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Research paper

Nutritional status plays the mediating role of the functional status and comorbidity among older patients admitted to the Geriatric Evaluation and Management Unit: A Tobit model application

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ABSTRACT

Health care for older people is featured by simultaneous management of the multiple comorbid complex conditions, including acute illnesses, underlying comorbid conditions, nutritional status, functional status and many others. The purpose of this study was to investigate nutritional status and its effect on the relationship between co-existing diseases and functional status among older patients admitted to the geriatric ward in Taiwan. A descriptive correlational design was used and data of 401 patients were retrospectively collected for analysis. Comprehensive geriatric assessment was performed for all patients, which included the Mini-Nutritional Assessment, the Barthel Index, and the Charlson Comorbidity Index. The Tobit model was used to manage censoring data, and hierarchical logistic regressions were conducted to determine the relationships among nutrition status, functional status and comorbid conditions. A significant mediating effect of nutritional status on the relationship between multimorbidity and functional status was found. Although multimorbidity, nutritional status, and functional status are usually interlinked in geriatric care, results of this study showed that nutritional intervention may play a stronger role in improving functional status of older patients admitted for acute geriatric services. Further intervention study is needed to confirm the mediating role of nutritional status between comorbidity and functional status for older patients.

1. Introduction

Population aging is a global phenomenon that affects both developed and developing countries, and Taiwan is no exception. The major challenge of geriatric care is the balance of managing multimorbidity and disability simultaneously for older people. Taiwan has become an aging country in 1993, and is estimated to become an aged country by 2017. Moreover, the percentage of people aged 65 years and older will reach 20% by 2025, and may hit 30% by 2050 [1–3]. This rapid demographic transition makes Taiwan one of the fastest aging countries in the world, and poses various challenges to the health care systems. Among all health care challenges to the older patients, malnutrition is of great importance in different healthcare settings [4–6]. Poor nutrition is common in the elderly, especially in those with chronic diseases, and malnutrition has been reported to aggravate the physical conditions of older people [7–9]. Fritz and Elmadfa surveyed the nutritional status of 233 Australian elderly in 2003, showing that they had an insufficient intake of nutrient-dense foods, over-consumed meat and under-consumed carbohydrates and fiber [10]. In addition, these people's intake of folate, vitamin D, calcium, iodine, magnesium, and vitamin C was considered inadequate. In Taiwan, approximately 9.5% of the 497 older persons participating in the annual health check-up were at risk of malnutrition by using Mini-Nutritional Assessment (MNA) [11].

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It is generally agreed that the health status may deteriorate gradually as people become older, and the effects of morbidity may increase significantly with aging [12]. It has been reported that 65.2% of elderly people in Taiwan had certain chronic conditions, and 12.7% of elderly people had difficulties in basic activities of daily living [13]. Among patients admitted to the Geriatric Evaluation and Management Unit (GEMU), they usually suffer from multiple complex care needs, including disease treatment, disability care, cognitive-affective conditions, and malnutrition as well [14]. Functional status is the best indicator to measure health status of older people, and the Barthel Index is a widely used instrument for basic activities of daily living [15]. Despite the extensive use of Barthel Index in research and clinical settings, the potential ceiling effect, floor effect, or both eventually reduce its clinical applications [16]. However, the Tobit model, interchangeable with a censor regression model, has been developed to manage censoring the distribution of dependent variables, which is appropriate for analysis of these functional measurements. Among the complex interrelationship between diseases, functional status, and nutritional status, we hypothesize that nutritional status is a mediating factor to poor functional status. Therefore, the main purpose of this study is to investigate nutritional status and its effect on the relation between co-existing diseases and functional status among older patients admitted to GEMU in Taiwan using the Tobit model.

2. Methods

2.1. Data source

Data of all elderly patients admitted to the GEMU of Taipei Veterans Hospital between May 2011 and May 2012 were retrospectively collected for this study. In GEMU, all patients received the Comprehensive Geriatric Assessment (CGA) within 72 hours of admissions, and care plans were developed based on the consideration of diseases and functional assessment. However, patients who had communication difficulties or were too acutely ill were not included for study because they were not able to complete all functional assessments. The study was approved by the Institutional Review Board of the Taipei Veterans Hospital.

