Evans:** Conceptualization. **Kumar B Rajan:** Writing – review & editing, Supervision, Conceptualization.

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Declaration of Generative AI and AI-assisted technologies in the writing process

I confirm that I have disclosed the use of AI and AI-assisted technologies in the writing process

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tjpad.2024.100052.

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