BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018443
Article Type:	Research
Date Submitted by the Author:	30-Jun-2017
Complete List of Authors:	Sharma, Yogesh; Flinders Medical Centre, General Medicine; Flinders University Faculty of Medicine Nursing and Health Sciences Miller, Michelle; Flinders University Faculty of Medicine Nursing and Health Sciences, Nutrition & Dietetics Kaambwa, Billingsley; Flinders University Faculty of Medicine Nursing and Health Sciences, Health Economics Shahi, Rashmi; Flinders University Faculty of Medicine Nursing and Health Sciences Hakendorf, Paul; Flinders Medical Centre Horwood, Chris; Flinders Medical Centre Thompson, Campbell; University of Adelaide, Discipline of Medicine
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Geriatric medicine
Keywords:	GERIATRIC MEDICINE, NUTRITION & DIETETICS, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, GENERAL MEDICINE (see Internal Medicine)

Malnutrition and its association with readmission and death within 7 days and 180 days post-discharge in older patients-a prospective study

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Word count: 2800

Abstract

Objective The relationship between admission nutritional status and clinical outcomes following hospital discharge is not well established. This study investigated whether nutrition status at admission predicts unplanned readmission or death in the very early or late period following hospital discharge in older patients.

Design, Setting and Participants We prospectively recruited 297 patients ≥60 years presenting to the General Medicine Department of a tertiary care hospital in Australia. Nutrition status was assessed at admission by using the Patient Generated Subjective Global Assessment (PG-SGA) tool and patients were classified as either nourished (PG-SGA class A) or malnourished (PG-SGA class B and C). Multivariate logistic regression model was used to adjust for other covariates known to influence clinical outcomes, to determine whether malnutrition is a predictor for early (0-7days) or late (8-180 days) readmission or death following discharge.

Outcome measures The impact of nutritional status was measured on a combined endpoint of any readmission or death within 0-7 days and between 8-180 days following discharge from hospital.

Results Within 7 days following discharge, 29 (10.5%) had an unplanned readmission or death whereas an additional 124 (50.0%) patients reached this combined endpoint within 8-180 days post-discharge. Malnutrition was associated with a significantly higher risk of combined endpoint of readmissions or death both within 7 days (OR 4.57, 95% CI 1.69-12.27, p<0.001) as well within 8-180 days (OR 1.98, 95% CI 1.19-

3.28, p=0.007) following discharge and this risk remained significant even after adjustment for other covariates.

Conclusions Malnutrition at the time of hospital admission is a significant predictor of readmission or death both in very early and late period following hospital discharge in older patients and nutritional state should be included in future risk prediction models.

Strengths and limitations of this study

- Large prospective observational study evaluating the association between nutritional status and readmission or death in medical inpatients ≥ 60 years
- Use of a comprehensive and valid nutritional assessment tool by a dietitian to confirm diagnosis of malnutrition
- Readmissions presenting to all other hospitals were captured
- Single-centre study included only older medical patients

Introduction

Recent decades have witnessed a vast improvement in life expectancy with consequent increasing numbers of older patients with multiple chronic problems. While the number of beds for acute patients has declined unplanned hospital admissions have increased, especially among the elderly.[1] Older patients with multiple comorbid illnesses experience poor clinical outcomes after discharge from hospital including recurrent unplanned readmissions and mortality.[2] Adverse outcomes following discharge may be indicative of unresolved acute illness,[3] ongoing chronic illness,[4] the development of new medical problems or gaps in outpatient care.[5] Although adverse outcomes following discharge are not totally preventable, studies does suggest that targeted intervention such as improved discharge planning with a focus on transitional care services may provide beneficial results.[6]

The likelihood of an unplanned admission is highest in the immediate post discharge period,[7] so there may be advantages in predicting re-admissions that occur shortly after discharge. However, the majority of studies have only assessed readmission patterns within 30 days of discharge and very few studies have studied readmission patterns up to 180 days post-discharge. Grahams et al[8] have suggested that different risk factors may be responsible for very early and late readmissions and each type of readmission needs differently targeted interventions which can only be implemented in advance if predictive factors are identified.

Readmission and mortality risk prediction remains poorly understood and is a complex endeavour. A recent meta-analysis[9] of 26 readmission risk prediction models of medical patients tested in a variety of populations and settings and used for comparisons of different hospitals and appropriate application of transitional care

services found poor predictive ability of these models and suggested a need for high quality data sources that include clinical relevant variables. None of the studies included in this meta-analysis has taken into account the nutritional status of patients during index admission as a determinant of readmissions.

Studies suggest that up to 30% of hospitalized patients may be malnourished at the time of admission[10] and malnutrition has a negative impact on convalescence, reduces resistance to future infections and diseases with consequent poor clinical outcomes.[11] [12] However few studies have assessed the association between nutrition status at admission and clinical outcomes in the very early and late period following discharge from hospital. Moreover, the majority of these studies are retrospective and the use of a comprehensive nutritional assessment tool like Patient Generated Subjective Global Assessment (PG-SGA) to diagnose malnutrition is rare. This study was therefore designed to determine whether nutrition status at admission as diagnosed by PG-SGA by a qualified dietitian influences a combined clinical outcome of readmission or mortality within 7 days and between 8-180 days following discharge from hospital and whether malnutrition could be used as one of the predictors of early and late readmissions and death.

Methods

Study design and population

In this prospective cohort study, we included patients ≥60 years of age admitted to the Department of General Medicine of a large tertiary care hospital in Australia (Flinders Medical Centre, 520 beds), between August 2014 and March 2016. The exclusion

criteria were refusal or inability to give informed consent, patients referred to palliative care and non-English speaking patients. Non-English speaking patients were excluded due to lack of funds to seek services of an interpreter. Ethical approval was obtained from Southern Adelaide Human Research Committee (SAC HREC) approval number (273.14-HREC/14/SAC/282) on 21st July 2014. For this observational cohort study we did not perform sample size calculation and limited our sample size to the resources available.

Outcomes

We defined our primary outcome as a combined endpoint of either the first unplanned readmission to any of the acute care hospitals in the state of South Australia or death, within 0-7 days and between 8-180 days after discharge from index hospitalization. In this study unplanned readmission was defined as any unscheduled hospitalization to any hospital in the state of South Australia which was not for a planned investigation (eg, elective endoscopy) or non-emergent treatment (eg, planned drug infusion). The primary endpoint of readmissions or deaths were recorded from a central computer database, which captures these events for all state hospitals.

Nutritional status assessment

After obtaining written informed consent from patients, nutrition screening was performed by a member of the research team using the Malnutrition Universal Screening Tool (MUST) and all patients were then referred to a qualified dietitian for

confirmation of nutrition status by PG-SGA. The PG-SGA[13] generates a numerical score while also providing an overall global rating divided into three categories: well nourished (PG-SGA A), moderately malnourished or suspected of being malnourished (PG-SGA B) or severely malnourished (PG-SGA C). For each component of the PG-SGA, points (0-4) are awarded depending on the impact on nutritional status. Component scores are summed up to obtain total scores that range from 0-35 with scores ≥7 indicating a critical need for nutritional intervention and symptom management in older subjects.[14] Three different dietitians who were involved in the assessment of nutritional status using the PG-SGA received training prior to commencement of this study. We dichotomized PG-SGA classes into two categories by combining PG-SGA class B and C into malnourished category for ease of interpretation of patients as nourished (PG-SGA class A) and malnourished (PG-SGA class B and C). Further, PG-SGA scores were dichotomized into a categorical variable with a PG-SGA score of <7 indicative of no critical need for nutrition intervention and ≥7 indicating critical need for intervention.

