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

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26 **Abstract**

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

33 **Methods:** This is a secondary analysis of the Australasian Nutrition Care Day Survey dataset
34 (N = 3122), a prospective cohort study conducted in hospitals from Australia and New Zealand
35 in 2010. At baseline, hospital dietitians recorded participants' BMI, evaluated nutritional status
36 using Subjective Global Assessment (SGA), and recorded 24-hour food intake (as 0%, 25%,
37 50%, 75%, and 100% of the offered food). Post-three months, participants' length of stay
38 (LOS), readmissions, and in-hospital mortality data were collected. Bivariate and regression
39 analyses were conducted to investigate if there were an association between BMI, nutritional
40 status, poor food intake, and health-related outcomes.

41 **Results:** Of the 3122 participants, 2889 (93%) had eligible data. Obesity was prevalent in 26%
42 of the cohort (n = 750; 75% females; 61 ± 15 years; $37 \pm 7 \text{kg/m}^2$). Fourteen percent (n = 105)
43 of the obese patients were malnourished. Over a quarter of the malnourished obese patients (N
44 = 30/105, 28%) consumed $\leq 25\%$ of the offered meals. Most malnourished obese patients
45 (74/105, 70%) received standard diets without additional nutritional support. After controlling
46 for confounders (age, disease type and severity), malnutrition and intake $\leq 25\%$ of the offered
47 meals independently trebled the odds of in-hospital mortality within 90 days of hospital
48 admission in obese patients.

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

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

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

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77 1. INTRODUCTION

78 Recently, Cereda and colleagues investigated the association between BMI and in-hospital
79 mortality from the 2006-2014 combined 'nutritionDay worldwide' dataset including over
80 97000 adult patients from hospitals in 51 countries (1). After controlling for confounders such
81 as demographics (age, gender), nutritional factors (history of weight change, food intake in
82 week preceding data collection), and medical factors (reason for hospitalisation, surgical
83 procedures performed, intensive care admission, number of medications) and mobility,
84 researchers found that low BMI ($<18.5 \text{ kg/m}^2$) was an independent predictor for in-hospital
85 mortality (odds ratio (OR): 1.35, 95% confidence interval (CI): 1.20-1.53, p value <0.001) (1).
86 Cereda et al. concluded that overweight and obesity had protective associations with 30-day in-
87 hospital mortality given that mortality was lowest in patients in the obese category (BMI \geq
88 30 kg/m^2 ; OR: 0.73, 95% CI: 0.62-0.86, p value <0.001) (1).

89
90 Despite strong associations with increased healthcare costs and mortality in healthy populations
91 (2-4), in 2002, Gruberg and colleagues noticed that obesity (BMI $\geq 30 \text{ kg/m}^2$) had a protective
92 association in a cohort of post-percutaneous coronary interventions (5). Many studies since
93 have demonstrated this phenomenon, known as the 'obesity paradox' or 'reverse
94 epidemiology', particularly in cardiovascular and metabolic disease, some cancers and end-
95 stage renal disease (5, 6). However, studies demonstrating protective associations between
96 obesity and improved survival define obesity using BMI, an inherent limitation of which is that
97 it does not distinguish lean body mass from fat mass, which have different implications for
98 health and survival (7). In a large observational study of critically ill patients (N= 6518)
99 admitted in medical and surgical ICUs from 2004-2011, Robinson et al. demonstrated that the
100 presence of malnutrition confounded the positive association between obesity and 30-day in-
101 hospital mortality (8). Critically ill obese patients (BMI $\geq 30 \text{ kg/m}^2$) with malnutrition had

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

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105 Malnutrition is the result of nutritional intake that is inadequate to support physiological
106 requirements (9). Several factors can contribute to inadequate nutritional intake, including
107 physical, physiological, psychological, and socio-environmental (10). Evidence-based
108 guidelines support the use of a range of validated nutrition screening tools (such as Malnutrition
109 Screening Tool (MST) (11)) and assessment methods (such as Subjective Global Assessment
110 (SGA) (12)) to identify malnutrition (13). Further, the International Classification of Diseases
111 and Related Health Problems, version 10, Australian modification (ICD-10-AM), defines
112 malnutrition as BMI <18.5 kg/m² or unintentional weight loss of at least 5% with evidence of
113 sub-optimal intake resulting in subcutaneous fat loss and/or muscle wasting” (14).

