Malnutrition, poor food intake, and adverse healthcare outcomes in non-critically ill obese acute care hospital patients

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Title: **Malnutrition, poor food intake, and adverse healthcare outcomes in non-critically ill obese acute care hospital patients**

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Abstract

Background and Aims: Obesity, defined as a BMI ≥ 30kg/m^2, has demonstrated protective associations with mortality in some diseases. However, recent evidence demonstrates that poor nutritional status in critically ill obese patients confounds this relationship. The purpose of this paper is to evaluate if poor nutritional status, poor food intake and adverse health-related outcomes have a demonstrated association in non-critically ill obese acute care hospital patients.

Methods: This is a secondary analysis of the Australasian Nutrition Care Day Survey dataset (N = 3122), a prospective cohort study conducted in hospitals from Australia and New Zealand in 2010. At baseline, hospital dietitians recorded participants' BMI, evaluated nutritional status using Subjective Global Assessment (SGA), and recorded 24-hour food intake (as 0%, 25%, 50%, 75%, and 100% of the offered food). Post-three months, participants' length of stay (LOS), readmissions, and in-hospital mortality data were collected. Bivariate and regression analyses were conducted to investigate if there were an association between BMI, nutritional status, poor food intake, and health-related outcomes.

Results: Of the 3122 participants, 2889 (93%) had eligible data. Obesity was prevalent in 26% of the cohort (n = 750; 75% females; 61 ± 15 years; 37 ± 7 kg/m^2). Fourteen percent (n = 105) of the obese patients were malnourished. Over a quarter of the malnourished obese patients (N = 30/105, 28%) consumed ≤25% of the offered meals. Most malnourished obese patients (74/105, 70%) received standard diets without additional nutritional support. After controlling for confounders (age, disease type and severity), malnutrition and intake ≤25% of the offered meals independently trebled the odds of in-hospital mortality within 90 days of hospital admission in obese patients.

Conclusion: Although malnourished obese experienced significantly adverse health-related outcomes they were least likely to receive additional nutritional support. This study

demonstrates that BMI alone cannot be used as a surrogate measure for nutritional status and warrants routine nutritional screening for all hospital patients, and subsequent nutritional assessment and support for malnourished patients.

Keywords: Body Mass Index, malnutrition, sarcopenic obesity, food intake, length of stay, hospital mortality

1. INTRODUCTION

Recently, Cereda and colleagues investigated the association between BMI and in-hospital mortality from the 2006-2014 combined 'nutritionDay worldwide' dataset including over 97000 adult patients from hospitals in 51 countries (1). After controlling for confounders such as demographics (age, gender), nutritional factors (history of weight change, food intake in week preceding data collection), and medical factors (reason for hospitalisation, surgical procedures performed, intensive care admission, number of medications) and mobility, researchers found that low BMI (<18.5 kg/m^2) was an independent predictor for in-hospital mortality (odds ratio (OR): 1.35, 95% confidence interval (CI): 1.20-1.53, p value <0.001) (1). Cereda et al. concluded that overweight and obesity had protective associations with 30-day in-hospital mortality given that mortality was lowest in patients in the obese category (BMI ≥ $30kg/m^2$; OR: 0.73, 95% CI: 0.62-0.86, p value <0.001) (1).

Despite strong associations with increased healthcare costs and mortality in healthy populations (2-4), in 2002, Gruberg and colleagues noticed that obesity (BMI ≥ $30kg/m^2$) had a protective association in a cohort of post-percutaneous coronary interventions (5). Many studies since have demonstrated this phenomenon, known as the 'obesity paradox' or 'reverse epidemiology', particularly in cardiovascular and metabolic disease, some cancers and end-stage renal disease (5, 6). However, studies demonstrating protective associations between obesity and improved survival define obesity using BMI, an inherent limitation of which is that it does not distinguish lean body mass from fat mass, which have different implications for health and survival (7). In a large observational study of critically ill patients (N= 6518) admitted in medical and surgical ICUs from 2004-2011, Robinson et al. demonstrated that the presence of malnutrition confounded the positive association between obesity and 30-day in-hospital mortality (8). Critically ill obese patients (BMI ≥ $30kg/m^2$) with malnutrition had

greater odds of 30-day in-hospital mortality (OR: 1.58; CI: 1.21 – 2.07, p = 0.001) than well-nourished counterparts (8).