Covariates

A number of known variables which can influence outcomes after discharge from hospital were recorded at the baseline. Sociodemographic data, number of hospitalisations during the 6months before index admission and clinical information were recorded at the baseline. Comorbidity was assessed by the Charlson comorbidity index and the total number of medications were recorded at the time of admission. Health-related quality of life (HRoL) was assessed using EuroQoL 5 dimensions 5 level (EQ-5D 5L)[15] questionnaire, a simple, self-administered instrument which is able to distinguish between 3,125 states of health. A UK-specific algorithm developed

using time-trade-off techniques was used to convert the EQ-5D 5L health description into a valuation ranging from -0.281 to 1.[16] A visual analogue scale (VAS) score, which provides an unweighted measure of HRoL, can also be calculated from the questionnaire. The main diagnosis of index admission was retrieved from medical records and divided into 7 categories according to the system affected: (1) respiratory disease, (2) cardiovascular disease (3) neuropsychiatric disease, (4) gastrointestinal disease, (5) Falls, (6) renal disease, and (7) miscellaneous diseases including infections. The acuity of the index admission was gauged from the total number of medical emergency response team calls and number of hours spent in the intensive care unit. Length of hospital stay (LOS) was determined from the day of admission to the day of discharge. We recorded any unplanned hospital presentations to any of the hospitals in South Australia within 0-7days and between 8-180days after discharge from hospital in addition to any recorded deaths at the same time points using central hospital computer database.

Statistics

Demographic variables were assessed for normality using Skewness and kurtosis (sk) test. Data are presented as mean (SD) or median (IQR) and student t test and rank sum tests were applied as appropriate. Categorical variables are expressed as frequency and percent and compared using Pearson's x^2 or Fisher's exact test as appropriate. Univariate logistic regression was used to assess the association between nutritional status and a combined end point of unplanned readmission or death within 7 days and between 8-180 days post-discharge. In a multivariate logistic regression analysis the relationship between readmission/death and nutrition status at admission was adjusted

for other variables-age, gender, Charlson index, principal diagnosis at presentation, number of medications at admission, length of hospital stay, number of medical emergency response team calls during index admission and total number of hours spent in intensive care unit (ICU). Variance inflation factor and tolerance values[17] were used to detect collinearity between variables included in the model. A link test was used to confirm that the linear approach to model the outcome was correct. Model fit was assessed using the Hosmer-Lemeshow goodness-of–fit test. Kaplan Meier survival curve was plotted from time of discharge to the first onset of any of the primary outcomes to detect proportion of patients who did not experience the primary outcome. Log rank test was used to compare survival proportions in the nourished and malnourished groups. A two-sided $p<0.05$ was considered to indicate statistical significance. All analysis were performed using STATA version 13.1 (StataCorp, College Station, Texas, USA).

Results

We recruited 297 patients in this study and nutrition status, as determined by PG-SGA, was available for 277 patients. Mean age was 80.3 years (SD 8.7, range 60-97) and 178 (64.3%) were females. Patients had multiple comorbidities (mean number of comorbidities 6.2, SD 2.7, range 0-16) and mean Charlson comorbidity index was 2.3 (SD 1.8). Median length of stay for index hospitalization was 7.0 (IQR 3.4-14.6) days. Within 7 days after discharge, 29 (10.5%) patients had an unplanned readmission or death (primary endpoint). Among the 29 patients who had primary endpoint within 7 days, 13 (44.8%) had been previously readmitted prior to the index admission. Primary endpoint occurred in 124 (50.0%) patients within 8-180 days post-discharge and 69 (55.7%) of these patients had been admitted in the six months prior to the

index admission. Patients who were malnourished at the time of index admission were significantly older (p=0.001), had lower quality of life (p=0.03) and stayed longer (p=0.02) in hospital as compared to nourished patients. Respiratory illness, miscellaneous diseases including sepsis and cardiovascular diseases were the three frequent main diagnosis of index hospitalization with 86 (28.9%), 67 (22.6%) and 55 (18.5%) cases, respectively.

Table 1 Baseline characteristics according to primary endpoint (readmission/death) at 0-7 days and 8-180 days post-discharge

	Readmission/death within 0-7 days (n= 29)	No readmission/death within 0-7 days (n=248)		Readmission/death within 8-180 days (n=124)	No readmission/death within 8-180 days (n=124)	
			p value			p value
Age mean (SD)	81.2 (7.6)	80.2 (8.8)	0.74	80.3 (8.6)	80.0 (9.0)	0.77
Female sex n (%)	13 (44.8)	165 (66.5)	0.02	80 (64.5)	85 (68.5)	0.50
Total comorbidities mean (SD)	6.8 (3.0)	6.1 (2.7)	0.20	6.6 (2.9)	5.7 (2.5)	0.012
Charlson index mean (SD)	2.8 (2.1)	2.2 (1.8)	0.09	2.4 (1.8)	2.1 (1.8)	0.16
Total medications mean (SD)	9.1 (4.5)	9.6 (4.4)	0.56	10.3 (4.5)	8.9 (4.2)	0.007
Principal diagnosis at index admission n (%)						
Respiratory	13 (44.8)	72 (29.0)	0.34	33 (26.6)	39 (31.5)	0.02
CVS	6 (20.7)	44 (17.7)		28 (22.6)	16 (12.9)	
Neuropsychiatric	2 (6.9)	23 (9.3)		11 (8.9)	12 (9.7)	
GIT	2 (6.9)	17 (6.9)		11 (8.9)	6 (4.8)	
Falls	0 (0)	21 (8.5)		4 (3.2)	17 (13.7)	
Renal	0 (0)	16 (6.5)		6 (4.8)	10 (8.1)	
Miscellaneous	6 (20.7)	55 (22.2)		31 (25.0)	24 (19.4)	
LOS median (IQR)	13.3 (6.7-35.9)	6.8 (3.2-13.7)	0.004	7.9 (3.6-15.2)	5.7 (3.1-11.5)	0.11
MUST score[a]	1.9 (1.4)	1.1 (1.2)	0.001	1.3 (1.3)	0.9 (1.2)	0.03
Nutrition status PG-SGA[b] n (%)						
Nourished	5 (17.2)	121 (48.8)	0.001	50 (40.3)	71(57.3)	0.008
Malnourished	24 (82.8)	127 (51.2)		74 (59.7)	53 (42.7)	
Patients with PG-SGA ≥7 n (%)	25 (86.2)	142 (57.3)	0.002	80 (64.5)	62 (50.0)	0.02
QoL mean (SD)						
EQ-5D index[c]	0.678 (0.226)	0.709 (0.222)	0.49	0.700 (0.229)	0.717 (0.217)	0.31
VAS[d]	55.2 (17.1)	59.5 (20.1)	0.28	55.9 (20.4)	62.8 (18.1)	
Total MET calls mean (SD)	0.24 (1.0)	0.13 (0.4)	0.38	0.10 (0.32)	0.15 (0.53)	0.95
Total ICU hours mean (SD)	4.3 (19.3)	1.9 (13.4)	0.53	2.3 (15.5)	1.5 (11.0)	0.62