2.2. Comprehensive Geriatric Assessment

The demographic characteristics of the study subjects were collected including age, gender, marital status, educational level, tobacco use, alcohol use, and primary caregiver. The Charlson Comorbidity Index (CCI), a widely used instrument across healthcare settings [17–20], was used to evaluate co-existing diseases in individual patients. The CCI contained evaluations of 19 conditions, and the total scores of patients were categorized into 0, 1–2, 3–4 and >5 in this study; higher scores suggested poorer health statuses of patients.

Activities of Daily Living (ADL) were measured by the Barthel Index, which was first developed in 1965 and revised in 1979 [21]. These activities can be categorized into two entities: self-care (feeding, grooming, bathing, dressing, bowel and bladder care, and toilet use) and mobility (ambulation, transfers, and stair climbing). The individuals reported what they did in each specific activity, and scores ranged from 0–10 for each item with intervals of 5 points (0 refers to completely dependent, 5 refers to the need for assistance for daily activities, and 10 refers to independent but with some assistance). The lowest sum score of 0 indicates a completely dependent state, and a maximum sum score of 100 indicates that a patient is fully independent in physical functioning. The validity and reliability were confirmed by previous research, and this index has been used with different chronic diseases in various age groups [22].

The nutritional status of the study subjects was assessed by the Mini-Nutritional Assessment (MNA) [23]. The MNA consists of 18 questions in four areas: (1) anthropometric assessment such as body mass index, mid-arm circumference, and calf circumference; (2) global assessment, such as living in nursing homes, medications, dementia, and depression; (3) dietary questions, such as eating full meals and various food intakes; and (4) a subjective self-assessment referring to how subjects perceive their need for help compared with individuals of a similar age. The scores range from 0–30 and are divided into three levels of nutritional status. A score below 17 points suggests malnutrition, 17–23.5 points suggests a risk of malnutrition, and more than 24 points refers to being well nourished. The MNA has been widely used in geriatric populations with good psychometric properties [11,24–28].

2.3. Statistical analysis

G*Power version 3.1 (Department of Criminology, University of Melbourne, Parkville, Victoria 3010, Australia) software was used to estimate sample size. The significance level was set at $\alpha = .05$, the statistical power at $(1 - \beta) = .90$, and effect size at .25 to determine the sample size. Based on this information, at least 108 participants needed to have been recruited; however, in this study, 401 patients submitted data. The Tobit regression model was used to manage the ceiling and floor effects of functional status. The hierarchical regression model and the Tobit regression model were employed to determine differences among nutritional status, functional status and comorbid conditions. In addition, a comparison of these two models was presented [16,29].

3. Results

3.1. Demographic characteristics

During the study period, 709 patients were admitted to the GEMU and 308 patients were not included due to the acuteness of diseases or refusal to participate in the study. Therefore, data of the remaining 401 patients were obtained for analysis. Among these patients, the mean age was 84.9 years, and 295 (73.6%) were male. Approximately 40% of these patients had an elementary school education or below. Table 1 summarizes the demographic characteristics of the study participants descriptive data of nutritional status, comorbidity condition and functional status of the study subjects. Table 2 shows that the mean of the Barthel Index of all patients was 6.59, which indicates the middle level of disability and a need for help with daily activities. Approximately 80% of the patients were completely dependent or requiring assistance in at least one item of the Barthel Index, and only the remaining 20% could perform their daily activities independently. On the other hand, the mean MNA score of the study subjects was 20.2, which suggested a risk of malnutrition in all patients. Among the patients, 22.7% were classified as malnourished, and 44.4% of them were at risk of malnutrition. As for comorbidities, 45.9% of all patients were categorized into score 1–2 of the CCI, and 30.7% of the patients were categorized to score 3–4 of the CCI, which indicated that the majority of patients had more than one co-existing disease. Among all study subjects, geriatric syndrome is the leading cause of GEMU admission, which was followed by diseases of psychiatry, infection, neurology, and so on (Table 2).

3.2. Interrelation of functional status, nutritional status and comorbidity

Fig. 1 shows that the Barthel Index of all study subjects was not normally distributed, and the floor and ceiling effects were noted as expected. Because the dependent variable was censored, and the

Table 1
Demographic characteristics of the study participants ($n = 401$).