Malnutrition is the result of nutritional intake that is inadequate to support physiological requirements (9). Several factors can contribute to inadequate nutritional intake, including physical, physiological, psychological, and socio-environmental (10). Evidence-based guidelines support the use of a range of validated nutrition screening tools (such as Malnutrition Screening Tool (MST) (11)) and assessment methods (such as Subjective Global Assessment (SGA) (12)) to identify malnutrition (13). Further, the International Classification of Diseases and Related Health Problems, version 10, Australian modification (ICD-10-AM), defines malnutrition as BMI <18.5 kg/m^2 or unintentional weight loss of at least 5% with evidence of sub-optimal intake resulting in subcutaneous fat loss and/or muscle wasting" (14).

The Australasian Nutrition Care Day Survey (ANCDS) conducted in 2010 reported the prevalence of malnutrition, poor food intake and associated health-related outcomes in over 3000 acute care patients admitted in 56 hospitals across Australia and New Zealand (15, 16). Malnutrition was observed in 30% of the cohort and defined as low BMI (<18.5kg/m^2) and moderate/severe malnutrition as determined by SGA (15). Food intake observed over a 24-hour period indicated that one-in-four participants consumed no more than 25% of the offered food (15). After controlling for confounders (age, disease type and severity, and type of admission), the hazard ratio of 90-day in-hospital mortality for malnourished patients who consumed up to a quarter of the offered food was 2.3 times greater than well-nourished patients (CI: 1.39-3.76, p < 0.001) (16).

The contrasting results from the studies by Cereda et al. (1) and Robinson et al. (8) prompted this secondary analyses of the ANCDS dataset with the aim to determine nutritional issues

(presence of malnutrition and poor food intake) and their independent association with health-related outcomes specifically in obese acute care patients. This paper will also provide insight on malnutrition coding and nutrition support offered to not critically ill obese acute care patients who were malnourished.

2. METHODS

2.1 Study design: The ANCDS was a prospective cohort study conducted over two phases. Phase I (baseline) was conducted in June-July 2010 (15) and Phase II was conducted after three months (16).

2.2 Study setting: The ANCDS was conducted in 56 acute care hospitals across Australia and New Zealand (15, 16)

2.3 Study population: Acute care patients aged ≥ 18 years of age were invited to participate in the study by providing written informed consent (15). Patients were excluded if they were likely to be discharged or undergo surgery during the baseline data collection period, were either terminally ill or undergoing end-of-life palliative care, had disordered eating, were outpatients or admitted in certain wards (including maternity and obstetrics, high dependency units, emergency departments, intensive care units, rehabilitation) (15). Further details on inclusion and exclusion criteria, patient recruitment and data elements have been previously published (15).

2.4 Ethics: Ethics approval for the ANCDS was provided by the Human Research Ethics Committees of The University of Queensland and the participating hospitals (15).

2.5 Data collection: Details on data collection methodology for both phases have been previously reported (15, 16) and a brief summary has been provided below:

2.5.1 Phase I: Dietitians from participating hospitals recorded participants' age, gender, self-reported ethnicity, weight and height at baseline (15). Using these measurements the first author calculated each participants' BMI and then categorised as per WHO classification: underweight (BMI < 18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), class I obese (30-34.9 kg/m^2), class II obese (35-39.9 kg/m^2), and class III obese (40 kg/m^2) (17). Dietitians also screened the participants for nutrition risk using the MST (11). The MST includes two questions related to

appetite and recent unintentional weight loss and provides a score ranging from 0-5, with a score of ≥ 2 indicating nutritional risk (11). Dietitians used the valid and reliable Subjective Global Assessment (SGA) to comprehensively assess patients with an MST score ≥ 2 to determine a diagnosis of malnutrition (12). The SGA is a valid and reliable measure that considers changes in two components: medical history (body weight, dietary intake, presence of nutrition impact symptoms, and functional capacity); and physical examinations (subcutaneous fat and muscle mass stores). (12). Results from both components are combined to provide an overall rating of well-nourished (SGA-A), moderately malnourished (SGA-B) or severely malnourished (SGA-C) (12). Participants who had an MST score of <2 or were rated as well-nourished (SGA-A) were grouped in the "well-nourished" category. In keeping with the International Classification of Diseases and Related Health Problems, version 10, Australian modification (ICD-10-AM), malnutrition was defined as BMI <18.5 kg/m^2 or unintentional weight loss of at least 5% with evidence of sub-optimal intake resulting in subcutaneous fat loss and/or muscle wasting") (14). Therefore, participants with a BMI <18.5 kg/m^2 and/or assessed as SGA-B or SGA-C were grouped in the "malnourished" category (14).