SD, standard deviation; CVS, cardiovascular; GIT, gastrointestinal; LOS, length of hospital stay; IQR, interquartile range; MUST, malnutrition universal screening tool; PG-SGA, patient generated subjective global assessment; QoL, quality of life; EQ-5D, european quality of life 5 dimension; VAS, visual analogue scale; MET, medical emergency team; ICU, intensive care unit
[a]Higher MUST score indicates high risk for malnutrition, [b]PG-SGA class dichotomized to PG-SGA A (nourished) and PG-SGA B and C (malnourished), [c]Higher EQ-5D index indicates better QoL, [d]Higher VAS indicates better QoL

Association of malnutrition very early and late unplanned readmissions and mortality

Table 1 shows the baseline characteristics according to the occurrence of combined endpoint of readmission or death within 0-7 days and 8-180 days of discharge, respectively. Malnutrition risk as determined by the MUST score and classification of patients as being malnourished by PG-SGA class were significantly higher in subjects who developed the combined endpoint both within 0-7 days (83% vs 51%) and 8-180 (60% vs 43%) days post-discharge ($p<0.05$). Similarly a significantly higher proportion of patients who were in critical need of nutrition therapy (as indicated by PG-SGA score of ≥7) at the time of index admission suffered the combined endpoint both within 0-7 days ($p=0.002$) as well as 8-180 days ($p=0.02$) following discharge from hospital (Table 1).

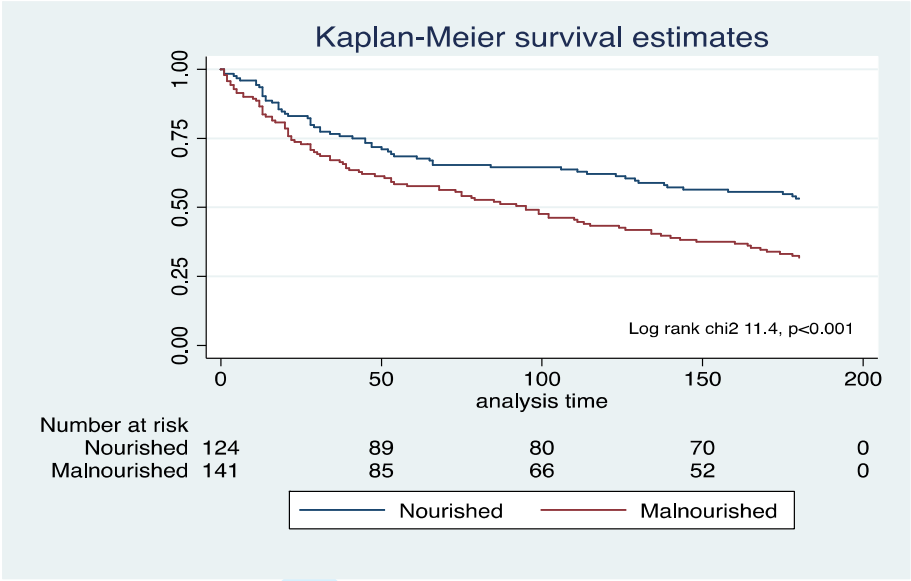
Table 2 Multivariable regression model for early and late readmission/mortality

Variable	Early readmission/death (0-7 days) Odds ratio (95% CI)[a]	Late readmission/death (8-180 days) Odds ratio (95% CI)
Malnourished	5.01 (1.69-14.75)*	1.97 (1.12-3.47)*
Age	1.00 (0.94-1.05)	1.00 (0.97-1.03)
Female sex	0.42 (0.17-1.04)	0.93(0.52-1.66)
Total comorbidities	1.15 (0.96-1.38)	1.08 (0.95-1.22)
Charlson comorbidity index	1.08 (0.84-1.39)	1.03 (0.86-1.23)
Medications during index admission	0.91 (0.81-1.02)	1.05 (0.98-1.12)
LOS of index admission	1.03 (1.00-1.05)*	1.01 (0.99-1.02)
Admissions in last 6 months prior to index admission	0.66 (0.27-1.58)	1.38 (0.79-2.40)
Principal diagnosis index admission Reference (Resp. illness) CVS CNS GIT Falls Urinary Miscellaneous	 - 0.63 (0.20-2.04) 0.34 (0.06-1.93) 0.42 (0.07-2.36) - - 0.35 (0.11-1.12)	 - 2.06 (0.91-4.70) 1.12 (0.41-3.04) 1.91 (0.58-6.28) 0.26 (0.07-0.89) 0.71 (0.21-2.32) 1.36 (0.63-2.92)
ICU hours during index admission	1.01 (0.97-1.05)	1.01 (0.98-1.03)
Total MET calls index admission	0.84 (0.31-2.22)	0.66 (0.32-1.34)

[a]odds ratio determined using multivariable logistic regression (using early/late readmissions as outcome variable)
*p value <0.05
CI, confidence interval; LOS, length of hospital stay; CVS, cardiovascular; CNS, central nervous system; GIT, gastrointestinal; ICU, intensive care unit; MET, medical emergency team

Malnutrition was associated with a higher risk of combined endpoint of readmissions and death within 7 days after discharge (OR 4.57, 95% CI 1.69-12.27, p<0.001). After adjusting for covariates including age, gender, Charlson index, LOS, number of medications, principal diagnosis at current admission and hours spent in intensive care unit during index admission, the association was even stronger for the combined end point (OR 5.01, 95% CI 1.69-14.75, p=0.009) (Table 2). Similarly between 8-180 days post discharge, malnourished patients had higher odds to have a combined end point of readmission and death (OR 1.98, 95% CI 1.19-3.28, p=0.007) and this remained significant even after adjustment for the above covariates (OR 1.97, 95% CI 1.12-3.47, p=0.002) (Table 2). The p-value for the Hosmer-Lemeshow goodness-of-fit was >0.05 for both the adjusted models, indicating a good fit. The variance inflation factors and tolerance were near 1.00 for all variables, excluding significant collinearity. The link test confirmed that the linear approach to model the outcomes was correct. The Kaplan meier survival curve (Figure 1) shows that the nourished group had significant less readmissions and deaths at 180 days than the malnourished group (log rank chi2=0.11, p<0.001).

Figure 1 Kaplan-Meier survival curve for combined outcome in nourished and malnourished



Discussion

The results of the present study indicate that malnutrition at admission as determined by the PG-SGA, was a significant predicting factor of a combined end point of readmission or mortality in older general medical patients, both during early period as well as late after discharge from hospital. Malnutrition was associated with an almost four-fold increased risk of readmission or mortality within 7 days after discharge and the risk almost doubled between 8-180 days after discharge. Malnutrition remained a significant predictor even after adjustment for other covariates, which could have influenced clinical outcome.

One appealing explanation for these results is that the acute condition responsible for the index admission weakens the overall health of the patients and malnutrition further compounds this problem with a consequent higher risk of complications or exacerbations of previously stable comorbidities.[18] The post-discharge period is a fragile period, referred to as "post-hospital syndrome."[19] This syndrome has been

described as a period of vulnerability due to impaired physiological systems, depleted reserves, and lower body resistance against health threats, on top of the recent acute illness responsible for the index admission. Our study results brings another dimension to this theory: that impaired nutritional status may play a significant role in the post-discharge period beyond 7 days. Malnutrition might well be exacerbated by the acute illness and the stress of the index admission, and may consequently induce a relapse or predispose to new acute illnesses[20] that increase the risk of readmission or mortality.