114

115 The Australasian Nutrition Care Day Survey (ANCDS) conducted in 2010 reported the
116 prevalence of malnutrition, poor food intake and associated health-related outcomes in over
117 3000 acute care patients admitted in 56 hospitals across Australia and New Zealand (15, 16).
118 Malnutrition was observed in 30% of the cohort and defined as low BMI (<18.5kg/m²) and
119 moderate/severe malnutrition as determined by SGA (15). Food intake observed over a 24-
120 hour period indicated that one-in-four participants consumed no more than 25% of the offered
121 food (15). After controlling for confounders (age, disease type and severity, and type of
122 admission), the hazard ratio of 90-day in-hospital mortality for malnourished patients who
123 consumed up to a quarter of the offered food was 2.3 times greater than well-nourished patients
124 (CI: 1.39-3.76, p < 0.001) (16).

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

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

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152 **2. METHODS**

153 **2.1 Study design:** The ANCDs was a prospective cohort study conducted over two phases.

154 Phase I (baseline) was conducted in June-July 2010 (15) and Phase II was conducted after

155 three months (16).

156 **2.2 Study setting:** The ANCDs was conducted in 56 acute care hospitals across Australia and

157 New Zealand (15, 16)

158 **2.3 Study population:** Acute care patients aged ≥ 18 years of age were invited to participate

159 in the study by providing written informed consent (15). Patients were excluded if they

160 were likely to be discharged or undergo surgery during the baseline data collection period,

161 were either terminally ill or undergoing end-of-life palliative care, had disordered eating,

162 were outpatients or admitted in certain wards (including maternity and obstetrics, high

163 dependency units, emergency departments, intensive care units, rehabilitation) (15).

164 Further details on inclusion and exclusion criteria, patient recruitment and data elements

165 have been previously published (15).

166 **2.4 Ethics:** Ethics approval for the ANCDs was provided by the Human Research Ethics

167 Committees of The University of Queensland and the participating hospitals (15).

168 **2.5 Data collection:** Details on data collection methodology for both phases have been

169 previously reported (15, 16) and a brief summary has been provided below:

170 **2.5.1 Phase I:** Dietitians from participating hospitals recorded participants' age, gender,

171 self-reported ethnicity, weight and height at baseline (15). Using these measurements

172 the first author calculated each participants' BMI and then categorised as per WHO

173 classification: underweight (BMI < 18.5 kg/m²), normal weight (18.5-24.9 kg/m²),

174 overweight (25-29.9 kg/m²), class I obese (30-34.9 kg/m²), class II obese (35-39.9

175 kg/m²), and class III obese (40 kg/m²) (17). Dietitians also screened the participants

176 for nutrition risk using the MST (11). The MST includes two questions related to

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

194
195 Dietitians also recorded the type of diet offered to participants along with observing
196 their food intake over the 24-hour data collection period after each main meal
197 (breakfast, lunch and dinner) and snack (morning and afternoon tea) (15). Intake for
198 supper was recorded by visual estimation, nursing records or patient recall the
199 following morning (15). Intake was recorded on a five-point scale (0%, 25%, 50%,
200 75%, and 100%) (15). From a list of possible options, patients selected their reason/s
201 for not consuming all the offered food at each main meal and snack (15).

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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 ($BMI \geq 30\text{kg/m}^2$). 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.

227 **3.0 RESULTS**

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

230 **3.1 Comparison of characteristics within the cohort as per BMI:**

231 Over 25% of the cohort were classified as obese (n = 750; Median BMI: 34 kg/m² (range:
232 30-85kg/m²)) (Table 1). Participants in the obese category were significantly younger, had
233 the highest proportion of females and those who identified themselves as Maori (p<0.001)
234 (Table 1).

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

237 Malnutrition risk was significantly lower in obese participants (p<0.001) (Table 1). The
238 average prevalence of malnutrition in the obese group was 14% (n = 105) which was
239 significantly lower than other BMI categories (Table 1). In comparison to other BMI
240 categories, a significantly greater proportion of patients in the obese categories consumed
241 100% of the offered meals during Phase I of the study (Table 1).

