Additional costs of inpatient malnutrition, Victoria
(Australia), 2003-04

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ABSTRACT

Our objective was to estimate the cost of inpatient malnutrition, conditional upon admitting diagnosis and recorded nutritional treatment. We analysed a de-identified administrative data set for inpatients treated in Victorian hospitals; 2003-04. The dataset included patient-level cost data, clinical markers, demographic and episode variables. The dataset was analysed to identify codes, which indicated the presence of malnutrition or its treatment. Linear regression was used to ascertain to what extent malnutrition affected the cost of admission. Controlling for the underlying condition and any treatment administered, recorded malnutrition is estimated to add \$A1745 per admission. The total cost of coded malnutrition to the Victorian public hospital system in 2003-04 was estimated to be least \$A10.7 million. Only 1.87% of the inpatients were coded as malnourished. As administrative data are known to underreport the prevalence of malnutrition, our estimate represents a credible lower bound on the true cost of inpatient malnutrition.

Keywords: Malnutrition; Quality of Care; Administrative data; Cost-of-illness.

BACKGROUND

Malnutrition is an important but under-recognised co-morbidity that continues to impact on the health of inpatients hospitalized in Australia. The Australian literature suggests that (i) the prevalence of malnutrition in the inpatient population is significant, [1-6] (ii) there is gross under reporting of this co-morbidity in the clinical record [2, 4, 7] and (iii) malnutrition is associated with poorer clinical outcomes [1, 3, 8]. A small number of cost-of-illness studies report that the treatment costs of inpatients identified as malnourished are greater than inpatients who are not malnourished [9-12]. However, a limitation of these studies is that they compare average costs, with no attempt to control for patient acuity. It is not possible therefore, to attribute the entire cost difference to malnutrition *per se*, because the more seriously ill a patient is, the higher will be their hospital costs. One notable exception used multivariate analysis to report positive correlations between poor nutritional status and complications, mortality and costs[13].

Our aim was to evaluate the cost of malnutrition to the Victorian (Australia) public hospital system once the admitting diagnosis and any recorded nutrition interventions are taken into account. The approach we use is novel for two reasons. Firstly, we use an administrative data set of patient-level costs supplied by the Victorian Department of Human Services to estimate costs. Secondly, our cost estimate controls for patient acuity and any existing treatment of malnutrition via ordinary least squares (OLS) regression.

METHODS

Design and Sample: We analysed the de-identified patient-level costing dataset that the Victorian Department of Human Services uses to set hospital payment relativities for casemix-based hospital funding [14]. This comprises patient-level costs from 45 hospital campuses that use computerized clinical costing systems to track individual-level utilisation of hospital services. These represent most large public acute care hospitals in the state of Victoria. The file comprises records of 979,834 hospitalisations for the period 1 July 2003 to 1 June 2004. The dataset includes variables from the standard hospital morbidity report to the Department of Human Services, specifically: 40 International Classification of Diseases, 10th Version, Australian Modification (ICD-10-AM; [15]) diagnosis fields and 40 ICD-10-AM procedure fields, length of stay and other descriptors of the patient stay. Diagnoses are routinely abstracted from the medical record for all patients and coded by professionally trained coders supervised by qualified health information managers.

Costs are estimated on the basis of patient-level utilisation counts of inputs to care (days of ward care, minutes of surgical theatre time, number and complexity of imaging and laboratory tests) using by-product data from routine hospital order entry and payroll data systems [16]. The costs of these inputs to care are determined on the basis of hospital-

specific algorithms for allocating general ledger expenditures to wards, theatres, and other departments of the hospital [17]. The costing database is assembled annually by the Victorian Department of Human Services, and subjected to a set of routine data quality checks before being used to set Australian Refined Diagnostic Related Group (AR-DRG) [18] cost weights. Costs are reported in 2004 Australian dollars.