The results of the present study are in line with Mogensen et al[21] who found that malnourished patients who survived intensive care admission had higher 90-day mortality (OR 3.72, 95% CI 1.2-6.3) and malnutrition was a significant predictor of their 30-day unplanned hospital readmission. Studies in heart failure patients have suggested that malnutrition may mediate progression of the underlying heart disease due to low-grade inflammation leading to poor outcomes and was a significant predictor of readmissions.[22]

Older general medical patients are known to have substantial long-term morbidity and mortality. Known risk factors for adverse events following discharge include multiple comorbidity,[23] severity of index admission and institutional care rather than domiciliary care.[2] Hospital readmissions represent a multifaceted problem that still needs better understanding.[18] Presumably there are other factors which influence patient outcomes after discharge which are not well known. What our study illustrates is that early and late post discharge outcomes in patients discharged from hospital appear to be associated with the presence of malnutrition early in the course of admission. While causation cannot be inferred from an observational study, the malnutrition-post discharge outcome has biological plausibility.

To date, no study has included nutritional status in the development of predictive tool for readmissions and this area needs further research. Studies do suggest that nutritional intervention initiated early during hospitalization by providing high energy protein-energy supplements with continuation post hospital discharge does have a favorable impact on nutritional parameters and reduces length of hospital stay[24] but its impact on mortality and readmissions is unclear and such an intervention may be too late for some.[25] While the ideal intervention to improve nutritional status in hospitalized patients has yet to be identified,[26] the solution may lie in recognizing and managing malnutrition in the community well before any admission to hospital.

Limitations

This study has several limitations. Firstly, it is a single centre study in a tertiary care hospital. The case mix of patients discharged from our hospital may differ from that of other hospitals, so the results may not be generalizable to other hospitals, especially to community hospitals, although it is likely to be similar to other academic hospitals in Australia. We were unable to adjust our analysis for functional status or other factors such as appropriateness of drugs, clinical stability at discharge or social factors that might influence readmission. This study involved older general medical patients who frequently suffer from multiple comorbidities and are our results may not be applicable to relatively younger subspeciality patients with single organ system involvement.

One of the strengths of this study is that it was a prospective study and diagnosis of malnutrition was confirmed by a comprehensive nutrition assessment tool by a dietitian. We were able to assess all readmissions in all the hospitals of the state

unlike some of the other studies, which were only able to capture readmissions to a single hospital.

Implications

This study has several implications. Transitions of care should focus not only on the acute condition but also on patients' nutrition status, because the latter may increase risk of readmission or death. There is a need for future well-designed studies to look into the beneficial effects of an intervention targeting malnutrition and whether this prevents readmissions and mortality. In the interim, nutritional intervention should be most effective if begun early during admission and should be continued in the community following discharge by referral to either a community dietitian or follow-up in outpatient dietetics clinics. Overall, public health policies to optimize nutrition of all those over 60 years of age may result in a reduction in health care utilization.

Conclusion

Impaired nutritional status at admission predicts poor clinical outcomes in both early and late post-discharge periods as determined by readmissions and mortality in older general medical patients and a targeted nutritional intervention may prove beneficial in malnourished patients.

Contributors: YS, CT and MM designed the study and YS, CT, BK and MM carried out the analysis and interpretation. YS and RS lead the study and was responsible for data acquisition. YS, PH and CH provided statistical input. YS and RS undertook

recruitment. YS and CT wrote the manuscript, which was edited by BK and MM. All authors approved final manuscript.

Funding: This study did was not supported by any funding.

Competing interests: None

Data sharing statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **(Within the title page 1 and methods section of abstract page 3)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **(see results section of abstract page 3 and 4)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **(pages 5-6)**
Objectives	3	State specific objectives, including any prespecified hypotheses **(page 6)**
Methods		
Study design	4	Present key elements of study design early in the paper **(Methods section pages 6-7)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **(pages 6-7)**
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants **(pages 6-7)**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **(pages 7-8)**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **(pages 8-9)**
Bias	9	Describe any efforts to address potential sources of bias **(N/A)**
Study size	10	Explain how the study size was arrived at **(page 7)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **(pages 8-9)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **(pages 9-10)**
		(*b*) Describe any methods used to examine subgroups and interactions **(N/A)**
		(*c*) Explain how missing data were addressed **(N/A)**
		(*d*) If applicable, describe analytical methods taking account of sampling strategy **(N/A)**
		(*e*) Describe any sensitivity analyses **(N/A)**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed

		(page 10 and Table 1)
		(b) Give reasons for non-participation at each stage (N/A)
		(c) Consider use of a flow diagram **(N/A information in Table 1)**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **(pages 10-11 and Table 1)**
		(b) Indicate number of participants with missing data for each variable of interest **(N/A)**
Outcome data	15*	Report numbers of outcome events or summary measures **(pages 10-11)**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **(page 12 and Table 2)**
		(*b*) Report category boundaries when continuous variables were categorized **(page 12)**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **(N/A)**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **(N/A)**
Discussion		
Key results	18	Summarise key results with reference to study objectives **(page 14)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **(page 16)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **(pages 15-16)**
Generalisability	21	Discuss the generalisability (external validity) of the study results **(pages 16-17)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **(page 18)**

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Malnutrition and its association with readmission and death within 7 days and within 8 to 180 days post-discharge in older patients: a prospective observational study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-018443.R1
Article Type:	Research
Date Submitted by the Author:	20-Sep-2017
Complete List of Authors:	Sharma, Yogesh; Flinders Medical Centre, General Medicine; Flinders University Faculty of Medicine Nursing and Health Sciences Miller, Michelle; Flinders University Faculty of Medicine Nursing and Health Sciences, Nutrition & Dietetics Kaambwa, Billingsley; Flinders University Faculty of Medicine Nursing and Health Sciences, Health Economics Shahi, Rashmi; Flinders University Faculty of Medicine Nursing and Health Sciences Hakendorf, Paul; Flinders Medical Centre Horwood, Chris; Flinders Medical Centre Thompson, Campbell; University of Adelaide, Discipline of Medicine
Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Geriatric medicine
Keywords:	GERIATRIC MEDICINE, NUTRITION & DIETETICS, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, GENERAL MEDICINE (see Internal Medicine)

Malnutrition and its association with readmission and death within 7 days and within 8 to 180 days post-discharge in older patients: a prospective observational study

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Word count: 2800

ABSTRACT

Objective

The relationship between admission nutritional status and clinical outcomes following hospital discharge is not well established. This study investigated whether older patients' nutritional status at admission predicts unplanned readmission or death in the very early or late periods following hospital discharge.

Design, Setting and Participants

The study prospectively recruited 297 patients ≥60 years old who were presenting to the General Medicine Department of a tertiary care hospital in Australia. Nutritional status was assessed at admission by using the Patient Generated Subjective Global Assessment (PG-SGA) tool and patients were classified as either nourished (PG-SGA class A) or malnourished (PG-SGA classes B and C). A multivariate logistic regression model was used to adjust for other covariates known to influence clinical outcomes and to determine whether malnutrition is a predictor for early (0-7 days) or late (8-180 days) readmission or death following discharge.

Outcome measures

The impact of nutritional status was measured on a combined endpoint of any readmission or death within 0-7 days and between 8-180 days following hospital discharge.