Dietitians also recorded the type of diet offered to participants along with observing their food intake over the 24-hour data collection period after each main meal (breakfast, lunch and dinner) and snack (morning and afternoon tea) (15). Intake for supper was recorded by visual estimation, nursing records or patient recall the following morning (15). Intake was recorded on a five-point scale (0%, 25%, 50%, 75%, and 100%) (15). From a list of possible options, patients selected their reason/s for not consuming all the offered food at each main meal and snack (15).

2.5.2 Phase II: Staff members of health information records departments of participating hospitals compiled their respective participants' admission-related information 90 days after baseline data collection (16). This included admission status, type of admission, clinical diagnosis, disease severity (as per the Patient Clinical Complexity Level Scores (PCCL), and health-related outcomes information including LOS in hospital at baseline, number of readmissions, and in-hospital mortality (Table 1) (16).

2.6 Statistical analyses: Data were analysed using IBM SPSS Statistics for Windows (Release 23.0, 2015; IBM Corp, Armonk, New York). Categorical variables are presented as frequency and percentage. Continuous variables were not normally distributed (age, LOS, BMI) and therefore presented as median and range. Comparisons of proportions was undertaken using Chi-square tests. Comparisons of means were performed using non-parametric tests.

The dataset file was split to identify variables that demonstrated significant associations with outcome variables at a bivariate level for obese patients (BMI $\geq$ 30kg/m^2). These variables were then incorporated into regression models to identify independent associations with outcome variables. Survival analysis was conducted using the Kaplan-Meier test to evaluate differences between participants that were obese and malnourished versus those who were non-obese and well-nourished or malnourished. Preliminary assumption testing was conducted to ensure no violation of the assumptions, including multicollinearity. High inter-correlations were observed between diet type and nutritional status, and therefore diet type was excluded from the regression models. A p-value < 0.05 was considered statistically significant.

3.0 RESULTS

After data cleaning, analyses were completed for 2889 of the 3122 recruited participants (93%) who had complete data.

3.1 Comparison of characteristics within the cohort as per BMI:

Over 25% of the cohort were classified as obese (n = 750; Median BMI: 34 kg/m^2 (range: 30-85kg/m^2)) (Table 1). Participants in the obese category were significantly younger, had the highest proportion of females and those who identified themselves as Maori ($p<0.001$) (Table 1).

Obese participants had a significantly higher proportion of elective admissions and a significantly lower proportion of severe/catastrophic disease severity ($p<0.001$) (Table 1).

Malnutrition risk was significantly lower in obese participants ($p<0.001$) (Table 1). The average prevalence of malnutrition in the obese group was 14% (n = 105) which was significantly lower than other BMI categories (Table 1). In comparison to other BMI categories, a significantly greater proportion of patients in the obese categories consumed 100% of the offered meals during Phase I of the study (Table 1).

Overweight and obese participants had a significantly lower LOS in comparison to participants in other BMI categories ($p<0.001$) (Table 1). There was no significant difference in readmission rates and 30-day in-hospital mortality amongst the participants in the underweight, normal weight, overweight and obese categories (Table 1). Ninety day in-hospital mortality rates were significantly higher in participants in the underweight category and significantly lower in participants in the overweight category ($p = 0.030$) (Table 1).

3.2 Comparison of food intake and provision of nutritional support as per nutritional status within BMI categories

When BMI categories were compared as per nutritional status, one-in-three malnourished participants across all BMI categories consumed ≤25% of the offered meals during Phase I of the study p<0.001) (Table 2). Seventy percent of malnourished obese participants were offered diets without additional nutritional support during Phase 1 of the study, which was significantly higher than malnourished patients in other BMI categories (p = 0.018) (Table 2).

