Original Article

Dietary diversity offsets the adverse mortality risk among older indigenous Taiwanese

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Background and Objectives: The extent to which health and survival inequality between indigenous and nonindigenous older Taiwanese is associated with diet is uncertain. **Methods and Study Design:** Participants from the Elderly Nutrition and Health Survey in Taiwan (1999–2000) formed this cohort. Dietary information was collected by 24-hr recall and simplified food frequency questionnaire. Dietary quality was assessed by dietary diversity score (DDS, 0-6). Annual medical service utilization and expenditure were derived from National Health Insurance claims until 2006. Survivorship was ascertained from the National Death Registry until 2008. Cox proportional-hazards models were used to determine the association between aboriginality and mortality in conjunction with dietary diversity. **Results:** Indigenes (n=156) compared with nonindigenes (n=1182) significantly differed in socio-demography, behaviors and chronic disease prevalences. For up to 8 years, indigenes had a higher mortality rate (46.2% vs 33.6%, p=0.003). Indigenes' nutrient intakes were less for polyunsaturated fat, dietary fiber, vitamins and minerals (but more sodium); food intakes more for meat, with less cooking oil, dairy products and fruits; and a lower DDS, (3.61 vs 4.54). They had a 41% higher mortality risk (HR: 1.41, 95% CI: 1.09-1.81, p=0.008). Control for demographic variables did not change the findings. However, the increase in HR was substantially attenuated by the inclusion of DDS (HR: 1.15, 95% CI: 0.88-1.49, p=0.316). There was no significant interaction between aboriginality and DDS on mortality (p=0.673). **Conclusions:** Older indigenous Taiwanese have a higher mortality risk than their majority counterparts. Irrespective of aboriginality, the more diverse diet is associated with a lower risk of mortality.

Key Words: Indigenous, mortality, dietary diversity, Taiwan, NAHSIT

INTRODUCTION

Indigenous minorities in affluent countries like Australia, Canada, New Zealand and the United States have considerably lower life expectancies compared with their counterpart nonindigenous populations.[1-8] In Taiwan, the average life expectancy and disease patterns also differ greatly by aboriginality.[9-11] The collective mortality rate of the ten leading causes of death among indigenous Taiwanese is 1.8 times that of nonindigenes, resulting in an average life expectancy of indigenes being 10.2 years in men and 7.4 years in women less than that of the entire country. In addition, several major disease incidences and disease specific mortalities of indigenes are higher than the general population.[9] This health profile is shared by other indigenous and ethnic minority populations around the world against a background of historical, sociodemographic and health care system disadvantage.[1-4,6]

Traditionally, indigenes were usually able to achieve a high degree of dietary biodiversity because of their close proximity to nature and its resources, and a combination of hunting, gathering, cultivation and grazing.[12,13] However, despite proximate food biodiversity, barriers to consumption, food preferences and beliefs, ownership and territorialism, weather patterns and other factors diminished ultimate dietary diversity.[14] In addition, local soil and water nutrient and contaminant characteristics may have compromised nutritionally-related health, as with iodine and Se deficiencies.[15-17] In Taiwan, tribal location, both traditional and consequent on colonization has determined differential mountainous, coastal and urban food system availabilities and dependencies. The contribution of dietary pattern to disability adjusted life years (DALYS) among indigenous peoples includes limited fruit and vegetable intakes[18] and may relate to the biodiversity of the diet.[19] In the general Taiwanese population, especially the aged, food diversity is an important determinant of health and survival.[20,21]

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Manuscript received 23 January 2019. Initial review completed 07 April 2019. Revision accepted 08 May 2019.
doi: 10.6133/apjcn.201909_28(3).0019

The purpose of the present study is to explore the role of dietary quality in the mortality difference between indigenous and nonindigenous Taiwanese elderly by using a population based Nutrition Survey.

METHODS

Study design and participants

A prospective study design was used to assess the mortality difference between indigenous and nonindigenous Taiwanese elderly. Participants were from the 1999–2000 Nutrition and Health Survey in Taiwan (NAHSIT), a nation-wide representative free-living elderly survey. Some 1338 older people aged 65 y or older with complete aboriginality, dietary intake and survivorship information were eligible for analysis. The design and sampling of the Elderly NAHSIT is provided elsewhere.[22] The ethics committees of both Academia Sinica and the National Health Research Institutes approved this study. All participants provided their consent.

