

Dietary Diversity Predicts Type of Medical Expenditure in Elders

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In the formulation of health policy, economic factors have an inescapable role, but the medical costs of diet-related and nutritionally related diseases are rarely given attention. Yet the opportunities to reduce the burden and costs of this disease subset are considerable.¹⁻³ Popkin and colleagues⁴ estimated that effects of unhealthy dietary habits in China contributed US \$3.9 billion to medical costs from 2000 to 2005. However, such research has tended to focus on single nutrients as contributors to costs rather than overall dietary patterns. In addition, estimates of the medical costs of nutritionally related and diet-related diseases depend on reliable attributions of risk and of disease prevalence, and on the governance of a country's medical system. The deduced nutritional economics may, therefore, be very divergent.

Dietary quality⁵ can be represented by indices that provide evidential support for international and national dietary guidelines and recommendations.⁶ This is because better diet quality is associated with decreased morbidity and mortality.⁷ Food-based indicators, as simple measures of dietary quality, can be useful predictors of morbidity⁸ and longevity, even in those aged 65 years.^{9,10} The Dietary Diversity Score (DDS) developed by Kant and colleagues¹¹ is a practical and simple tool for assessing dietary quality. The DDS is also a predictor of all-cause mortality in Taiwanese elderly.⁹

Taiwan's National Health Insurance (NHI) program is a universal health insurance scheme financed by a mandatory means-related premium system. More than 99% of Taiwanese are enrolled.^{12,13} The NHI benefits are broad, including inpatient and outpatient care, pharmaceuticals, dental care, and catastrophic illness,¹³ but require copayments by users (waived for those defined as poor). Total medical care expenditure increased from Taiwanese new dollars (NT\$) 288 billion in 2000 to NT \$442 billion in 2010, or 6.5% of the gross domestic product.¹⁴ Without recourse to other government revenue, the program had an accumulated deficit of NT \$22.9 billion at the end of June 2011.¹⁵ Analysts project that the National Health Expenditure will continue to rise as the population ages and costs increase.¹⁴ In the

case of Taiwan, the NHI data for 2009 show that medical expenditure for people more than 65 years accounted for one-third of the country's total medical

Objectives: To assess the association between Dietary Diversity Scores (DDSs, range: 0-6 points) and medical service utilization and expenditures.

Study Design: Prospective cohort study.

Methods: The Elderly Nutrition and Health Survey in Taiwan (1999-2000) provided a 24-hour dietary recall for DDSs. National Health Insurance claims were linked for 1650 eligible elders. Generalized linear models were used to appraise the association between DDS and annual medical utilization and expenditures.

Results: Those with a higher DDS had lower medical service utilization and expenditures for emergencies and hospitalization. After adjustment for potential confounders, emergency and hospitalization expenditures for elders with a DDS of 6 were lower than those with a DDS of 3 or lower. However, for preventive care and dental services, the highest DDS of 6 predicted greater utilization (0.25 and 0.5 times) and expenditure (270 and 420 Taiwanese new dollars). Findings remained unchanged when those who died in the first year or had any medical utilizations and expenditures 1 year prior to death were excluded.

Conclusions: Greater dietary diversity is associated with lower emergency and hospitalization utilization and expenditures, but not lower use of ambulatory services. There is a need for health services to develop a nutrition policy for nutritionally disadvantaged groups.

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Take-Away Points / e416

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Take-Away Points

- Healthy eating may minimize healthcare costs.
- The National Nutrition and Health Surveys linked to the National Health Insurance system database in Taiwan provide an opportunity to address this issue.
- We found that those whose diets were more favorable to health, as judged by the Dietary Diversity Score (DDS), had greater expenditures on preventive services and dental care, but lower medical service utilization and expenditures for emergencies and hospitalization.
- Because an increased DDS costs more in Taiwan, health and nutrition policy needs to focus on the socioeconomically disadvantaged if cost containment is to be fully realized.

expenses. In addition, the elderly have greater per capita healthcare expenses.¹⁶

The public health sector, which extends beyond the conventional healthcare system, has long promoted healthy diets. This sector's settings provide an opportunity to consider whether better dietary quality can decrease healthcare expenditures. If so, this might motivate governments to maintain and develop dietary programs, and encourage citizens to adhere to healthy diets to reduce medical costs. Therefore, we investigated the association between dietary quality and medical care utilization and expenditures in older Taiwanese. The hypothesis was that better dietary quality among elders would reduce both overall medical expenditures and types of expenditures.