3.3 Comparison of health-related outcomes as per nutritional status within BMI categories

Malnourished participants across all BMI categories had significantly longer median LOS in comparison to their well-nourished counterparts (p = 0.005) (Table 3). However, sub-group analyses indicated that malnourished participants in the obese class III category had the longest median LOS (23 days (range: 3-199), p = 0.009) (Table 3). There was no significant difference for readmissions amongst the participants (p= 0.183) (Table 3). The highest proportion of 30-day and 90-day in-hospital mortality was observed in malnourished obese participants (p<0.001) (Table 3).

3.4 Malnutrition coding

A significantly lower proportion of malnourished overweight and obese participants were coded for malnutrition (p<0.001) (Table 4).

3.5 Regression analyses

3.5.1 LOS: The multiple regression analysis model explained 26% of the variance in LOS in obese participants (BMI≥30kg/m^2; R^2= 0.26, adjusted R^2=0.25, F (9, 766) =29.62, p-value<0.0001). PCCL scores were the largest unique contribution (beta: 0.256, CI:

0.929-1.240, p-value<0.0001). Nutritional status made a significant contribution (beta: 0.116, CI: 0.283-0.980, p-value<0.0001). Percentage food intake made no significant contribution.

3.5.2 Readmissions: Logistic regression analyses did not find nutritional status and/or food intake to be a significant risk factor for readmissions in obese participants. Neoplastic disease, discharge to other healthcare facilities, and disease severity were the independent risk factors that increased the risk of readmissions within 90 days of index hospitalisation (p<0.005).

3.5.3 In-hospital mortality: After controlling for confounding factors, consumption of ≤ 25% of the offered food increased the odds of in-hospital mortality within 30 days of admission by more than 5.5 times (Table 5). Malnutrition did not have a significant association with 30-day in-hospital mortality (Table 5). However, both, malnutrition and consumption of ≤ 25% of the offered food trebled the odds of in-hospital mortality within 90 days of hospital admission (Table 5). Malnourished obese patients had significantly lower survival than those who were not obese and were either well-nourished or malnourished (p = 0.043). After controlling for potential confounders, the hazard ratio of 90-day in-hospital mortality for malnourished obese patients who also consumed ≤ 25% of the offered food was 2.9 times greater (CI: 1.13-7.54, p = 0.027) than well-nourished obese patients who ate > 25% of the offered food (Figure 1).

4.0 DISCUSSION

The aims of the present paper were to determine if malnutrition and poor food intake exists in obese, non-critically ill acute care patients and the independent association of these nutritional issues with health-related outcomes. In comparison to other BMI categories, the prevalence of malnutrition, poor food intake, and risk of adverse outcomes was significantly lower in obese participants. However, when BMI categories were further classified by nutritional status as assessed by SGA, malnourished obese patients were least likely to be offered diets with additional nutritional support and experienced the highest in-hospital mortality in comparison to all other participants. Malnourished obese participants who also consumed a quarter or less of the offered meals were three times more likely to experience 90-day in-hospital mortality in comparison to well-nourished obese patients who consumed at least half the offered meals. Therefore, these results highlight the limitation of using BMI as a surrogate measure for nutritional status and emphasise the importance of validated nutrition screening and assessment methods to routinely determine nutritional status in acute care hospital patients.

Sarcopenia is characterised by the generalised and age-related loss of muscle mass, consequent loss of strength and function, and progressive risk of adverse outcomes particularly prolonged hospital LOS and overall mortality (18, 19). Obese patients who are acutely ill are at an increased risk for metabolic stress-induced loss of muscle mass (20). The loss of lean muscle mass in the presence of high fat mass is referred to as sarcopenic obesity (21). Because sarcopenic obesity carries the cumulative risk of sarcopenia and obesity, it has a greater effect on overall morbidity and mortality than either sarcopenia or obesity alone (21). Although diagnostic techniques such as imaging or functional tests were not used in the ANCDS to diagnose sarcopenia (22, 23) participants who were at risk of malnutrition were assessed for

loss of muscle mass using the SGA (15). It is possible that sarcopenic obesity contributed to the negative outcomes observed in the malnourished obese participants.