Dietary information

Through face-to-face interviews by trained interviewers, participants recalled food items consumed over the previous 24 hour period. The nutrient intake estimation methods used are described elsewhere.[23] Fatty acid type is referred to by saturation of double bonds i.e. polyunsaturated fatty acids (PUFA). Dietary quality was assessed as a dietary diversity score (DDS) based on a half serving of 6 food groups according to the Taiwanese Food Guides, namely: grains, dairy, eggs/bean/fish/meat, vegetables, fruits, oil/fat. The DDS ranged up to 6, with a higher score representing better dietary quality.[21] DDS was further grouped as ≤3 (poor quality diet), 4 and >4 (good quality diet) according to the degree of risk for mortality in the same cohort.[20,21,24]

Medical service utilization and expenditure

Taiwan launched a single-payer National Health Insurance (NHI) Program in 1995. As of 2007, 98.4% of Taiwanese was enrolled in this program. For research purposes, NAHSIT was linked to the NHI Research Database (NHIRD) derived from this system by a unique personal identification (ID) number for citizens through a third party using scrambling methodology to protect privacy. From the NHIRD, we derived the average annual medical care usage and expenditure (ambulatory care and hospitalization) of the participants from baseline until the end of 2006.[24]

Covariates

Potential covariates included demographics (gender, age, education level, location, marriage status, family income, money sufficiency), personal behavior (exercise frequency, smoking, alcohol drinking, betel nut chewing), health status (nutrition awareness, body mass index (BMI), waist circumference, Charlson Comorbidity Index (CCI), major chronic disease histories)

Survivorship ascertainment

We linked this cohort to the National Death Registry by ID to determine their survival status. All deaths of participants recorded between the baseline (1999-2000) and the end of 2008 were counted.

Statistical analysis

Continuous and categorical variables are expressed as mean±SD and percentages, respectively. Either t-tests or chi-square tests were used to compare the differences in covariates by aboriginality. Cox proportional-hazards models were used to assess the association between aboriginality and time to event (mortality). In these models, the time variable was the interval between the date of interview and the date of death, or December 31, 2008, for those who were censored. Potential covariates or intermediate variables included demographics, personal behaviors, health status and DDS for which adjustment was made wherever applicable. Where variables were associated with one another, collinearity was taken into account in formulating the models. IBM SPSS Statistics 22.0 was used for data processing and analysis.

RESULTS

Indigenous and nonindigenous older Taiwanese were found to have different distributions in gender, education level, household locality (indigenes mainly lived in mountainous areas and the East coast), marital status, family income, financial status, and personal behaviors (less regular exercise, more alcohol drinking and betel nut chewing among indigenes) (Table 1).

In terms of health status, indigenes had higher prevalences of chronic bronchitis, gout, arthritis and hypertension. Thus, indigenes have a higher CCI than nonindigenes (4.08 vs 3.59), though not significant. There was no significant difference in total medical expenditure between the two groups. However, indigenes used more ambulatory care and emergency services. For up to 8 years, 33.6% nonindigenous and 46.2% indigenous participants died (p=0.003). The cumulative mortality density for nonindigenous and indigenous participants was 53.8 and 81.4 per 1000 person-yrs, respectively (Table 2).

Table 3 provides participant dietary information. There were no differences in daily energy or three macro nutrient intakes (protein, carbohydrate, fat as nutrient densities per 1000 kcal) between the two groups. However, indigenes ate less PUFA, dietary fiber, vitamins A and E, niacin, vitamins B6 and C, Ca, Mg, P, and K, but more Na. Compared to nonindigenes, indigenes ate more chicken, pork/beef (141 g vs 87.9 g), but consumed less cooking oil, dairy products (14.7 g vs 48.2 g) and fruits (47.2 g vs 162 g). Collectively, indigenous people have a less diverse diet (DDS, 3.61 vs 4.54). Some 45.5% of indigenes had a DDS ≤3 (poor quality diet) and only 14.4% >4 (good quality diet), by contrast, they were 15.4% and 54.1% for nonindigenes, respectively (Figure 1).