METHODS

Study Population

The national Elderly Nutrition and Health Survey in Taiwan is a cross-sectional survey that incorporates a multistage, stratified, clustered probability sampling scheme. Participants were community-dwelling seniors 65 years or older between 1999 and 2000. The study design has been published elsewhere.¹⁷ A household interview was carried out by trained interviewers. Out of a total of 1937 participants, 1911 with demographic information were interviewed face-to-face and were asked to provide a 24-hour dietary recall and their family recipes.¹⁸ In order to have a representative estimate of an individual's dietary quality, 126 participants with unreasonably high or low total daily energy intakes (<500 or >3500 kcal/day in women, <800 or >4200 kcal/day in men¹⁹) were excluded, along with 2 participants on a liquid diet. Of this group, 1783 elders were linked to the National Death Registry up to December 31, 2008 (10-year follow-up) and NHI claim data up to December 31, 2006 (8-year follow-up). We excluded participants who had inaccurate death records, no NHI records because of incorrect personal identification numbers, or catastrophic illness before the interview. Beneficiaries of NHI who suffer a major disease receive a catastrophic illness certificate,

which grants exemption from copayment. These claim data are recorded in a Registry of Catastrophic Illness Database, which forms a subpart of the NHI claim data.^{20,21} The final sample included 1650 participants for analysis (Figure 1). This study was approved by the ethics committees of both Academia Sinica and the National Health Research Institutes in Taiwan. All participants provided signed informed consent.

Participants' Characteristics and Socioeconomic Status

Participants were grouped by age (65-69, 70-74, 75-79, and ≥80 years old). Participants were sampling from 13 regions (Hakka, Mountainous areas, Eastern, Penghu, Northern 1, Northern 2, Northern 3, Central 1, Central 2, Central 3, Southern 1, Southern 2, and Southern 3). Education (illiterate, primary and below, secondary education and above), household monthly income (NT \$<15,000, NT \$15,000-29,999, NT \$30,000-49,999, NT \$50,000), smoking (yes, no), alcohol drinking (yes, no), betel nut chewing (yes, no), and perceived health status (good, fair, poor) were obtained from the face-to-face interview at baseline. These variables provided the required covariates in the multivariable models.

Dietary Diversity Score

The DDS is based on the 24-hour dietary recall obtained during the household interview at baseline. It comprised 6 foods group and was scored on a scale of 0 to 6, with 1 point per food group consumed (with a minimum intake of a half serving a day to score). The 6 food groups (dairy, egg/bean/fish/meat, rice and grains, fruits, vegetables, and fat and oil) were in accordance with the Taiwanese Food Guide.²² Previous reports detail the DDS methodology.^{9,11}

Annual Medical Utilization and Expenditures

Medical utilization and expenditures were derived from ambulatory care visit and inpatient admission expenditures as subparts of the NHI claim data.²¹ Medical service utilization was calculated as the frequency of outpatient visits and days of hospitalization. Outpatient visits were categorized as outpatient services, preventive care (eg, influenza vaccination, smoking cessation), emergency services, and dental services. Medical service expenditures included outpatient (all costs including physician's fees, examinations, laboratory tests, and medication) and inpatient (all costs including treatments and surgery-related medical service fees) expenditures.²³ Medical data were collected from the 1999 to 2000 interview date to

the day of death or December 31, 2006, based on NHI claim data. The expenditures for each participant were totaled to compute the sum of ambulatory and inpatient medical service utilization and expenditures. The average annualized medical service utilization and expenditures were calculated by dividing the total by each participant's follow-up time. In addition, successive annual medical expenditures were assigned a yearly discount rate of 3%, based on a yearly core consumer price index adjustment, and then summed for final arithmetic division.

Statistical Analyses

All analyses were conducted using SAS 9.2 (SAS Institute Inc, Cary, North Carolina). The mean and standard deviation were used to express the annual medical utilization and expenditure measurements among various DDSs. The median was also presented because of wide variation. Generalized linear models were used to test associations between DDS and medical utilization and expenditures. A log-link function with Poisson distribution for medical utilization and a log-link function with gamma distribution for medical expenditures were used.^{24,25} Two-tailed $P < .05$ was considered significant.