The present study found that one-in-three malnourished obese patients had poor food intake during hospitalisation. However, malnourished obese patients were also least likely to receive additional nutritional support during hospitalisation. Previous studies have found that patients prioritise medical treatment over nutrition during hospitalisation (24), and tend to accept anorexia (15, 24-26) as an expected outcome of hospitalisation. These patient-related barriers could explain the poor food intake observed amongst malnourished obese patients. Perhaps healthcare providers need to emphasise that evidence-based guidelines support nutritional support in obese acute care patients and contraindicate the use of hypocaloric and low protein diets as these have demonstrated association with unfavourable outcomes (27).

The ANCDS reported that nutrition screening and assessment were not routinely conducted in participating hospitals (17) so it is likely that malnutrition in obese patients was not identified and diagnosed, and therefore additional nutritional support was not offered. A review by Puhl and Heuer (2013) concluded that negative and biased attitudes towards obesity, and subsequent inequities with treatment provision have been reported amongst healthcare professionals including physicians, nurses, allied health staff members and students-in-training (28). This may also explain why malnourished obese patients may not have received required nutritional care during hospitalisation even though evidence-based guidelines recommend early screening and identification for appropriate nutrition for all hospital patients (13).

Whilst the gaps in processes related to malnutrition documentation and coding were undeniable in the ANCDS (29), the current paper found that malnutrition coding was significantly lower

in obese malnourished patients as compared to non-obese malnourished patients. Dobak et al recently surveyed over 600 registered dietitians in the United States and found that healthcare professionals continue to use BMI in the hospital setting to identify malnutrition (30). The survey also identified gaps in the processes related to diagnosing, documenting and coding for malnutrition (30). Combined findings from these studies indicate the need for implementing structured processes for identifying, documenting and eventually coding for malnutrition.

5.0 Limitations

Although malnutrition and/or poor food intake were significantly and independently associated with adverse outcomes in obese patients, the observational nature of this study does not allow the establishment of a causal relationship. It is also not clear if excessive fat and lack of lean tissue attributed to the increased mortality risk in malnourished obese patients. While it was beyond the scope of this study to conduct body composition analysis, the methods used to diagnose malnutrition involved physical examination for evidence of muscle wasting and loss of subcutaneous fat.

6.0 Conclusion

For the first time internationally, results from the current paper demonstrate that poor food intake is relatively common and associated with adverse health-related outcomes in malnourished obese acute care patients. Obesity, including morbid obesity, is a form of malnutrition. In the face of the global obesity pandemic (31) the current paper highlights that an isolated anthropometric measure such as BMI cannot be used as the sole indicator of nutritional status in adult acute care patients. Two or more multidimensional factors including involuntary weight loss, body composition analyses, and measurement of functional strength and capacity are better indicators of malnutrition (32, 33). Valid and reliable nutrition screening

tools and assessment methods must be routinely used to ascertain acute care patients' nutritional status. Dietitians have an opportunity to implement processes for diagnosing, documenting and coding for malnutrition by actively leading an interdisciplinary approach. Finally, results from this study reiterate the importance of routinely monitoring and evaluating food intake in all acute care patients and providing appropriate nutritional support.

Table 1: Characteristics of the ANCDS cohort as per body mass index (N= 2889)

Variable	Underweight[a] (n=227)	Normal weight[b] (n=1048)	Overweight[c] (n=864)	Obese Class[d] (n= 750)	p-value
Demographic					
Gender[g]					
Male	106 (47%)	579 (55%)	514 (60%)	340 (46%)	0.000
Female	121 (53%)	468 (45%)	350 (40%)	408 (54%)	
Ethnicity[g]					
Caucasian	190 (86%)	950 (92%)	771 (91%)	643 (87%)	
Aboriginal & Torres Strait Islander	8 (3%)	15 (2%)	21 (2%)	15 (2%)	0.000
Maori	3 (1%)	14 (1%)	17 (2%)	46 (6%)	
Asian	12 (5%)	25 (2%)	25 (3%)	2 (0.5%)	
Other	11 (5%)	29 (3%)	18 (2%)	33 (5%)	
Median Age (Range), years	73 (18-99)	72 (18-99)	68 (18-110)	62 (18-95)	0.023
Age[g]					
<65 years	85 (38%)	394 (38%)	355 (41%)	436 (59%)	0.000
≥ 65 years	141 (62%)	650 (62%)	504 (59%)	306 (41%)	
Clinical					
Admission status[g]					
Emergency	176 (78%)	789 (75%)	619 (72%)	523 (70%)	0.000
Elective	29 (12%)	204 (20%)	190 (22%)	181 (24%)	
Other	22 (10%)	53 (5%)	54 (6%)	46 (6%)	
Admission type[g]					
Surgical	74 (32%)	430 (41%)	397 (46%)	327 (44%)	
Medical	135 (60%)	563 (54%)	412 (48%)	393 (53%)	0.001
Other	18 (8%)	52 (5%)	52 (6%)	29(4%)	