Variable	Mean (SD)	*n*	%
Gender			
Male		295	73.6
Female		106	26.4
Educational levels			
None		64	16.0
Elementary school		95	23.7
Junior high school		63	15.7
Senior high school		81	20.2
College		98	24.4
Smoking			
Yes		31	7.7
No		370	92.3
Habitual alcohol drinking			
Yes		49	12.2
No		352	87.8
Main caregiver			
Self		171	42.6
Spouse		77	19.2
Children		77	19.2
Other		76	19.0
Age (years)	84.87 (6.09)		
65–74		25	6.2
75–84		158	39.4
≥85		218	54.4
Body mass index (kg/m^2)	22.64 (4.19)		
Waist circumference (cm)	86.94 (11.89)		

Tobit model was used, scores of less than 10 and over 90 were excluded. The linear regression model and the Tobit model are both presented in Table 3. In model 2, the results suggested that the CCI was significantly associated with ADL ($\beta = -4.40$, $P < 0.001$), and the β of CCI changed from −2.69 to −1.70 when the MNA was added to the model, suggesting that the relationship between the CCI and ADL had been minimized. Therefore, the MNA played the key mediating role in the relationship between the CCI and ADL.

Table 2
Health status of the study participants ($n = 401$).

Variable	Mean (SD)	*n*	%
Charlson Comorbidity Index	2.51 (1.93)		
0	0.11 (0.49)	45	11.2
1–2	1.20 (0.73)	184	45.9
3–4	2.89 (1.00)	123	30.7
>5	4.65 (1.96)	49	12.2
Main diagnosis of admissions			
Geriatric syndrome		125	31.2
Psychiatry		60	15.0
Infectious diseases		44	11.0
Neurology		39	9.7
Cardiovascular diseases		33	8.2
Musculoskeletal diseases		27	6.7
Hemato-oncology		31	7.7
Respiratory diseases		17	4.2
Endocrinology		13	3.2
Nephrology		12	3.0
Mini-Nutritional Assessment	20.23 (5.19)		
<17	12.71 (3.38)	91	22.7
17–23.5	20.14 (1.80)	178	44.4
≥23.5	25.53 (1.57)	132	32.9
Barthel Index			
Total dependence (0–20)	8.97 (7.99)	58	14.5
Severe dependence (21–60)	45.41 (12.14)	104	25.9
Moderate dependence (61–90)	80.19 (8.25)	131	32.9
Mild dependence (91–99)	95.00 (0.00)	23	5.8
Total independence (100)	100.00 (0.00)	84	20.9
Preserved items of activities of daily living	6.59 (3.18)		
0		28	7.4
≥1 ~ <5		78	19.5
≥5 ~ <10		211	52.6
10		84	20.9

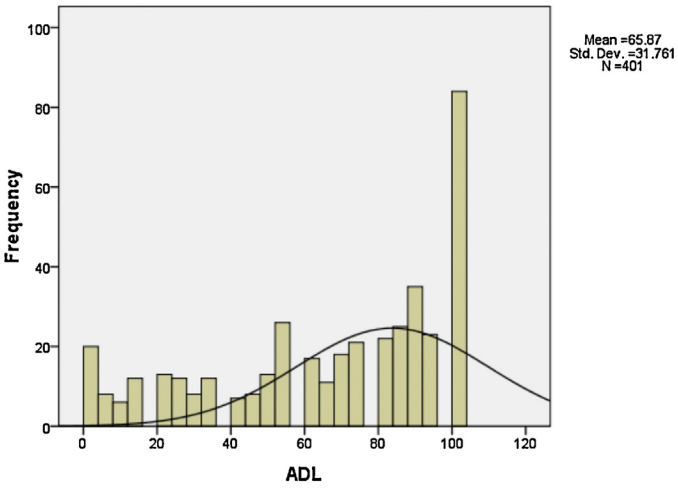

Fig. 1. Distribution of Barthel Index.

Table 3
Comparisons of the differences between linear regression and the Tobit model on censoring distributions.

	Model 1		Model 2	
	Linear regression		Tobit model	
	β	*P*	β	*P*
Intercept				
Step 1				
CCI	−2.838	0.001	−4.404	<0.001
Step 2				
CCI	−1.702	0.012	−2.698	0.008
MNA	3.435	<0.001	4.776	<0.001
Model-fit parameters				
AIC	2611		2537	
BIC	2623		2553	

CCI: Charlson Comorbidity Index; MNA: Mini-Nutritional Assessment; AIC: Akaike's information criteria; BIC: Bayesian information criteria.