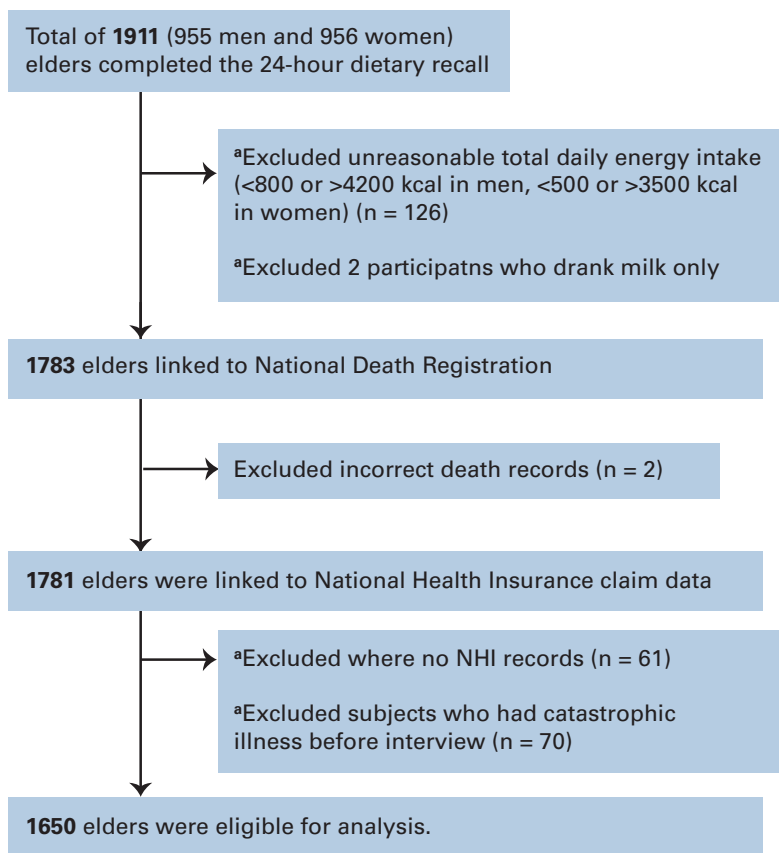
Sensitivity analyses were exclusion of all participants who died in the first year of follow-up or those who had any medical utilization and expenditures 1 year before death.

RESULTS

Participants' characteristics are shown in **Table 1**. Women, individuals 80 years or older, those with lower education, and those with lower household income had a lower proportion with a DDS of 3 or lower compared with those whose DDS was 6, which is the highest score. However, only personal education and household income were significant ($P < .01$). Cumulative death rates decreased as the DDS increased.

After an 8-year follow-up, participants with a higher DDS were found to use emergency services less frequently and have fewer hospitalization days (**Table 2**). The difference in length of hospital stay between those with a DDS of 3 or lower and those with a DDS of 6 was 3.74 days. However, those with a higher DDS had more annual outpatient visits for outpatient services, preventive care, and dental care, which translated into greater

■ **Figure 1.** Flow Chart of Participation of Subjects in This Study



NHI indicates National Health Insurance.

annual average medical expenditures. The annual median expenditure on dental care in those with a DDS of 3 or lower was NT \$0, whereas their annual median hospitalization expenditure was NT \$11,100. The total medical expenditure difference between those with a DDS of 3 or lower and those with a DDS of 6 was NT \$4,100.

The relationship between ambulatory care and hospitalization (annual medical utilization and expenditures) and the DDS after adjusting for potential covariates is shown in **Table 3**. A higher DDS was associated with more frequent use of ambulatory care, preventive care, and dental services, and the increasing linear trend was significant ($P < .001$). For preventive care and dental services, the highest DDS of 6 predicted greater utilization (0.25 and 0.5 times) and expenditures (NT \$270 and NT \$420) than those of the reference group (DDS of 3 or lower). A shorter length of hospitalization was correlated with a higher DDS (P for linear trend was $< .001$). Conversely, a lower DDS was associated with more emergency care, although the linear trend was not significant. For the medical expenses of outpatient service, preventive care, and dental services, there was a positive association and linear increas-

■ **Table 1.** Characteristics of Participants (N = 1650)