Major Diagnostic Category[g]					
Circulatory	16 (7%)	133 (12%)	129 (15%)	98 (13%)	
Digestive	39 (17%)	206 (20%)	165 (19%)	139 (19%)	
Endocrine	3 (1%)	25 (2%)	24 (3%)	22 (3%)	
Musculoskeletal	38 (16%)	152 (15%)	127 (14%)	119 (16%)	
Neoplastic	6 (3%)	27 (3%)	38 (4%)	10 (1%)	0.003
Nervous	25 (11%)	99 (9%)	70 (8%)	67 (9%)	
Renal	8 (4%)	27 (3%)	38 (4%)	32 (4%)	
Respiratory	43 (19%)	146 (14%)	82 (9%)	89 (12%)	
Other	49(22%)	230 (22%)	188 (24%)	173 (23%)	
Disease severity[g]					
Not severe	62 (28%)	376 (36%)	353 (41%)	330 (44%)	0.000
Severe/catastrophic	163 (72%)	668 (64%)	504 (59%)	417 (56%)	
Nutritional					
Median BMI (kg/m^2, Range)	17 (10-18.4)	22 (18.5-24.9)	27 (25-29.9)	34 (30-85)	0.000
Malnutrition Risk[g,h]					
Not at risk of malnutrition	72 (32%)	516 (49%)	566 (66%)	547 (73%)	0.000
At risk of malnutrition	152 (68%)	531 (51%)	292 (34%)	201 (27%)	
SGA[g]					
A (well-nourished)[i]	10 (7%)	116 (22%)	105 (36%)	89 (12%)	0.000
B (moderately malnourished)	80 (53%)	341 (64%)	162 (55%)	101 (14%)	
C (severely malnourished)	60 (40%)	67 (14%)	19 (9%)	4 (3%)	
Overall nutritional status[g]	0	632 (61%)	671 (79%)	636 (86%)	0.000
Well-nourished[i]	226 (100%)	408 (39%)	181 (20%)	105 (14%)	
Malnourished[j]					

Food intake[g]					
0%	31 (14%)	108 (10%)	71 (8%)	31 (8%)	
25%	41 (18%)	151 (15%)	110 (13%)	42 (10%)	
50%	54 (24%)	218 (21%)	162 (19%)	74 (18%)	0.000
75%	75 (25%)	295 (28%)	231 (27%)	110 (27%)	
100%	41 (18%)	265 (26%)	286 (33%)	158 (38%)	
Health-related outcomes					
Length of stay (LOS; days (Range))	16 (2-245)	13 (2-395)	11 (2-467)	11 (2-224)	0.000
Readmission[g]	77 (34%)	338 (32%)	273 (32%)	247 (33%)	0.896
In-hospital mortality[g]					
Within 30 days[k]	6 (3%)	20 (2%)	9 (1%)	13 (2%)	0.300
Within 90 days[k]	13 (6%)	28 (2.5%)	14 (1.5%)	18 (3%)	0.007

Note: Reported percentage values indicate proportion of participants within the BMI category.
[a]BMI < 18.5 kg/m^2; [b]BMI:18.5-24.9 kg/m^2; [c]BMI: 25-29.9 kg/m^2; [d]BMI: ≥30kg/m^2 (34);
[g] presented as n(%);
[h]Malnutrition Risk assessed using Malnutrition Screening Tool (MST) (11);
[i]includes SGA-A (12) and MST<2(11);
[j]includes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m^2 (14); [k]within 30 or 90 days of hospital admission.