Without any adjustment, the risk of death for indigenes was significantly higher than for nonindigenes by 41% (HR: 1.41, 95% CI: 1.09-1.81, p=0.008). After controlling for demographic variables, the relative risk of death remained significantly greater (HR: 1.36, 95% CI: 1.04-1.78, p=0.027). When personal behaviors were taken into account, borderline significance was found (HR: 1.28, 95% CI: 0.97-1.68, p=0.077). However, with the

Table 1. Socio-demographic characteristics, personal behaviors and health profiles by aboriginality of elderly Taiwanese (n=1338)

	Total (n=1338)	Aboriginality		*p*-value
		Nonindigenous (n=1182)	Indigenous (n=156)	
%	100	88.3	11.7	
Men	51.6	52.8	42.3	0.017
Age, yr (mean±SD)	71.9±5.4	71.9±5.4	72.1±5.3	0.595
65-69	39.3	39.8	35.9	0.682
70-74	33.5	33.2	35.9	
75-79	17.5	17.6	16.7	
≥80	9.7	9.5	11.5	
Education level				<0.001
Illiterate	33.3	35.3	17.9	
Elementary and below	5.7	41.7	75.6	
High School	14.1	15.3	5.1	
College and above	7.0	7.7	1.3	
Location				<0.001
Mountain area	9.2	2.4	60.9	
Eastern	8.1	4.0	39.1	
Other area	82.7	93.7	0	
Marriage				<0.001
Married living without spouse	30.9	28.3	50.0	
Married living with spouse	66.1	68.4	48.7	
Single	3.1	3.3	1.3	
Family income, NTD/month				<0.001
<15000	21.8	18.2	49.4	
15000-29999	9.7	9.8	9.0	
30000-49999	11.1	11.5	8.3	
≥50000	13.1	14.0	5.8	
Missing	44.2	46.4	27.6	
Enough money				<0.001
More than enough	13.7	15.1	2.6	
Just enough	54.8	57.4	35.3	
Some difficulty	23.0	20.2	44.2	
Very difficult	5.5	4.1	16.7	
Missing	3.0	3.2	1.3	
Nutrition awareness				0.152
Often	16.2	16.9	10.9	
Sometimes	22.6	22.3	25.0	
Rarely	61.1	60.7	64.1	
Personal behaviors				
Smoking	22.9	23.2	19.9	0.397
Alcohol drinking	20.5	18.5	35.3	<0.001
Betel nut chewing	9.0	5.5	35.3	<0.001
Regular exercise	52.2	54.9	31.4	<0.001

inclusion of DDS, representing the quality of the diet in the model, the significance disappeared (HR: 1.15, 95% CI: 0.88-1.49, p=0.316). None of any combination of demographic variables, personal behaviors or DDS in the multivariable models was significant. In particular, when DDS was included in the model, the magnitude of aboriginality on mortality was weaker (Table 4). When individual foods or nutrients in Table 3 were included in the models, no change in the HR significance for indigenes' survival was found (data not shown).

These was no significant interaction between aboriginality and DDS on mortality (p=0.673) (Figure 2). Irrespective of aboriginality, the higher the DDS, the risk of death was lower.

DISCUSSION

The minority indigenous Taiwanese elderly have less good survival than their majority counterparts. There are evident differences in demographic, socioeconomic and educational advantage, and in personal health behaviors, which might account for the survival disadvantage. However, modeling shows that, when all these factors are considered, food patterns which are more diverse are the better predictors of later life expectancy.

Dietary patterns and survival

In terms of dietary diversity, a higher proportion of indigenous people have a DDS ≤3, or DDS=4 (45.5% and 39.1% respectively), so if dietary quality (diversity) were improved, the risk differential between the ethnic groups, defined by aboriginality, would be less. DDS would appear to be more important than adverse health behaviors (alcohol, betel nut chewing, and physical activity). Of course, DDS may be a surrogate for many health seeking behaviors. Some which are recognized in these participants are eating constraints like chewing difficulty and its interdependency with DDS and health[25] and physical inactivity.[26] It must be emphasized that our findings are

Table 2. Health status and medical service utilization by aboriginality of elderly Taiwanese