Characteristics	Percentage of Sample	DDS, %				P ^a
		≤3 (n = 280)	4 (n = 548)	5 (n = 556)	6 (n = 266)	
Male sex	49.1	41.8	50.0	51.1	50.4	
Age, y						
65-69	39.4	37.5	39.8	38.9	41.7	
70-74	32.9	29.6	32.3	33.6	35.7	
75-79	17.8	22.1	17.2	17.3	15.4	
≥80	10.0	10.7	10.8	10.3	7.14	
Personal education						<.001
Illiterate	34.8	40.1	36.9	34.7	25.3	
Primary and below	44.6	48.0	47.3	41.9	40.8	
Secondary	14.0	8.24	11.2	17.3	19.3	
Above	6.6	3.58	4.59	6.12	14.7	
Household income, NT\$/mo						<.001
<15,000	36.0	52.0	38.8	29.1	27.1	
15,000-29,999	19.1	19.6	17.1	20.4	20.1	
30,000-49,999	21.0	14.9	18.3	24.2	27.1	
50,000	23.9	13.5	25.8	26.3	25.7	
Current smoker	21.3	25.7	24.1	20.9	11.7	<.001
Alcohol drinker	20.0	21.5	19.7	18.5	21.9	
Betel nut chewer	8.08	13.3	10.4	5.94	2.26	<.001
Perceived health status						
Good	39.3	36.7	38.2	39.0	44.9	
Fair	46.4	44.4	47.1	48.9	42.3	
Poor	14.3	18.9	14.8	12.1	12.8	
Cumulative death rate^b	—	86.0	61.8	49.2	36.8	

DDS indicates Dietary Diversity Score.
^aBy the χ^2 test.
^bPer 1000 person-years.

ing trend between DDS and medical expenditure (*P* for trend <.001).

With sensitivity analyses, the findings were unchanged. Except for emergency attendance, there were significantly positive linear relationships between DDS and medical utilization (Figures 2A and 2B). Medical spending on preventive care and dental services increased along with the DDS in a significant dose-response manner (Figure 2C). However, those with a lower DDS had higher emergency expenditures, hospitalization expenditures, and total expenditures. Furthermore, those with a DDS of 3 or lower had an annual total medical expenditure of NT \$57,400, whereas those with a DDS of 6 had a lower total medical expenditure of NT \$53,100 (Figure 2D).

DISCUSSION

We expected to find that greater dietary diversity would be associated with lower overall medical expenditures. However, this hypothesis was demonstrable only for emergency attendance and hospitalization. Outpatient visits led to increased expenditures for preventive care and dental services.

Dietary Diversity Score as a Valid Indicator for Dietary Quality

The DDS is based on 1-day food intakes, which may not represent long-term dietary habits.¹¹ Although misclassification is possible, the energy and nutrient intake and dietary patterns of community-dwelling elderly people are generally stable.^{9,26,27}

Table 2. Annual Ambulatory and Hospitalization Medical Utilization and Expenditures by Dietary Diversity Score (N = 1650)

Utilization and Expenditures	DDS ^a			
	≤3 (n = 280)	4 (n = 548)	5 (n = 556)	6 (n = 266)
Medical utilization				
Ambulatory visits, n				
Outpatient services	27.6 ± 20.9 (23.2)	26.3 ± 19.2 (22.7)	28.6 ± 19.7 (24.6)	27.8 ± 17.2 (24.5)
Preventive care	1.08 ± 0.88 (0.89)	1.08 ± 0.84 (0.95)	1.13 ± 0.80 (1.04)	1.26 ± 0.82 (1.15)
Dental services	0.80 ± 1.35 (0)	0.77 ± 1.23 (0.15)	0.98 ± 1.40 (0.40)	1.48 ± 2.01 (0.75)
Emergency	0.73 ± 1.54 (0.38)	0.62 ± 1.14 (0.28)	0.65 ± 1.35 (0.28)	0.53 ± 1.07 (0.15)
Hospitalization, days				
	9.34 ± 26.5 (2.27)	9.09 ± 25.4 (1.23)	7.54 ± 23.3 (1.32)	5.69 ± 16.8 (1.00)
Medical expenditures, 1000 NT\$^b				
Ambulatory				
Outpatient services	20.6 ± 22.6 (16.1)	22.5 ± 28.9 (15.5)	25.0 ± 26.6 (19.8)	29.1 ± 37.4 (19.7)
Preventive care	0.24 ± 0.23 (0.17)	0.24 ± 0.21 (0.20)	0.24 ± 0.20 (0.21)	0.27 ± 0.20 (0.25)
Dental services	0.69 ± 1.18 (0)	0.64 ± 1.13(0.10)	0.83 ± 1.24 (0.25)	1.29 ± 1.80 (0.69)
Emergency	2.33 ± 6.75 (0.65)	2.02 ± 6.18 (0.42)	1.79 ± 4.26 (0.57)	1.56 ± 3.62 (0.37)
Hospitalization				
	47.6 ± 135 (1.11)	52.6 ± 164 (5,71)	44.1 ± 204 (6.62)	35.1 ± 127 (4.91)
Total medical expenditures	68.3 ± 137 (35.4)	75.0 ± 171 (27.6)	69.1 ± 207 (30.4)	64.2 ± 138 (30.1)