Results

Within seven days following discharge, 29 (10.5%) patients had an unplanned readmission or death whereas an additional 124 (50.0%) patients reached this combined endpoint within 8-180 days post-discharge. Malnutrition was associated with a significantly higher risk of combined endpoint of readmissions or death both within seven days (OR 4.57, 95% CI 1.69-12.37, $p < 0.001$) and within 8-180 days (OR 1.98, 95% CI 1.19-3.28, $p = 0.007$) following discharge and this risk remained significant even after adjustment for other covariates.

Conclusions

Malnutrition in older patients at the time of hospital admission is a significant predictor of readmission or death both in the very early and in the late periods following hospital discharge. Nutritional state should be included in future risk-prediction models.

Strengths and limitations of this study

- The research was a large prospective observational study evaluating the association between nutritional status and readmission or death in medical inpatients ≥ 60 years old.
- A dietitian used a comprehensive and valid nutritional assessment tool to confirm the malnutrition diagnosis.
- Readmissions presenting to all other hospitals were captured.
- The single-centre study included only older medical patients.

INTRODUCTION

Recent decades have witnessed a vast improvement in life expectancy, leading to an increasing number of older patients with multiple chronic problems. While the number of beds for acute patients has declined, unplanned hospital admissions have increased, particularly among the elderly.[1] Older patients with multiple comorbid illnesses experience poor clinical outcomes after hospital discharge, including recurrent unplanned readmissions and mortality.[2] Adverse outcomes following discharge may be indicative of unresolved acute illness, ongoing chronic illness and the development of new medical problems or gaps in outpatient care.[3-5] Although adverse outcomes following discharge are not totally preventable, studies suggest that targeted intervention such as improved discharge planning with a focus on transitional care services may provide beneficial results.[6]

The likelihood of an unplanned admission is highest in the immediate post-discharge period.[7] There may be advantages in predicting re-admissions that occur shortly after discharge. However, most studies have only assessed readmission patterns within 30 days of discharge, and few studies have examined readmission patterns up to 180 days post-discharge.[8] Graham et al. have suggested that different risk factors may be responsible for very early and late readmissions and that each type of readmission needs differently targeted interventions that can only be implemented in advance if predictive factors are identified.[9]

Readmission and mortality risk prediction is a complex endeavour and remains poorly understood. A recent meta-analysis of 26 -readmission risk-prediction models for medical patients tested in a variety of populations and settings was used for comparing different hospitals and the appropriate applications of transitional care

services; the analysis found these models had a poor predictive ability and suggested a need for high-quality data sources that include clinically relevant variables.[10] None of the studies included in this meta-analysis considered patients' nutritional status during index admission as a determinant of readmissions.

Studies suggest that up to 30% of hospitalised patients may be malnourished at the time of admission and that malnutrition has a negative impact on convalescence and reduces resistance to future infections and diseases causing poor clinical outcomes.[11-13] Older patients are at a high risk of malnutrition than others and reasons for poor nutritional status in this group are multifactorial and include physiological, social and psychological factors which affect food intake and weight and this is further exacerbated by underlying medical illness.[14] Few studies have assessed the association between nutritional status at admission and clinical outcomes in the very early and the late periods following hospital discharge. Furthermore, most of these studies are retrospective, and the use of a comprehensive nutritional assessment tool, like the Patient Generated Subjective Global Assessment (PG-SGA), to diagnose malnutrition is rare. Therefore, this study was designed to determine whether nutritional status at admission, as diagnosed by a qualified dietitian using PG-SGA, influences a combined clinical outcome of readmission or mortality within seven days and between 8-180 days following hospital discharge and whether malnutrition could be used as one of the predictors of early and late readmissions and death.

METHODS

Study design and population

This prospective cohort study, included patients ≥60 years of age admitted to the Department of General Medicine of a large tertiary care hospital in Australia (Flinders Medical Centre, 520 beds), between August 2014 and March 2016. The exclusion criteria were refusal or inability to give informed consent, patients referred to palliative care and non-English-speaking patients, who were excluded due to a lack of funds to hire an interpreter. Ethical approval was obtained from Southern Adelaide Human Research Committee (SAC HREC; approval number 273.14-HREC/14/SAC/282) on 21 July 2014. The required sample size for this study, calculated on the basis of a previous study showing early readmission rate of 7.8%, was estimated at five hundred and sixty nine patients but insufficient resources led to the recruitment of only two hundred and ninety seven patients.[9]

Outcomes

The study's primary outcome was a combined endpoint of either the first unplanned readmission to any of the acute-care hospitals in the state of South Australia or death, within 0-7 days and between 8-180 days after hospital discharge. In this study, unplanned readmission was defined as any unscheduled hospitalisation to any hospital in the state of South Australia that was not for a planned investigation (e.g., elective endoscopy) or non-emergent treatment (e.g., planned drug infusion). The primary endpoint of readmissions or deaths were recorded from a central computer database, which captures these events for all state hospitals.

Nutritional status assessment

After obtaining written informed consent from patients, it was ensured that nutrition screening with Malnutrition Universal Screening Tool (MUST) had been performed. It is a standard policy in our hospital to screen all patients with MUST at the time of admission. MUST includes a body mass index (BMI) score, a weight loss score, and an acute disease score and classifies patients as low, moderate or high risk of malnutrition.[15] Following this all participating patients were then referred to a qualified dietitian for confirmation of their nutritional status by PG-SGA. The PG-SGA[16] generates a numerical score while also providing an overall global rating divided into three categories: well nourished (PG-SGA A), moderately malnourished or suspected of being malnourished (PG-SGA B) or severely malnourished (PG-SGA C). For each PG-SGA component, points (0-4) are awarded depending on the impact on nutritional status. Component scores are combined to obtain total scores that range from 0-35 with scores ≥7 indicating a critical need for nutritional intervention and symptom management.[17] The three different dietitians who were involved in the assessment of nutritional status using the PG-SGA received training prior to the study's commencement. The PG-SGA classes were divided into two categories by combining PG-SGA classes B and C into the malnourished category for easily interpreting patients as nourished (PG-SGA class A) and malnourished (PG-SGA classes B and C). Furthermore, PG-SGA scores were split into a categorical variable with a PG-SGA score of <7, indicative of no critical need for nutrition intervention and ≥7, indicating critical need for intervention.

Covariates

Several known variables that can influence outcomes after hospital discharge were recorded at the baseline. Sociodemographic data, number of hospitalisations during

the six months before index admission (current hospital admission) and clinical information were recorded at the baseline. Comorbidity was assessed with the Charlson comorbidity index, and the total number of medications were recorded at the time of admission. Health-related quality of life (HRQoL) was assessed using the EuroQoL 5 dimensions 5 level (EQ-5D 5L) questionnaire, a simple, self-administered instrument which is able to distinguish between 3,125 states of health.[18] A UK-specific algorithm developed using time-trade-off techniques was used to convert the EQ-5D 5L health description into a valuation ranging from -0.281 to 1.[19] A visual analogue scale (VAS) score, which provides an unweighted measure of HRQoL, can also be calculated from the questionnaire. The main diagnosis of index admission was retrieved from medical records and divided into seven categories according to the system affected: (1) respiratory disease, (2) cardiovascular disease, (3) neuropsychiatric disease, gastrointestinal disease, (5) falls, (6) renal disease, and miscellaneous diseases, including infections. The index admission's acuity was gauged from the total number of medical emergency response team calls and the number of hours spent in the intensive care unit (ICU). Length of hospital stay (LOS) was determined from the day of admission to the day of discharge. The study recorded any unplanned hospital presentations to any of the hospitals in South Australia within 0-7 days and between 8-180 days after hospital discharge, as well as any recorded deaths at the same time points, using the central hospital computer database.