	Total (n=1338)	Aboriginality		*p*-value
		Nonindigenous (n=1182)	Indigenous (n=156)	
Chronic disease history, %				
Pulmonary emphysema	1.1	1.1	1.3	1.000
Chronic bronchitis	9.0	8.1	15.4	0.005
Asthma	6.7	6.3	10.3	0.089
Peptic ulcer disease	12.7	12.7	12.8	1.000
Chronic hepatitis	4.2	4.6	1.3	0.087
Fatty liver	1.6	1.5	1.9	0.972
Liver cirrhosis	0.4	0.4	0	1.000
Gout	11.7	10.8	18.6	0.007
Arthritis	20.5	18.7	34.0	<0.001
Hypertension	34.8	33.6	44.2	0.011
Stroke	4.4	4.6	3.2	0.567
Diabetes	11.8	12.2	9.0	0.301
Kidney disease	3.4	3.4	3.2	1.000
Heart disease	18.4	17.8	23.1	0.134
Alzheimer's disease	1.5	1.5	1.3	1.000
Cancer	2.4	2.5	1.3	0.493
CCI	3.64±3.45	3.59±3.45	4.08±3.49	0.090
BMI, kg/m^2 (mean±SD)	23.7±3.65	23.8±3.66	23.5±3.60	0.467
<18.5	7.2	7.0	8.3	0.297
18.5-23.9	45.7	45.9	44.2	
24.0-26.9	29.2	28.6	34.0	
≥27	17.9	18.5	13.5	
Waist circumference, cm (mean±SD)	83.7±10.6	83.9±10.7	82.4±10.0	0.094
Men <90, Women <80	56.6	56.1	59.6	0.462
Medical expenditure, 1000 NTD/yr (mean±SD)				
Ambulatory care	24.6±29.4	25.1±30.4	21.1±20.4	0.031
Dental care	0.80±1.24	0.88±1.27	0.57±0.98	0.004
Traditional Chinese medicine	0.83±1.98	0.90±2.09	0.28±0.65	<0.001
Preventive care	0.27±0.22	0.25±0.02	0.40±0.26	<0.001
Emergency	1.97±5.86	1.92±6.10	2.38±3.59	0.356
Hospitalization	48.3±176	48.1±181	49.2±138	0.926
Ambulatory care pharmaceuticals	12.1±14.0	12.4±14.6	9.34±6.96	<0.001
Inpatient pharmaceuticals	8.90±40.4	8.99±42.7	8.21±14.9	0.821
Total expenditure	75.9±184	76.2±189	73.9±140	0.886
Medical service utilization, times/yr (mean±SD)				
Total ambulatory care	32.2±20.2	31.4±19.7	38.4±23.1	<0.001
Ambulatory care	27.8±18.9	26.9±18.2	34.7±22.0	<0.001
Dental care	0.94±1.41	0.97±1.44	0.68±1.12	0.003
Traditional Chinese medicine	1.64±3.91	1.79±4.11	0.56±1.30	<0.001
Preventive care	1.20±0.85	1.15±0.82	1.57±0.86	<0.001
Emergency	0.63±1.23	0.59±1.26	0.89±0.92	0.004
Hospitalization days	8.72±25.6	8.44±25.0	10.8±29.9	0.780
Percent deaths	35.1	33.6	46.2	0.003
CMD (per 1000 person-yrs)	56.8	53.8	81.4	

CCI: Charlson Comorbidity Index; BMI: body mass index; CMD: cumulative mortality density.

about an integrated index of food intake as a determinant of survival difference and not in favor of any particular food or nutrient as an explanator. This superiority of measures of dietary biodiversity over nutrients and foods in the prediction of health outcomes is now well-established.[21,24,27-29]

Nevertheless, the question is begged of ultimate causality. This is, firstly, because it is a longitudinal observational rather than intervention study that has been undertaken and, secondly, because more integrative and underlying measurements of the social determinants of health[30] and of ecosystem dysfunctionality have not been investigated.[31] Importantly, whatever the contributors to dietary diversity, aboriginality itself does not have an independent association with mortality once the dietary pattern is included in the models.