DDS indicates Dietary Diversity Score; NT\$, Taiwanese new dollars.
^aMean ± standard deviation (median).
^bNT\$, with an exchange rate of about NT \$30 to US \$1 in 2012.

The validity of DDS in this cohort is evident from previous studies where it provided predictive capacity and was significantly associated with known sociodemographic characteristics and mortality.^{3,9} Moreover, DDS is an integrative score and represents an eating pattern that characterizes the overall diet with relative stability.⁹

Diet and Socioeconomic Factors in Medical Expenditure

A healthy diet is one of the 8 core objectives for the Taiwanese Health Promotion Project for the Elderly (2009-2012).¹⁵ The average personal medical expenditure of individuals aged more than 60 years was approximately NT \$80,000 to NT \$120,000 in 2006 and reached NT \$123,000 in 2010. This amount is greater than that for other age groups.^{14,15,28} A study from the United States has suggested that modest to aggressive changes in diet (reduction in energy, sodium, and saturated fat) can improve health and reduce annual national medical expenditure by \$60 to \$120 billion.²⁹ Hence, a healthy diet in any aging population could help reduce health-related and nutritionally related medical care costs. Although this study found expenditure savings in acute care for those with a higher DDS, that was not so for preventive and ambulatory care. Individuals with a better socioeconomic status may exhibit greater health-seeking behavior,³⁰ given that better dietary quality is associated with a higher socioeconomic status.^{9,31,32}

Because those with lower incomes may cut back on basic needs like food and medication, they may avoid a more costly diverse diet, leading to food insecurity and greater acute care expenditure.^{3,33}

Dental Care, Nutrition, and Overall Health

Oral health is often overlooked as a health indicator for the elderly.^{34,35} Oral health problems, including missing teeth, ill-fitting dentures, cavities, gum disease, and infection, can cause difficulty in eating, with a resulting compromise in dietary quality.³⁵ Elders with impaired dentition have consistently lower scores on the Healthy Eating Index.³⁶ For older adults, chewing difficulty and lower socioeconomic status are associated with less dietary guideline compliance.³⁷ Poor dental health is also associated with higher mortality.^{26,38,39} Participants with a less diverse diet used fewer dental services. Possible reasons for fewer dental visits by elders with poor dietary quality may include limited mobility or financial constraints (eg, denture fees).^{34,35,40,41} Oral health and nutrition have a synergistic, bidirectional relationship.⁴² In addition, social inequalities among older adults are related to dietary quality.³²

International Comparisons

A Swedish intervention study on individualized meals and nutritional status among older people compared the direct healthcare costs of those living in municipal residen-

■ **Table 3.** Multivariable Generalized Linear Model for Annual Outpatient and Hospitalization Utilization by Dietary Diversity Score (N = 1650)