Table 2. Food intake and diets without additional nutritional support as per nutritional status within BMI categories (N=2889)

Variable	Underweight[a] (n=227)		Normal weight[b] (n=1048)		Overweight[c] (n=864)		Obese[d] (n= 750)		p-value
	WN[g] (n=0)	MN[h] (n=227)	WN[g] (n=617)	MN[h] (n=401)	WN[g] (n=655)	MN[h] (n=175)	WN[g] (n=636)	MN[h] (n=105)	
≤ 25% food intake	0	72 (32%)	134 (22%)	124 (31%)	122 (18%)	55 (30%)	90 (14%)	30 (29%)	0.000
Diets without additional nutritional support	0	134 (59%)	504 (82%)	239 (60%)	568 (87%)	118 (67%)	288 (87%)	49 (70%)	0.021

Note: Reported percentage values indicate proportion of participants within the BMI category.
[a]BMI < 18.5 kg/m^2; [b]BMI:18.5-24.9 kg/m^2; [c]BMI: 25-29.9 kg/m^2; [d]BMI: ≥30 kg/m^2(34);
WN: well-nourished; MN: Malnourished;
[g]includes SGA-A (12) and MST < 2(11);
[h]includes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m^2 (14);

Table 3. Health-related outcomes as per body mass index (BMI) and nutritional status (N=2889)

Variable	Underweight[a] (n=227)		Normal weight[b] (n=1048)		Overweight[c] (n=864)		Obese[d] (n= 750)		p-value
	WN[g] (n=0)	MN[h] (n=227)	WN[g] (n=617)	MN[h] (n=401)	WN[g] (n=655)	MN[h] (n=175)	WN[g] (n=636)	MN[h] (n=105)	
LOS (days (range))	**-**	**16 (2-245)**	**12 (2-395)**	**16 (2-259)**	**10 (2-291)**	**17 (2-467)**	**10 (2-222)**	**16 (2-224)**	**0.005**
Readmission	**-**	**76 (34%)**	**187 (30%)**	**148 (36%)**	**200 (30%)**	**67 (37%)**	**203 (32%)**	**42 (40%)**	**0.062**
In-hospital mortality within 30 days[i]	**-**	**6 (3%)**	**9 (1.5%)**	**11 (3%)**	**5 (1%)**	**3 (2%)**	**8 (1%)**	**5 (5%)**	**0.027**
In-hospital mortality within 90 days[i]	**-**	**13 (6%)**	**12 (2%)**	**16 (4%)**	**6 (1%)**	**7 (4%)**	**10 (2%)**	**8 (8%)**	**0.000**

Note: Reported percentage values indicate proportion of participants within the BMI category.
[a]BMI < 18.5 kg/m^2; [b]BMI:18.5-24.9 kg/m^2; [c]BMI: 25-29.9 kg/m^2; [d]BMI: ≥30kg/m^2 (34);
LOS: Length of stay; MN: Malnourished; WN: Well-nourished;
[g]includes SGA-A (12) and MST < 2(11);
[h]includes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m^2 (14);
[i]within 30 or 90 days of hospital admission.

Table 4. Malnutrition coding in malnourished participants as per body mass index (BMI)

Malnutrition Coding	Underweight[a] Malnourished[g] (n=227)	Normal weight[b] Malnourished[g] (n=401)	Overweight[c] Malnourished[g] (n=175)	Obese[d] Malnourished[g] (n=105)	p-value
Not coded	181 (82%)	322 (79%)	161 (90%)	92 (88%)	0.000
Coded	39 (18%)	83 (21%)	17 (10%)	10 (10%)	