Statistics

Demographic variables were assessed for normality using a skewness and kurtosis (sk) test. Data are presented as mean (SD) or median (IQR), and student t-test and rank-sum tests were applied as appropriate. Categorical variables are expressed as frequency and percent and compared using Pearson's x^2 or Fisher's exact test as appropriate.

Univariate logistic regression was used to assess the association between nutritional status and the combined end point of unplanned readmission or death within seven days and between 8-180 days post-discharge. In a multivariate logistic regression analysis, the relationship between readmission/death and nutrition status at admission was adjusted for other variables: age, gender, Charlson index, principal diagnosis at presentation, number of medications at admission, length of hospital stay, number of medical emergency response team calls during index admission and total number of hours spent in the ICU. Variance inflation factor and tolerance values were used to detect collinearity between variables included in the model.[20] A link test was used to confirm that the linear approach to model the outcome was correct. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test. A Kaplan Meier survival curve was plotted from time of discharge to the first onset of any of the primary outcomes to detect proportion of patients who did not experience the primary outcome. A Log rank test was used to compare survival proportions in the nourished and malnourished groups. A two-sided $p<0.05$ was considered to indicate statistical significance. All analysis was performed using STATA version 13.1 (StataCorp, College Station, Texas, USA).

RESULTS

This study recruited 297 patients, and nutrition status, as determined by PG-SGA, was available for 277 patients. Mean age was 80.3 years (SD 8.7, range 60-97) with 178 (64.3%) of the patients being females and the majority of patients came from home. There was no difference in the nutrition status between males and females (mean PG-SGA score 9.7 (SD 5.8) vs. 9.2 (SD 5.3), p = 0.44) in males and females respectively) and the nutrition status of patients who came from a nursing home was similar to those who came from home (mean PG-SGA score 9.0 (SD 4.5) vs. 9.4 (SD 5.6), p = 0.70) in nursing home and patients from home, respectively). Patients had multiple comorbidities (mean number of comorbidities 6.2, SD 2.7, range 0-16), and the mean Charlson comorbidity index was 2.3 (SD 1.8). The median length of stay for the index hospitalisation was 7 (IQR 3.4-14.6) days. Within seven days after discharge, 29 (10.5%) patients had an unplanned readmission or death (primary endpoint). Among the 29 patients who had the primary endpoint within seven days, 13 (44.8%) had been admitted prior to the index admission. The primary endpoint occurred in 124 (50.0%) patients within 8-180 days post-discharge and 69 (55.7%) of these patients had been admitted in the six months prior to the index admission. Patients who were malnourished at the time of index admission were significantly older (p = 0.001), had lower quality of life (p = 0.03) and stayed longer (p = 0.02) in the hospital as compared to the nourished patients. Respiratory illness, miscellaneous diseases including sepsis and cardiovascular diseases were the three main diagnoses during index hospitalisation with 86 (28.9%), 67 (22.6%) and 55 (18.5%) cases, respectively.

Table 1 Baseline characteristics according to primary endpoint (readmission/death) at 0-7 days and 8-180 days post-discharge

	Readmission/death within 0-7 days (n= 29)	No readmission/death within 0-7 days (n=248)		Readmission/death within 8-180 days (n=124)	No readmission/death within 8-180 days (n=124)	
			P value			P value
Age mean (SD)	81.2 (7.6)	80.2 (8.8)	0.74	80.3 (8.6)	80.0 (9.0)	0.77
Female sex n (%)	13 (44.8)	165 (66.5)	0.02	80 (64.5)	85 (68.5)	0.50
Total comorbidities	6.8 (3.0)	6.1 (2.7)	0.20	6.6 (2.9)	5.7 (2.5)	0.012

mean (SD)						
Charlson index mean (SD)	2.8 (2.1)	2.2 (1.8)	0.09	2.4 (1.8)	2.1 (1.8)	0.16
Total medications mean (SD)	9.1 (4.5)	9.6 (4.4)	0.56	10.3 (4.5)	8.9 (4.2)	0.007
Principal diagnosis at index admission n (%) Respiratory CVS Neuropsychiatric GIT Falls Renal Miscellaneous	 13 (44.8) 6 (20.7) 2 (6.9) 2 (6.9) 0 (0) 0 (0) 6 (20.7)	 72 (29.0) 44 (17.7) 23 (9.3) 17 (6.9) 21 (8.5) 16 (6.5) 55 (22.2)	 0.34	 33 (26.6) 28 (22.6) 11 (8.9) 11 (8.9) 4 (3.2) 6 (4.8) 31 (25.0)	 39 (31.5) 16 (12.9) 12 (9.7) 6 (4.8) 17 (13.7) 10 (8.1) 24 (19.4)	 0.02
LOS median (IQR)	13.3 (6.7-35.9)	6.8 (3.2-13.7)	0.004	7.9 (3.6-15.2)	5.7 (3.1-11.5)	0.11
MUST score[a]	1.9 (1.4)	1.1 (1.2)	0.001	1.3 (1.3)	0.9 (1.2)	0.03
Nutrition status PG-SGA[b] n (%) Nourished Malnourished	 5 (17.2) 24 (82.8)	 121 (48.8) 127 (51.2)	 0.001	 50 (40.3) 74 (59.7)	 71(57.3) 53 (42.7)	 0.008
Patients with PG-SGA ≥7 n (%)	25 (86.2)	142 (57.3)	0.002	80 (64.5)	62 (50.0)	0.02
QoL mean (SD) EQ-5D index[c] VAS[d]	 0.678 (0.226) 55.2 (17.1)	 0.709 (0.222) 59.5 (20.1)	 0.49 0.28	 0.700 (0.229) 55.9 (20.4)	 0.717 (0.217) 62.8 (18.1)	 0.31
Total MET calls mean (SD)	0.24 (1.0)	0.13 (0.4)	0.38	0.10 (0.32)	0.15 (0.53)	0.95
Total ICU hours mean (SD)	4.3 (19.3)	1.9 (13.4)	0.53	2.3 (15.5)	1.5 (11.0)	0.62

SD, standard deviation; CVS, cardiovascular; GIT, gastrointestinal; LOS, length of hospital stay; IQR, interquartile range; MUST, malnutrition universal screening tool; PG-SGA, patient generated subjective global assessment; QoL, quality of life; EQ-5D, european quality of life 5 dimension; VAS, visual analogue scale; MET, medical emergency team; ICU, intensive care unit
[a]Higher MUST score indicates high risk for malnutrition, [b]PG-SGA class dichotomized to PG-SGA A (nourished) and PG-SGA B and C (malnourished), [c]Higher EQ-5D index indicates better QoL, [d]Higher VAS indicates better QoL

Association of malnutrition with very early and late unplanned readmissions and mortality

Table 1 shows the baseline characteristics according to the occurrence of combined endpoint of readmission or death within 0-7 days and 8-180 days of discharge, respectively. Malnutrition risk, as determined by the MUST score, and the classification of patients as being malnourished per PG-SGA class were significantly higher in subjects who developed the combined endpoint both within 0-7 days (83% vs. 51%) and 8-180 (60% vs. 43%) days post-discharge ($p < 0.05$). Similarly, a significantly higher proportion of patients who were in critical need of nutrition therapy (as indicated by PG-SGA score of ≥ 7) at the time of index admission

suffered the combined endpoint both within 0-7 days (p = 0.002) and 8-180 days (p = 0.02) following hospital discharge (Table 1).