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

248

249 **3.2 Comparison of food intake and provision of nutritional support as per nutritional**
250 **status within BMI categories**

251 When BMI categories were compared as per nutritional status, one-in-three malnourished
252 participants across all BMI categories consumed $\leq 25\%$ of the offered meals during Phase I
253 of the study ($p < 0.001$) (Table 2). Seventy percent of malnourished obese participants were
254 offered diets without additional nutritional support during Phase 1 of the study, which was
255 significantly higher than malnourished patients in other BMI categories ($p = 0.018$) (Table
256 2).

257

258 **3.3 Comparison of health-related outcomes as per nutritional status within BMI** 259 **categories**

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

267

268 **3.4 Malnutrition coding**

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

271

272 **3.5 Regression analyses**

273 **3.5.1** LOS: The multiple regression analysis model explained 26% of the variance in LOS in
274 obese participants ($BMI \geq 30 \text{ kg/m}^2$; $R^2 = 0.26$, adjusted $R^2 = 0.25$, $F(9, 766) = 29.62$, p -
275 value < 0.0001). PCCL scores were the largest unique contribution (beta: 0.256, CI:

276 0.929-1.240, p-value<0.0001). Nutritional status made a significant contribution (beta:
277 0.116, CI: 0.283-0.980, p-value<0.0001). Percentage food intake made no significant
278 contribution.

279 **3.5.2** Readmissions: Logistic regression analyses did not find nutritional status and/or food
280 intake to be a significant risk factor for readmissions in obese participants. Neoplastic
281 disease, discharge to other healthcare facilities, and disease severity were the
282 independent risk factors that increased the risk of readmissions within 90 days of index
283 hospitalisation (p<0.005).

284 **3.5.3** In-hospital mortality: After controlling for confounding factors, consumption of $\leq 25\%$
285 of the offered food increased the odds of in-hospital mortality within 30 days of
286 admission by more than 5.5 times (Table 5). Malnutrition did not have a significant
287 association with 30-day in-hospital mortality (Table 5). However, both, malnutrition
288 and consumption of $\leq 25\%$ of the offered food trebled the odds of in-hospital mortality
289 within 90 days of hospital admission (Table 5). Malnourished obese patients had
290 significantly lower survival than those who were not obese and were either well-
291 nourished or malnourished (p = 0.043). After controlling for potential confounders, the
292 hazard ratio of 90-day in-hospital mortality for malnourished obese patients who also
293 consumed $\leq 25\%$ of the offered food was 2.9 times greater (CI: 1.13-7.54, p = 0.027)
294 than well-nourished obese patients who ate $> 25\%$ of the offered food (Figure 1).

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307 **4.0 DISCUSSION**

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

321

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

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

333

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

343

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

353

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

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

362

363 **5.0 Limitations**

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

371

372 **6.0 Conclusion**

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

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

386

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%)	0.000
Aboriginal & Torres Strait Islander	8 (3%)	15 (2%)	21 (2%)	15 (2%)	
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%)	0.001
Medical	135 (60%)	563 (54%)	412 (48%)	393 (53%)	
Other	18 (8%)	52 (5%)	52 (6%)	29(4%)	

Major Diagnostic Category^g					
Circulatory	16 (7%)	133 (12%)	129 (15%)	98 (13%)	0.003
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%)	
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/m², 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					
Well-nourished ⁱ	0	632 (61%)	671 (79%)	636 (86%)	0.000
Malnourished ^j	226 (100%)	408 (39%)	181 (20%)	105 (14%)	

Food intake^g					
0%	31 (14%)	108 (10%)	71 (8%)	31 (8%)	0.000
25%	41 (18%)	151 (15%)	110 (13%)	42 (10%)	
50%	54 (24%)	218 (21%)	162 (19%)	74 (18%)	
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.

^aBMI < 18.5 kg/m²; ^bBMI:18.5-24.9 kg/m²; ^cBMI: 25-29.9 kg/m²; ^dBMI: ≥30kg/m² (34);

^g presented as n(%);

^hMalnutrition Risk assessed using Malnutrition Screening Tool (MST) (11);

ⁱincludes SGA-A (12) and MST<2(11);

^jincludes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m² (14); ^kwithin 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.