Variable	DDS β (95% CI) ^a				P for Trend
	≤3	4	5	6	
Medical utilization					
Ambulatory visits, n					
Outpatient services	Reference	-0.06 (-0.10 to -0.02) ^b	0.10 (0.06-0.14) ^c	0.05 (0.01-0.10) ^d	<.001
Preventive care	Reference	0.06 (-0.13 to 0.25)	0.18 (-0.02 to 0.38)	0.25 (0.02-0.48) ^d	<.01
Dental services	Reference	-0.01 (-0.24 to 0.22)	0.25 (0.02-0.48) ^d	0.50 (0.26-0.74) ^c	<.001
Emergency	Reference	-0.40 (-0.64 to -0.15) ^b	-0.12 (-0.36 to 0.13)	-0.28 (-0.59 to 0.02)	
Hospitalization, days	Reference	-0.22 (-0.29 to -0.15) ^c	-0.36 (-0.43 to -0.29) ^c	-0.52 (-0.61 to -0.43) ^c	<.001
Medical expenditures, 1000 NT\$					
Ambulatory					
Outpatient services	Reference	-0.05 (-0.23 to 0.12)	0.08 (-0.10 to 0.26)	0.16 (-0.05 to 0.38)	<.05
Preventive care	Reference	0.10 (-0.05 to 0.25)	0.21 (0.05-0.37) ^b	0.27 (0.08-0.46) ^b	<.001
Dental services	Reference	-0.02 (-0.30 to 0.25)	0.09 (-0.20 to 0.37)	0.42 (0.10-0.74) ^b	<.01
Emergency	Reference	-0.39 (-0.69 to -0.10) ^b	-0.42 (-0.72 to -0.12) ^b	-0.26 (-0.62 to 0.10)	
Hospitalization	Reference	-0.55 (-0.92 to 0.19) ^b	-0.64 (-1.1 to -0.27) ^c	-0.50 (-0.94 to -0.07) ^d	<.01
Total medical expenditures	Reference	-0.37 (-0.61 to -0.12) ^b	-0.33 (-0.68 to -0.08) ^b	-0.27 (-0.57 to 0.02)	

CI indicates confidence interval; DDS, Dietary Diversity Score; NT\$, Taiwanese new dollars.

^aModels were adjusted for sex, age, regions (13 region), personal education (illiterate, primary and below, secondary education and above), household monthly income (NT \$<15,000, NT \$15,000-29,999, NT \$30,000-49,999, NT \$50,000), smoking (yes, no), alcohol drinking (yes, no), betel nut chewing (yes, no), and perceived health status (good, fair, poor).

^bP < .01.

^cP < .001.

^dP < .05.

tial homes with those of a control group. After 1 year of intervention, the intervention group had higher healthcare costs in primary healthcare, although costs for total health and hospital care were equivalent because of a small sample size and short follow-up time.⁴³ The findings of that study are consistent with ours, except that our participants were community-dwelling elders. Similarly, the Australian Longitudinal Study on Women's Health showed that middle-aged women who had a higher diet quality had fewer Medicare (the national universal health insurance scheme) claims but higher healthcare costs.⁴⁴ The sensitivity analyses in the present study show that better dietary quality was associated with less utilization of and lower expenditures for emergency services and hospitalization, and lower total medical costs. Those who follow more nutritious dietary patterns may also engage in other health-seeking behaviors with health-system costs, but these behaviors may enable downstream savings due to less use of costly, more acute emergency and inpatient services.⁴³⁻⁴⁶

We used sensitivity analyses for several reasons. Firstly, the elderly who died in the first year of follow-up might have experienced weakness or prior disease. Secondly, the use and

cost of health services during the last year of life can vary substantially for older people.^{47,48} However, these analyses did not alter the findings.