Table 2 Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for early readmission/death (0-7days)

Variable	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)[a]	P value
Malnourished	4.57 (1.69-12.37)	0.001	5.01 (1.69-14.75)	0.009
Age	1.00 (0.96-1.05)	0.73	1.00 (0.94-1.05)	0.80
Female sex	0.42 (0.19-0.89)	0.03	0.42 (0.17-1.04)	0.06
Total comorbidities	1.08 (0.95-1.23)	0.25	1.15 (0.96-1.38)	0.13
Charlson comorbidity index	1.16 (0.96-1.40)	0.12	1.08 (0.84-1.39)	0.55
Medications during index admission	0.97 (0.88-1.05)	0.47	0.91 (0.81-1.02)	0.12
LOS of index admission	1.03 (1.01-1.04)	0.001	1.03 (1.00-1.05)	0.02
Admission in last 6 months prior to index admission	0.77 (0.53-1.12)	0.13	0.66 (0.27-1.58)	0.35
Principal diagnosis index admission				
Reference (Resp. illness)	-	-	-	-
CVS	0.63 (0.23-1.75)	0.38	0.63 (0.20-2.04)	0.44
CNS	0.61 (0.16-2.32)	0.48	0.34 (0.06-1.93)	0.23
GIT	0.54 (0.13-2.59)	0.44	0.42 (0.07-2.36)	0.33
Falls	-	-	-	-
Urinary	-	-	-	-
Miscellaneous	0.61 (0.23-1.61)	0.31	0.35 (0.11-1.12)	0.07
ICU hours during index admission	1.03 (0.99-1.02)	0.56	1.01 (0.97-1.05)	0.63
Total MET calls index admission	1.55 (0.95-2.54)	0.08	0.84 (0.31-2.22)	0.72

[a]Odds ratio determined using multivariable logistic regression (using early/late readmissions as outcome variable)
CI, confidence interval; LOS, length of hospital stay; CVS, cardiovascular; CNS, central nervous system; GIT, gastrointestinal; ICU, intensive care unit; MET, medical emergency team

Table 3 Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for late readmission/death (8-180days)

Variable	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)[a]	P value
Malnourished	1.98 (1.19-3.28)	0.007	1.97 (1.12-3.47)	0.009
Age	1.00 (0.98-1.03)	0.81	1.00 (0.97-1.03)	0.94
Female sex	0.86 (0.51-1.44)	0.56	0.93(0.52-1.66)	0.83
Total comorbidities	1.14 (1.04-1.25)	0.006	1.07 (0.95-1.22)	0.30
Charlson comorbidity index	1.11 (0.97-1.28)	0.13	1.03 (0.86-1.23)	0.85
Medications during index admission	1.08 (1.02-1.14)	0.008	1.05 (0.98-1.12)	0.17
LOS of index admission	1.01 (0.99-1.02)	0.45	1.01 (0.99-1.02)	0.52
Admission in last 6 months prior to index admission	1.55 (0.96-2.53)	0.07	1.38 (0.79-2.40)	0.26

Principal diagnosis index admission				
Reference (Resp. illness)	-	-	-	-
CVS	1.58 (0.75-3.27)	0.22	2.06 (0.91-4.70)	0.08
CNS	1.09 (0.44-2.71)	0.85	1.12 (0.41-3.04)	0.81
GIT	2.03 (0.71-5.73)	0.18	1.91 (0.58-6.28)	0.29
Falls	0.26 (0.08-0.85)	0.03	0.26 (0.07-0.89)	0.03
Urinary	0.83 (0.28-2.41)	0.72	0.71 (0.21-2.32)	0.57
Miscellaneous	1.40 (0.70-2.79)	0.34	1.36 (0.63-2.92)	0.44
ICU hours during index admission	0.99 (0.98-1.01)	0.53	1.01 (0.98-1.03)	0.64
Total MET calls index admission	0.76 (0.41-1.39)	0.36	0.66 (0.32-1.34)	0.25

[a]Odds ratio determined using multivariable logistic regression (using early/late readmissions as outcome variable)
CI, confidence interval; LOS, length of hospital stay; CVS, cardiovascular; CNS, central nervous system; GIT, gastrointestinal; ICU, intensive care unit; MET, medical emergency team

Malnutrition was associated with a higher risk of the combined endpoint of readmissions and death within seven days after discharge (OR 4.57, 95% CI 1.69-12.37, $p < 0.001$; Table 2). After adjusting for covariates, including age, gender, Charlson index, LOS, number of medications, principal diagnosis at current admission and hours spent in the ICU during index admission, the association was even stronger for the combined end-point (OR 5.01, 95% CI 1.69-14.75, $p = 0.009$; Table 2). Similarly, between 8-180 days post-discharge, malnourished patients had higher odds to have a combined end point of readmission and death (OR 1.98, 95% CI 1.19-3.28, $p = 0.007$; Table 3), and this remained significant even after adjustment for the above covariates (OR 1.97, 95% CI 1.12-3.47, $p = 0.002$; Table 3). The p-value for the Hosmer-Lemeshow goodness-of-fit was > 0.05 for both the adjusted models, indicating a good fit. The variance inflation factors and tolerance were near 1.00 for all variables, excluding significant collinearity. The link test confirmed that the linear approach to model the outcomes was correct. The Kaplan Meier survival curve (Figure 1) shows that the nourished group had significantly fewer readmissions and deaths at 180 days than the malnourished group (log rank chi2=11.4, $p < 0.001$).

DISCUSSION

The present study's results indicate that malnutrition at admission, as determined by the PG-SGA, was a significant predictor of a combined end-point of readmission or mortality in older general-medical patients, during both the early and late periods after hospital discharge. Malnutrition was associated with an almost four-fold increased risk of readmission or mortality within seven days after discharge, and the risk almost doubled between 8-180 days after discharge. Malnutrition remained a significant predictor even after adjustment for other covariates that could have influenced the clinical outcome.

One appealing explanation for these results is that the acute condition responsible for the index admission weakens the patient's overall health, and malnutrition further compounds this problem with a consequent higher risk of complications or exacerbations of previously stable comorbidities.[21] The post-discharge period is a fragile period, referred to as –'post-hospital syndrome'.[22] This syndrome has been described as a period of vulnerability due to impaired physiological systems, depleted reserves, and lower body resistance against health threats, on top of the recent acute illness responsible for the index admission. The current study's results introduce another dimension to this theory: impaired nutritional status may play a significant role in the post-discharge period beyond seven days. The acute illness and the stress of the index admission may exacerbate malnutrition, possibly inducing a relapse or predisposing the patient to new acute illnesses that increase the risk of readmission or mortality.[23 24]

The present study's results are in line with Mogensen et al., who found that malnourished patients who survived intensive care admission had higher 90-day mortality (OR 3.72, 95% CI 1.2-6.3) and that malnutrition was a significant predictor of their 30-day unplanned hospital readmission.[25] Studies in heart-failure patients have suggested that malnutrition may contribute to the progression of the underlying heart disease due to low-grade inflammation leading to poor outcomes and was a significant predictor of readmissions.[26]

Older general-medical patients are known to have substantial long-term morbidity and mortality. Known risk factors for adverse events following discharge include multiple comorbidity, severity of index admission and institutional care rather than domiciliary care.[2 27] Hospital readmissions represent a multifaceted problem that require a better understanding.[21] Presumably there are other unknown factors that influence patient outcomes after discharge. The present study illustrates that early and late post-discharge patient outcomes appear to be associated with the presence of malnutrition during admission. While causation cannot be inferred from an observational study, the malnutrition-post-discharge outcome has biological plausibility.