^aBMI < 18.5 kg/m²; ^bBMI:18.5-24.9 kg/m²; ^cBMI: 25-29.9 kg/m²; ^dBMI: ≥30 kg/m²(34);

WN: well-nourished; MN: Malnourished;

^gincludes SGA-A (12) and MST < 2(11);

^hincludes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m² (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
	WNg (n=0)	MN ^h (n=227)	WNg (n=617)	MN ^h (n=401)	WNg (n=655)	MN ^h (n=175)	WNg (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 daysⁱ	-	6 (3%)	9 (1.5%)	11 (3%)	5 (1%)	3 (2%)	8 (1%)	5 (5%)	0.027
In-hospital mortality within 90 daysⁱ	-	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.

^aBMI < 18.5 kg/m²; ^bBMI:18.5-24.9 kg/m²; ^cBMI: 25-29.9 kg/m²; ^dBMI: ≥30kg/m² (34);

LOS: Length of stay; MN: Malnourished; WN: Well-nourished;

^gincludes SGA-A (12) and MST < 2(11);

^hincludes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m² (14);

ⁱwithin 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.

^aBMI < 18.5 kg/m²; ^bBMI:18.5-24.9 kg/m²; ^cBMI: 25-29.9 kg/m²; ^dBMI: ≥ 30kg/m² (34);

^gincludes moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m² (14);

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

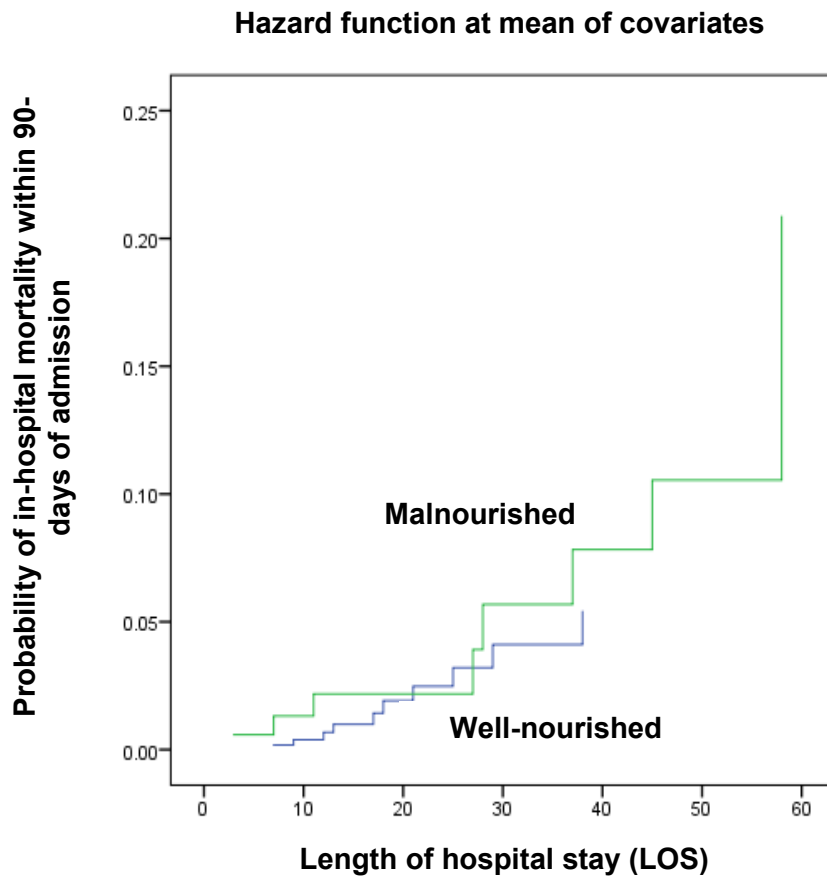
Risk factors	Bivariate analyses			Logistic regression	
	No in-hospital mortality n (%)	In-hospital mortality n (%)	p-value	Odds ratio (95% CI)	p-value
30-day in-hospital mortality					
Ethnicity: Maori	42 (93%)	3 (7%)	0.006	7.262 (1.763-29.922)	0.006
Food intake ≤ 25%	143 (95%)	7 (5%)	0.003	5.729 (1.798-18.249)	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;