This finding has a bearing on food security, at the individual[21] and household levels (FAO) where dietary diversity is a determinant. In this age group it may be difficult to achieve on account its affordability[27,28,32] difficulties with accessibility among the disabled and biodiverse food constraints with food storage, preparation and eating with others.[20,33]

Survivor effect: older people

It must be borne in mind that the present cohort study is of people who have survived at least to age 65 to be eligible. Thus, it does not explore those factors which may

Table 3. DDS and food intakes by elderly Taiwanese aboriginality

	Total (n=1388)	Aboriginality		*p*-value
		Nonindigenous (n=1182)	Indigenous (n=156)	
Total energy (kcal)	1715	1710	1756	0.638
Nutrient density (per 1000 Kcal)				
Protein (g)	42.3	42.3	42.6	0.945
Fat (g)	28.7	29	26.6	0.061
SAT fat (g)	8.58	8.65	8.10	0.264
Oleic acid (g)	9.78	9.84	9.33	0.330
PUFA (g)	8.83	8.99	7.63	0.003
Chol (mg)	128	126	150	0.104
CHO (g)	141	141	140	0.559
Dietary fiber (g)	12.3	12.6	10.3	0.004
Vit A (IU)	6104	6330	4396	<0.001
Vit E (mg)	4.71	4.9	3.25	<0.001
Vit B-1 (mg)	0.70	0.71	0.67	0.456
Vit B-2 (mg)	0.85	0.89	0.56	<0.001
Niacin (mg)	8.75	8.73	8.93	0.767
Vit B-6 (mg)	0.69	0.7	0.6	0.005
Vit C (mg)	93.6	98.6	55.8	<0.001
Fe (mg)	7.40	7.34	7.91	0.243
Ca (mg)	415	427	324	0.001
Mg (mg)	145	148	126	<0.001
P (mg)	615	624	545	<0.001
Na (mg)	3130	3028	3898	0.011
K (mg)	1466	1496	1241	<0.001
Food groups intake				
Rice and grains (g)	236±178	232±153	271±310	0.120
Oil (g)	15.2±27.7	16.2±29.0	7.84±13.1	<0.001
Chicken (g)	18.9±65.0	16.2±45.0	39.1±143	0.049
Pork/Beef (g)	75.2±128	71.7±123	102±156	0.023
Fish and shellfish (g)	62.6±116	62.5±105	63.2±177	0.961
Eggs (g)	15.2±31.8	15.3±31.1	14.6±37.0	0.797
Dairy products (g)	44.3±115	48.2±120	14.7±55.8	<0.001
Soybean products (g)	47.8±122	47.0±121	53.6±135	0.508
Vegetables (g)	320±294	322±275	300±410	0.373
Fruits (g)	149±253	162±261	47.2±137	<0.001
Sweets (g)	66.6±198	63.3±195	91.5±218	0.125
Miscellaneous (g)	21.1±94.6	22.0±98.6	14.5±55.7	0.354
DDS, %	4.44±1.06	4.54±1.03	3.61±0.98	<0.001
≤3	18.0	14.4	45.5	<0.001
4	32.4	31.6	39.1	
>4	49.6	54.1	15.4	

DDS: dietary diversity score.

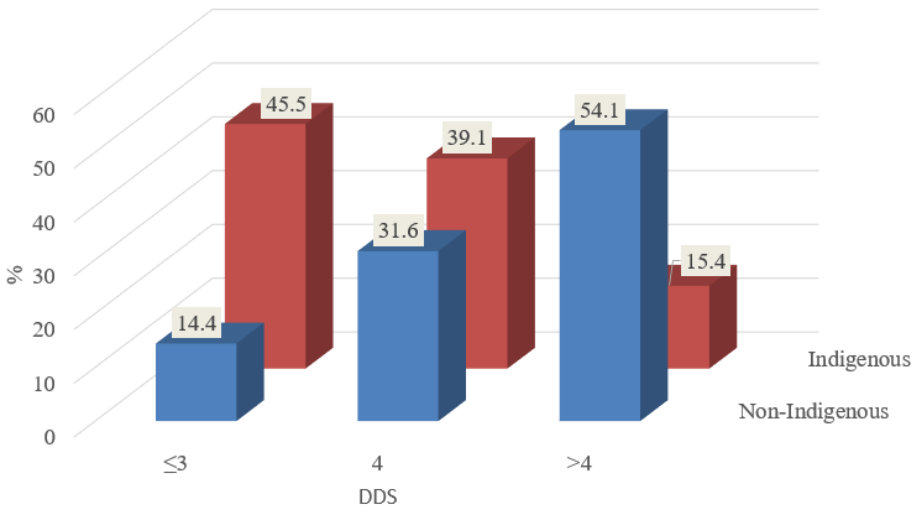

Figure 1. Distribution of DDS (%) among Indigenous and non-Indigenous older adults in Taiwan, NAHSIT 1999-2000. DDS: dietary diversity score.