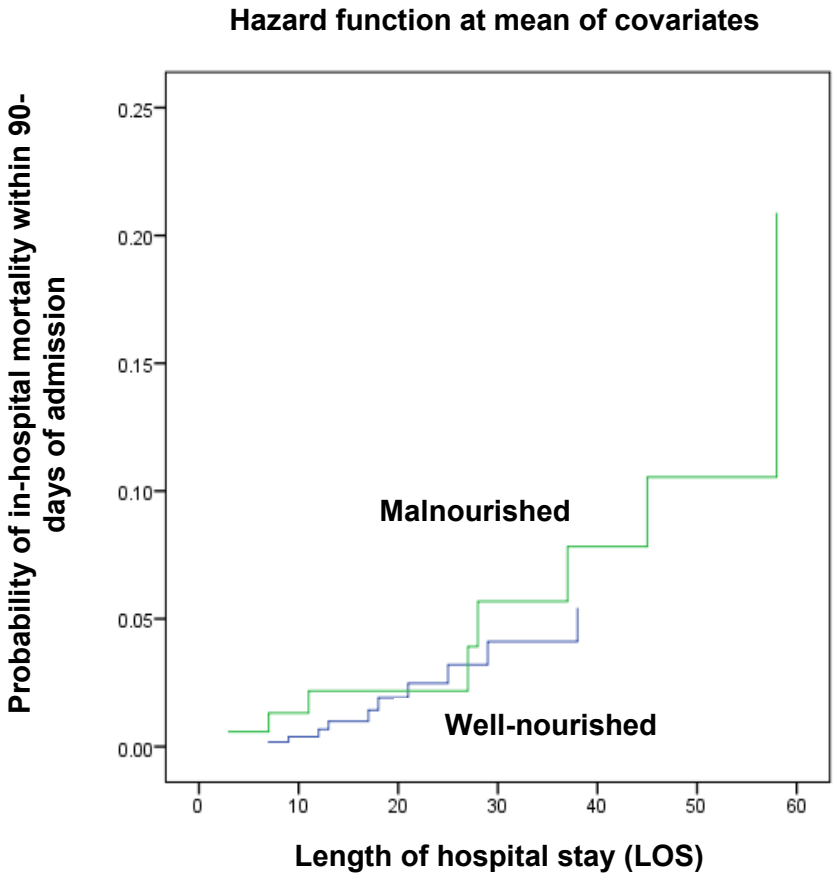
Note: Reported percentage values indicate proportion of participants within the BMI category.
[a]BMI < 18.5 kg/m^2; [b]BMI:18.5-24.9 kg/m^2; [c]BMI: 25-29.9 kg/m^2; [d]BMI: ≥ 30kg/m^2 (34);
[g]includes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m^2 (14);

Table 5. Bivariate and logistic regression analyses for in-hospital mortality in obese patients (n= 750)

Risk factors	Bivariate analyses			Logistic regression	
	No in-hospital mortality n (%)	In-hospital mortality n (%)	p-value	Odds ratio (95% CI)	p-value
30-day in-hospital mortality					
Ethnicity: Maori	42 (93%)	3 (7%)	0.006	7.262 (1.763-29.922)	0.006
Food intake ≤ 25%	143 (95%)	7 (5%)	0.003	5.729 (1.798-18.249)	0.003
Malnutrition[a]	128 (96%)	5 (4%)	0.063	3.110 (0.938-10.304)	0.063
90-day in-hospital mortality					
MDC: Endocrine	26 (89%)	3 (11%)	0.026	7.612 (1.786-32.448)	0.006
Malnutrition[a]	124 (93%)	9 (7%)	0.002	3.814 (1.417-10.269)	0.008
Food intake ≤ 25%	141 (94%)	9 (6%)	0.004	3.407 (1.281-9.062	0.014
Severe/catastrophic PCCL score	458 (97%)	16 (3%)	0.031	3.068 (0.804-11.704)	0.101
Age ≥ 65 years	331 (96%)	13 (4%)	0.032	3.013 (1.091-8.321)	0.033
Hospital LOS	11 days (2-224 days)	21 days (3-58 days)	0.009	0.997 (0.979-1.014)	0.712

Note: Reported percentage values indicate proportion of participants within the BMI category.
CI: Confidence Intervals; LOS: Length of stay; MDC: Major Diagnostic Category; PCCL: Patient Clinical Complexity Level;
[a]Malnutrition defined as moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m^2 (14)

Figure 1. Cumulative incidence of 90-day in-hospital mortality in well-nourished and malnourished obese patients consuming ≤25% of the offered meals



Authors' contributions to manuscript

EA conceptualised, designed and coordinated the ANCDS; acquired, analysed and interpreted the data; and wrote the first draft of the manuscript. MF, MB and EI provided significant advice on the ANCDS study design. EA and AV conceptualised secondary analysis for the current paper. MBatterham provided statistical advice. JB and SC made significant contributions to the revisions of the manuscript. All authors participated in editing and final revisions of the manuscript; and have approved the final manuscript.

Conflict of Interest

The authors have no conflict of interest to declare.

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