^aMalnutrition defined as moderate (SGA-B) and severe (SGA-C) malnutrition (12), and BMI < 18.5 kg/m² (14)

Figure 1. Cumulative incidence of 90-day in-hospital mortality in well-nourished and malnourished obese patients consuming $\leq 25\%$ 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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References:

1. Cereda E, Klersy C, Hiesmayr M, Schindler K, Singer P, Laviano A, et al. Body mass index, age and in-hospital mortality: The NutritionDay multinational survey. *Clinical Nutrition*. In Press. Corrected Proof.
2. Colagiuri S, Lee C, Colagiuri R, Magliano D, Shaw J, Zimmet P, et al. The cost of overweight and obesity in Australia. *Med J Aust*. 2010;192(5):260-4.
3. Lal A, Moodie M, Ashton T, Siahpush M, Swinburn B. Health care and lost productivity costs of overweight and obesity in New Zealand. *Australian and New Zealand Journal of Public Health*. 2012;36(6):550-6.
4. von Lengerke T, Krauth C. Economic costs of adult obesity: A review of recent European studies with a focus on subgroup-specific costs. *Maturitas*. 2011;69(3):220-9.
5. Gruberg L, Weissman NJ, Waksman R, Fuchs S, Deible R, Pinnow EE, et al. The impact of obesity on the short-term and long-term outcomes after percutaneous coronary intervention: the obesity paradox? *Journal of the American College of Cardiology*. 2002;39(4):578-84.
6. Lainscak M, von Haehling S, Doehner W, Anker S. The obesity paradox in chronic disease: facts and numbers. *Journal of Cachexia, Sarcopenia and Muscle*. 2012;3(1):1-4.
7. Hainer V, Aldhoon-Hainerová I. Obesity Paradox Does Exist. *Diabetes Care*. 2013;36(Supplement 2):S276-S281.
8. Robinson M, Mogensen K, Casey J, McKane C, Moromizato T, Rawn J, et al. The Relationship Among Obesity, Nutritional Status, and Mortality in the Critically Ill. *Critical Care Medicine*. 2015;43(1):87-100.
9. Agarwal E. Disease-related malnutrition in the twenty-first century: From best evidence to best practice. *Nutrition & Dietetics*. 2017;74:213-6.
10. Marshall S, Agarwal E. Comparing Characteristics of Malnutrition, Starvation, Sarcopenia and Cachexia in Older Adults. In: Preedy V, Patel VB, editors. *Handbook of Famine, Starvation, and Nutrient Deprivation: From Biology to Policy*. Cham: Springer International Publishing; 2017. p. 1-23.
11. Ferguson M, Capra S, Bauer J, Banks M. Development of a Valid and Reliable Malnutrition Screening Tool for Adult Acute Hospital Patients. *Nutrition*. 1999;15(6):458-64. doi: 10.1016/S0899-9007(99)00084-2.
12. Detsky A, McLaughlin J, Baker J. What is Subjective Global Assessment of nutritional status. *JPEN J Parenter Enteral Nutr*. 1987;11(1):8-13. doi: 0.1177/014860718701100108
13. Watterson C, Fraser A, Banks M, Isenring E, Miller M, Silvester K, et al. Evidence based guidelines for nutritional management of malnutrition in adult patients across the continuum of care. *Nutrition and Dietetics*. 2009;66(s3):s1-s34.
14. National Centre for Classification in Health. *The international statistical classification of diseases and related health problems, 10th revision, Australian modification (ICD-10-AM)*: New South Wales, Australia: National Centre for Classification in Health, Faculty of Health Sciences, The University of Sydney; 2010.
15. Agarwal E, Ferguson M, Banks M, Bauer J, Capra S, Isenring E. Nutritional status and dietary intake of acute care patients: Results from the Nutrition Care Day Survey 2010. *Clinical Nutrition*. 2012;31(1):41-7.
16. Agarwal E, Ferguson M, Banks M, Batterham M, Bauer J, Capra S, et al. Malnutrition and decreased food intake are associated with prolonged length of hospital stay, frequent hospital readmissions, and greater in-hospital mortality: Results from the Nutrition Care Day Survey 2010. *Clin Nutr*. 2013;32:737-45.
17. Agarwal E, Ferguson M, Banks M, Batterham M, Bauer J, Capra S, et al. Nutrition care practices in hospital wards: Results from the Nutrition Care Day Survey 2010. *Clin Nutr*. 2012;31(6):995-1001.
18. Cederholm T, Barazzoni R, Austin P, Ballmer P, Biolo G, Bischoff SC, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. *Clinical Nutrition*. 2017;36(1):49-64.
19. Bischoff SC, Boirie Y, Cederholm T, Chourdakis M, Cuerda C, Delzenne NM, et al. Towards a multidisciplinary approach to understand and manage obesity and related diseases. *Clinical Nutrition*. 2017;36(4):917-38.
20. Choban P, Dickerson R. Morbid Obesity and Nutrition Support: Is Bigger Different? *Nutrition in Clinical Practice*. 2005;20(4):480-7.