Table 4. Mortality risk for elderly indigenous against nonindigenous elderly Taiwanese

	HR	95% CI	*p*-value
Crude model	1.41	1.09-1.81	0.008
+ (1)	1.36	1.04-1.78	0.027
+ (2)	1.28	0.97-1.68	0.077
+ (3)	1.15	0.88-1.49	0.316
+ (1) + (2)	1.26	0.94-1.68	0.119
+ (1) + (3)	1.12	0.84-1.49	0.438
+ (1) + (2) + (3)	1.09	0.81-1.47	0.581

HR: hazard ratio.
(1) Demographic variables: gender, education level (illiterate, elementary school and below, high school, college and above), marital status (married and lived without spouse, married and lived with spouse, single) and enough money (more than enough, just enough, some difficulty, very difficult, missing).
(2) Personal behaviors: alcohol drinking (yes, no), betel nut chewing (yes, no) and regular exercise (yes, no).
(3) Dietary diversity score (≤3, 4, >4).

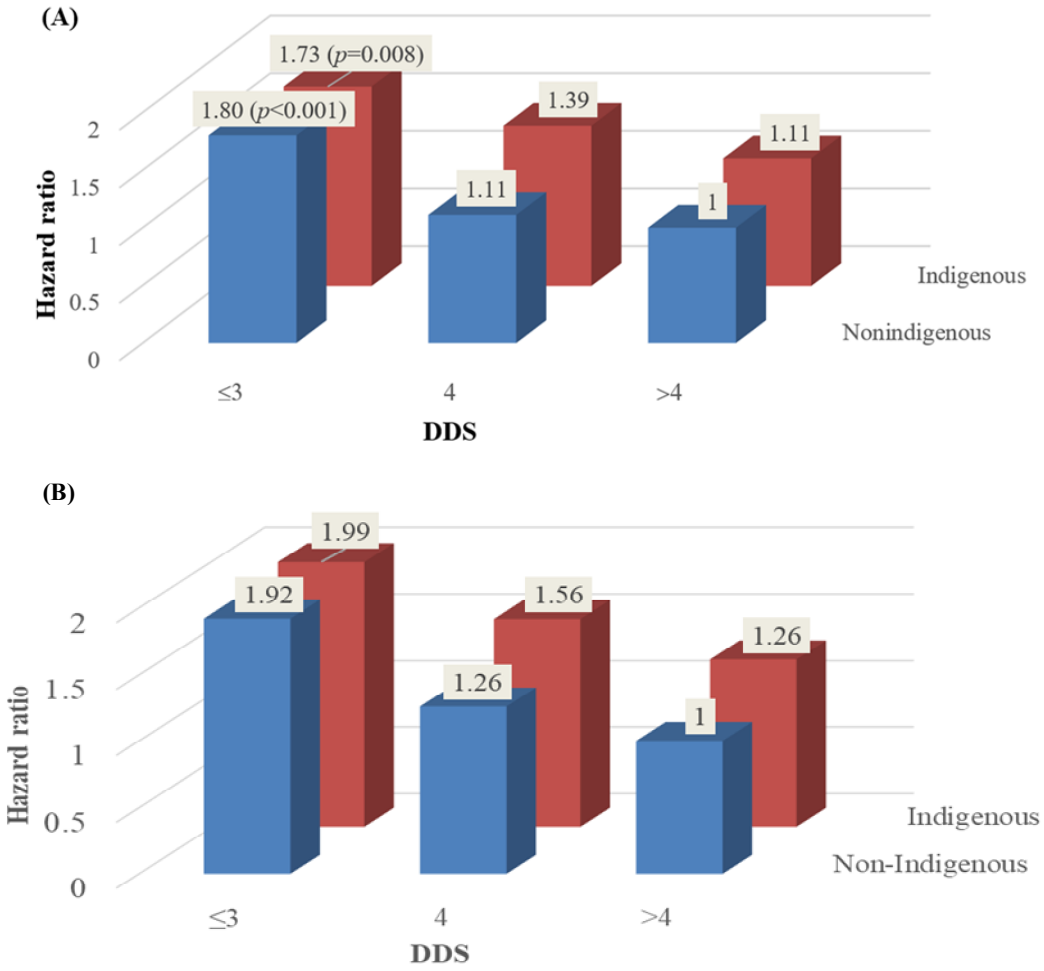

Figure 2. Mortality risk (hazard ratio) by DDS among elderly Indigenous and non-Indigenous Taiwanese. (a) without adjustment, (b) with adjustment of demographic and personal behavioral variables. (*p* for interaction=0.673). DDS: dietary diversity score.

have generated life expectancy differentials between indigenous and non-indigenous Taiwanese earlier in life. These will have included personal behaviors of the kind observed here, and factors which contribute to body compositional disorders and cardiovascular risk as observed in other studies.[23,34,35]

Health care system (expenditure and medical service utilization)

Insofar as medical care is concerned, total ambulatory care, dental care and ambulatory pharmaceutical utilization together with expenditure are less among indigenous, while hospitalization is not different. This is despite a greater burden of underlying disease (especially respiratory, hypertensive, musculoskeletal), not reflected in detectable CCI score difference. This suggests that there may be an underutilization or measure of inaccessibility to hospital facilities by indigenous elders. Interestingly, body compositional, diabetes, renal disease and cardiovascular disease prevalences were not different between these elderly participants, perhaps because they represent survivors in their ethnic group at study entry. Preventive care is more utilized which may also be a factor contributing to net mortality risk among the potential contribu-

tors to survival; this is perhaps an encouraging difference in favor of older indigenous people. Notwithstanding these complex observed differences in health care system utilization and expenditure by indigeneity, we find a protective association of dietary quality for survival irrespective of ethnicity.

Health relevance