Notably, Akaike's information criteria (AIC) and Bayesian information criteria (BIC) in the Tobit model were lower than in the regression model, and β was higher in the Tobit model. This indicated that Tobit offered a better fit to analyze this association. As shown in Table 4, age, caregiver, waist circumference and MNA scores were all contributors of ADL in both models. However, the

Table 4
Comparisons of the differences between linear regression and Tobit Model on censoring distributions of all variables.

	Model 1		Model 2	
	Linear regression		Tobit model	
	β	*P*	β	*P*
Intercept				
CCI	−0.431	0.472	−0.700	0.425
MNA	3.487	<0.001	4.864	<0.001
Primary caregiver	−9.480	<0.001	−13.347	<0.001
Smoking	−6.489	0.151	−10.198	0.119
Drinking	−1.137	0.752	−2.227	0.670
Gender	1.204	0.683	3.295	0.450
Age	−0.545	0.006	−0.802	0.007
Educational levels	−0.864	0.310	−0.862	0.493
Waist circumference	−0.466	0.009	−0.763	0.004
Body mass index	−0.232	0.667	−0.288	0.715
Model-fit parameters				
AIC	2503		2433	
BIC	2547		2481	

CCI: Charlson Comorbidity Index; MNA: Mini-Nutritional Assessment; AIC: Akaike's information criteria; BIC: Bayesian information criteria.

CCI was not a significant predictive factor for ADL after other associated demographic factors were entered into the model. The results in both models were similar to AIC and BIC (lower), and the β was higher in the Tobit model compared with the linear regression model.

4. Discussion

Results of this study clearly demonstrated that nutritional status plays the key mediating role in multimorbidity and disability among patients admitted to the GEMU. In this study, almost 90% of the patients had at least one chronic disease, which was similar to the previous research in Taiwan [12]. Notably, the percentage of functional dependence in daily activities (80%) and that of malnutrition or at risk for malnutrition (67%) were much higher than previous studies [13,15]. However, patients admitted to GEMU were often having multiple complex conditions, which explained the higher prevalence of disability and malnutrition than other studies. Although geriatricians usually have to deal with multiple complex care needs for older patients, care planning for these patients is always difficult, which deserves extensive consideration.

This study found that nutritional status had a great influence and mediating effect on the relation between functional status and underlying diseases. Other associative factors identified in this study include age, primary caregiver, education levels and waist circumference, which are non-modifiable factors except waist circumference. Functional decline is very common among older patients being admitted to acute hospitals, even though the diseases were well managed. Results of this study suggested that aggressive nutritional intervention may be of greater help for patients regaining their functional independence.

This study found the Tobit model to be an appropriate approach to analyze the relation between variables, especially for censoring outcome variables. The Barthel Index has been widely used in functional assessment of the geriatric population; however, the floor or ceiling effect is a common limitation for clinical application. Thus, Tobit offers a solution to manage the detection limit. Conversely, observed censoring data reflecting the choice of the participants may not be an appropriate way to manage this type of situation by Tobit [16,17]. Using this model, the interrelation between functional status, comorbidities and nutritional status can be demonstrated more clearly. Moreover, results from this study can be applied to inpatient, outpatient and community settings because preventing functional decline among older people with multimorbidity is the key of geriatric services.

Despite extensive research efforts went into this study, there are still several limitations. First, nearly three-quarters of the patients were males because the study was conducted in a veteran hospital, which may limit the extrapolation of study results to the general population. Although there was a significant gender difference, the study results may still be of certain implications in future researches. Second, the cross-sectional study design could not demonstrate a causal relation of these parameters and the concern of selecting Barthel Index as the functional measurement in acute care settings has been raised. However, this study aimed to use Tobit model to explore the possibilities to improve the application of Barthel Index in acute wards. Third, the prevalence of malnutrition and at risk for malnutrition in the study subjects was high at their GEMU admissions; whether poor nutritional status was related to acute conditions or underlying comorbid conditions remained unclear. Lastly, the cognitive function was not included in the study analysis because cognitive function of these patients may be influenced by their acute illnesses. Nevertheless, the role of cognitive function in physical disabilities and malnutrition in acute care settings deserves further investigations.

In conclusion, a high prevalence of comorbidity, risk for poor nutrition and poor functional status were found among patients admitted to the GEMU of a tertiary medical center in Taiwan. Health care providers should pay greater attention to nutritional status in geriatric inpatients, and a nutritional support program is badly needed. In addition, the Tobit model offers an alternative way to manage censoring health outcome data.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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