To date, no study has included nutritional status in the development of a predictive tool for readmissions and this area needs further research. Studies do suggest that nutritional intervention initiated early during hospitalisation, by providing high-energy protein supplements with a continuation post-hospital discharge, does have a favourable impact on nutritional parameters and reduces the length of hospital stay; however, its impact on mortality and readmissions is unclear, and such an intervention may be too late for some.[28 29] While the ideal intervention to improve nutritional status in hospitalised patients has yet to be identified, the solution may lie

in recognising and managing malnutrition in the community before any hospital admission.[30]

LIMITATIONS

This study has several limitations. First, it is a single-centre study in a tertiary care hospital. The case mix of patients discharged from this hospital may differ from that of other hospitals; thus, the results may not be generalisable particularly to community hospitals, although it is likely to be similar to other academic hospitals in Australia. The study was unable to adjust its analysis for functional status or other factors, such as appropriateness of drugs, clinical stability at discharge or social factors that might influence readmission. This study involved older general-medical patients who frequently suffer from multiple comorbidities, and our results may not be applicable to relatively younger sub-speciality patients with single organ system involvement.

One of the study's strengths is that it was a prospective study and that the malnutrition diagnosis was confirmed by a dietitian using a comprehensive nutrition assessment tool. The study also assessed all readmissions in all state hospitals, unlike some other studies that were only able to capture readmissions to a single hospital.

IMPLICATIONS

This study has several implications. Transitions of care should focus not only on the acute condition but also on the patient's nutritional status, because the latter may increase the risk of readmission or death. There is a need for future well-designed

studies to examine the beneficial effects of an intervention targeting malnutrition and whether this intervention prevents readmissions and mortality. In the interim, nutritional intervention should be most effective if begun early during admission and it should be continued in the community following discharge by referral to either a community dietitian or follow-up at an outpatient dietetic clinic. Overall, public health policies to optimise nutrition of those over 60 years of age may result in a reduction in health-care utilisation.

CONCLUSION

Impaired nutritional status at admission predicts poor clinical outcomes in both early and late post-discharge periods as determined by readmissions and mortality in older general-medical patients and a targeted nutritional intervention may prove beneficial in malnourished patients.

Contributors: YS, CT and MM designed the study and YS, CT, BK and MM carried out the analysis and interpretation. YS and RS lead the study and were responsible for data acquisition. YS, PH and CH provided statistical input. YS and RS undertook recruitment. YS and CT wrote the manuscript, which was edited by BK and MM. All authors approved final manuscript.

Funding: This study was not supported by any funding.

Competing interests: None

Data sharing statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Figure 1 Kaplan-Meier survival curve for combined outcome in nourished and malnourished

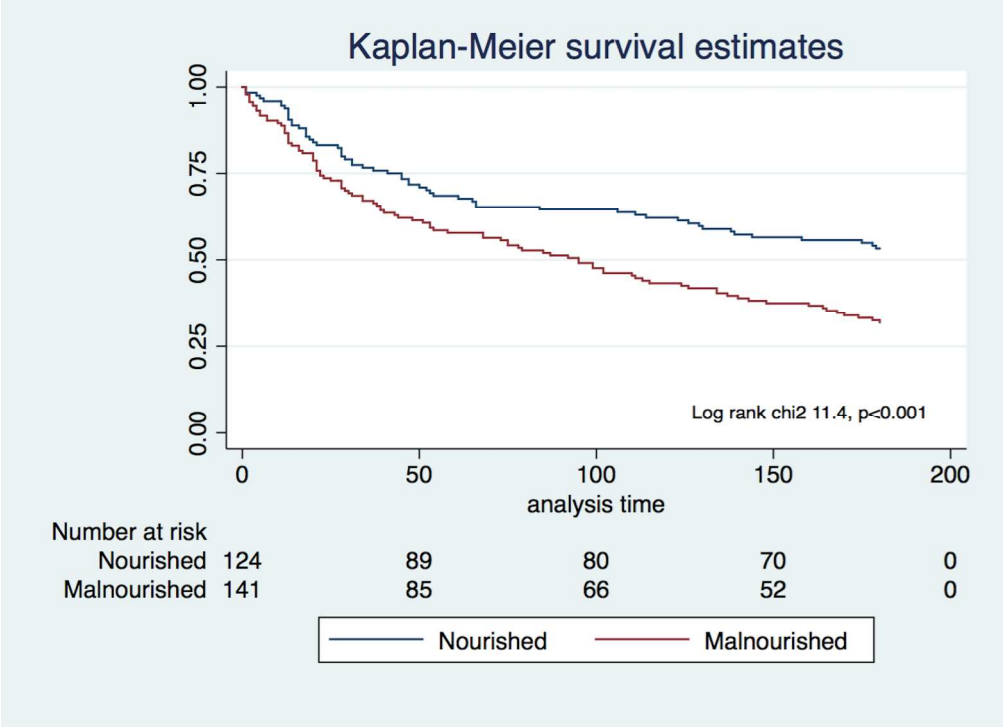

Figure 1 Kaplan-Meier survival curve for combined outcome in nourished and malnourished

222x161mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **(Within the title page 1 and methods section of abstract page 3)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **(see results section of abstract page 3 and 4)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **(pages 5-6)**
Objectives	3	State specific objectives, including any prespecified hypotheses **(page 6)**
Methods		
Study design	4	Present key elements of study design early in the paper **(Methods section pages 6-7)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **(pages 6-7)**
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants **(pages 6-7)**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **(pages 7-8)**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **(pages 8-9)**
Bias	9	Describe any efforts to address potential sources of bias **(N/A)**
Study size	10	Explain how the study size was arrived at **(page 7)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **(pages 8-9)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **(pages 9-10)**
		(*b*) Describe any methods used to examine subgroups and interactions **(N/A)**
		(*c*) Explain how missing data were addressed **(N/A)**
		(*d*) If applicable, describe analytical methods taking account of sampling strategy **(N/A)**
		(*e*) Describe any sensitivity analyses **(N/A)**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed

		(page 10 and Table 1)
		(b) Give reasons for non-participation at each stage (N/A)
		(c) Consider use of a flow diagram **(N/A information in Table 1)**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **(pages 10-11 and Table 1)**
		(b) Indicate number of participants with missing data for each variable of interest **(N/A)**
Outcome data	15*	Report numbers of outcome events or summary measures **(pages 10-11)**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **(pages 12-13 and Table 2 and 3)**
		(*b*) Report category boundaries when continuous variables were categorized **(page 12)**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **(N/A)**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **(N/A)**
Discussion		
Key results	18	Summarise key results with reference to study objectives **(page 15)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **(page 17)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **(pages 16-17)**
Generalisability	21	Discuss the generalisability (external validity) of the study results **(pages 17-18)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **(page 19)**

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.