21. Prado CMM, Wells JCK, Smith SR, Stephan BCM, Siervo M. Sarcopenic obesity: A Critical appraisal of the current evidence. *Clinical Nutrition*. 2012;31(5):583-601.
22. Scharf G, Heineke J. Finding good biomarkers for sarcopenia. *Journal of Cachexia, Sarcopenia and Muscle*. 2012;3(3):145-8.
23. Yu SCY, Khaw KSF, Jadczyk AD, Visvanathan R. Clinical Screening Tools for Sarcopenia and Its Management. *Current Gerontology and Geriatrics Research*. 2016;2016:10.
24. Hope K, Ferguson M, Reidlinger DP, Agarwal E. "I don't eat when I'm sick": Older people's food and mealtime experiences in hospital. *Maturitas*. 2017;97:6-13.
25. Agarwal E, Ferguson M, Banks M, Bauer J, Capra S, Isenring E. An exploratory study to evaluate whether medical nutrition therapy can improve dietary intake in hospital patients who eat poorly. *J Hum Nutr Diet*. 2013;26(6):538-43.
26. Hiesmayr M, Schindler K, Pernicka E, Schuh C, Schoeniger-Hekele A, Bauer P, et al. Decreased food intake is a risk factor for mortality in hospitalised patients: The NutritionDay Survey 2006. *Clin Nutr*. 2009;28(5):484-91. doi: 10.1016/j.clnu.2009.05.013.
27. Choban P, Dickerson R, Malone A, Worthington P, Compher C, American Society for Parenteral and Enteral Nutrition A.S.P.E.N. ASPEN clinical guidelines: nutrition support of hospitalized adult patients with obesity. *Journal of Parenteral and Enteral nutrition*. 2013;37(6):714-44.
28. Puhl RM, Heuer CA. The Stigma of Obesity: A Review and Update. *Obesity*. 2009;17(5):941-64.
29. Agarwal E, Ferguson M, Banks M, Bauer J, Capra S, Isenring E. Malnutrition coding shortfalls in Australian and New Zealand hospitals. *Nutr Diet*. 2015;72(1):69-73.
30. Dobak S, Peterson SJ, Corrigan ML, Lefton J. Current Practices and Perceived Barriers to Diagnosing, Documenting, and Coding for Malnutrition: A Survey of the Dietitians in Nutrition Support Dietetic Practice Group. *Journal of the Academy of Nutrition and Dietetics*. 2017;In Press, Corrected Proof.
31. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*. 2014;384(9945):766-81.
32. White JV, Guenter P, Jensen G, Malone A, Schofield M. Consensus Statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: Characteristics Recommended for the Identification and Documentation of Adult Malnutrition (Undernutrition). *J Acad Nutr Diet*. 2012;112(5):730-8.
33. Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition – An ESPEN Consensus Statement. *Clinical Nutrition*. 2015;34(3):335-40.
34. World Health Organisation. BMI classification. Global Database on Body Mass Index [Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html]. Accessed on 30 December 2016.