The health policy utility of the observation that dietary quality might overcome the survival differential between Taiwanese elders by indigeneity is that it is amenable to further evaluation and validation by intervention with good adherence prospects, at relatively low cost. The expected improvements would be not only in survival, but also in the burden of disease or DALYS.

Strengths and limitations

The study has strengths and limitations. The first is an example of both, namely that those studied are 65 years or older, so that we cannot extrapolate to a younger population while health benefits accrue to older people who might have been resistant to them in earlier life. The second is that the comparisons by aboriginality are not, and cannot be, equivalent in a number of respects, notably place of abode, and access to health services. Because all indigenes in this study resided either in Mountainous or Eastern areas of Taiwan, it was not possible to have both aboriginality and location in the same model. Compared to people in other areas, those in the Mountainous areas had a HR for mortality of 1.37 (p=0.028) and in Eastern areas of 1.29 (p=0.103). However, after adjusting for DDS, these were no longer significant. Though we cannot separate the effects of aboriginality and location, we can confirm that DDS offsets the mortality disadvantage seen for indigenous people who live in these locations. We have adjusted for the many covariates measured, but this will not be all potential confounders. Dietary diversity itself may represent a number and a collection of unmeasured confounding factors. The investigators are also mindful that differences in health outcomes by aboriginality reflect generations of socio-economic disadvantage and stigmatization for which dietary quality will be but a limited reflection. Considering the shorter life spans of indigenous people and the competing causes of death, the associations between aboriginality, food biodiversity and health outcomes such as mortality, may be underestimated.

Conclusions

Older Taiwanese indigenes have a greater mortality risk than their non-indigenous counterparts, partly dependent on limited dietary diversity. If effectively addressed, this could reduce the health outcome inequities presently evidenced among these people.

ACKNOWLEDGEMENTS

The Elderly Nutrition and Health Survey in Taiwan 1999–2000 (NAHSIT Elderly) project was conducted by the Institute of Biomedical Sciences of Academia Sinica and the Research Center for the Humanities and Social Sciences, Center for Survey Research, Academia Sinica, directed by Drs Wen-Harn Pan and Su-HaoTu and sponsored by the Taiwan Department of Health.

AUTHOR DISCLOSURES

No author has any conflict of interest.

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