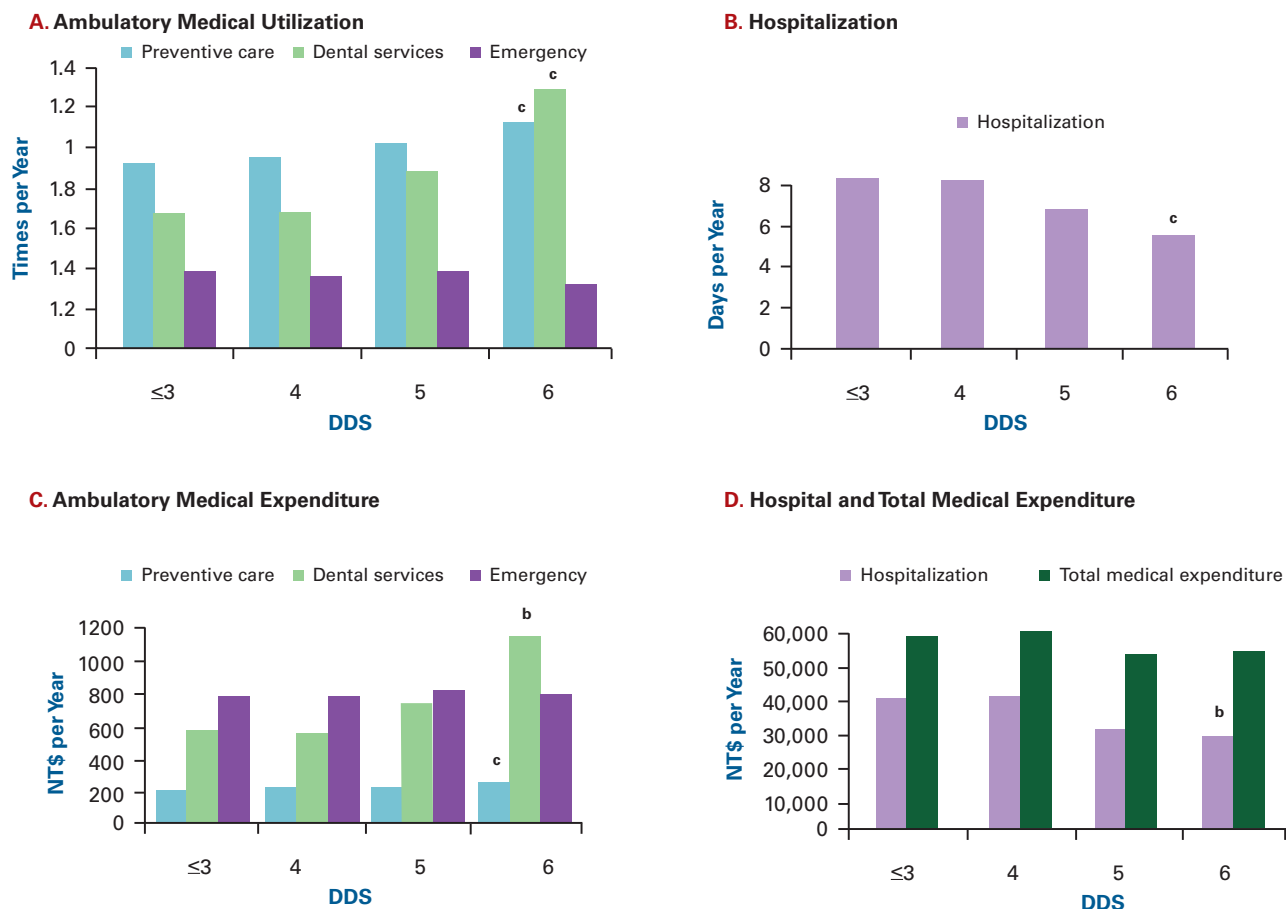
Strengths and Limitations

The major strength of the present study is that we were able to combine a national nutrition survey with National Health Insurance data, so as to evaluate the extent to which the cost of medical services was related to diet in the elderly.

However, the study has a number of limitations. First, whereas the Taiwanese NHI covers 99% of the population, there are out-of-pocket expenses not covered by the NHI.^{23,49} Affluent households are better able to afford the medical services not covered by the NHI compared with disadvantaged households. Thus, this study may underestimate the medical costs of households with a higher socioeconomic status. Second, there is still social disparity in healthcare access and affordability despite efforts to overcome this disparity,⁵⁰ which also leads to errors in estimating medical service use and costs. Finally, the NHI in Taiwan is a unique universal health insurance coverage system,¹³ and our findings may not apply to other countries.²³

Dietary Diversity Predicts Type of Medical Expenditure in Elders

Figure 2. Annual Medical and Hospital Utilization and Expenditure by Dietary Diversity: (A) Ambulatory Medical Utilization (Times per Year); (B) Hospitalization (Days per Year); (C) Ambulatory Medical Expenditure (NT\$ per Year); and (D) Hospital and Total Medical Expenditure (NT\$ per Year)^a



DDS indicates Dietary Diversity Score; NT\$, Taiwanese new dollars.

^aAll subjects who died in the first year of follow-up, as well as medical utilizations and expenditures 1 year before death, were excluded.

^b $P < .05$.

^c $P < .001$ (P for linear trend).

CONCLUSIONS

We investigated the relationship between dietary quality and medical care utilization and expenditures among a general Asian population. Elderly individuals with better dietary quality, as determined by a higher DDS, required fewer emergency and hospitalization services but obtained more preventive and ambulatory care. The findings have important implications for nutrition-related health service policy. Such a policy should pay close attention to socially disadvantaged groups with poorer dietary quality.

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Dietary Diversity Predicts Type of Medical Expenditure in Elders

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