We selected patient records for patients age >14 years, as approaches to paediatric nutrition status are likely to differ substantially from those for adults and there is little agreement about the best methods to assess malnutrition in children [19]. We also selected records with multi-day stays, as same-day admissions select for healthier patients, and stays of one day or less are unlikely to have additional diagnoses recorded for the episode [20]. We excluded 256 inpatients with a primary diagnosis of anorexia ¹ because these diagnoses frequently involve complex psychological issues and treatment modalities, not common to inpatients with malnutrition generally. Our sample was composed of 256,865 inpatients. Table 1 below provides summary data on inpatient costs, pre and post the exclusion of inpatients. As expected, excluding same-day patients increases the mean cost of treatment.

Table 1: Summary Statistics- pre and post sample exclusions

Cost of inpatient	Obs.	Mean	Std. Dev.	Min	Max
<i>Complete sample</i>	979,834	\$A2,996	\$A7,822	\$A34	\$A776,508
<i>Sample post exclusions</i>	256,865	\$A7,827	\$A12,366	\$A140	\$A558,759

The Model: The following OLS regression was used to estimate the cost of untreated malnutrition in the Victorian hospital system.

$$TC = \beta_0 + \beta_1 Dum-mal + \beta_2 Dum-R_x + \beta_3 Dum-interaction + \beta_4 Pat-acuity + \varepsilon_i$$

Where

TC = Total Cost of an inpatient admission
Dum-mal = Coded malnutrition- 5 categories

¹ The excluded ICD-10-AM codes were F50.0, F50.1, F50.2, F50.3, F50.5, F50.8 and F50.9.

<i>Dum-Rx</i>	= Coded treatment for malnutrition- 3 categories
<i>Dum-interaction</i>	= Full set of two-way interaction-terms- 15 categories
<i>Pat-acuity</i>	= Patient acuity- 3 variables
ε_i	= error term

The dependent variable is measured patient-level ‘Total cost of an inpatient admission’. The component elements include, the direct (clinical) and indirect (overhead) cost estimates for ICU-CCU, emergency department, imaging, pharmacy, lab tests, operating theatre, and medical, nursing and allied health services.

The explanatory variable of interest is coded malnutrition in the inpatient population and its effect on cost. Five categories of malnutrition were identified in the ICD-10-AM [15], four categories of protein-energy malnutrition and one additional category for a vitamin deficiency of any type. (See Appendix A) Mild, moderate, and severe protein-energy malnutrition were coded when an inpatient’s body mass index (BMI) was recorded as being between one and two, two and three, or greater than three standard deviations below the community mean, respectively [15]. We identified 235, 260 and 324 coded cases of mild, moderate and severe-malnutrition, respectively. A fourth category, unspecified protein-energy malnutrition contained 2,499 cases. The fifth and final diagnostic category included codes, which identified numerous forms of vitamin deficiency, 1,544 inpatients were included in this category (See Appendix A). The cost of malnutrition was obtained by summing the products of the coefficient for each of the fives categories of malnutrition with their frequency, as follows.

$$\text{Total Cost} = \sum (\text{Coefficient } DumMal \times \text{Frequency})$$

The treatment of malnutrition was controlled for by including dummy variables for any treatment of malnutrition received. Although an ICD-10-AM code for oral supplementation does exist, no inpatients were coded for this intervention. However, three other categories of coded intervention were identified. Firstly, 3,272 inpatients were coded as receiving an enteral intervention, either because they received an enteral infusion directly or underwent a clinical procedure to insert an enteral feeding tube. Secondly, 655 inpatients were coded as receiving total parenteral nutritional (TPN) and finally 42,651 inpatients were identified as receiving either nutritional counselling or education that may or may not have related to malnutrition *per se*. (See Appendix B)

Approximately 7% of inpatients were coded with either dual treatment and or diagnostic codes, for example, some inpatients who were seen by a nutritionist also received enteral feeds. To ensure that the dummy variables used in the regression were mutually exclusive, a coding hierarchy, reflecting severity of malnutrition or intervention, was established. The

ranking of dummy variables, used to classify the diagnosis of malnutrition was; (i) severe, (ii) moderate, (iii) mild, (iv) unspecified-malnutrition and finally (v) vitamin deficiency. The ranking of dummy variables used to classify the treatment of malnutrition was (i) parenteral nutrition, (ii) enteral nutrition and (iii) consultation with a nutritionist. This resulted in a small adjustment of the treatment and diagnostic categories used in the analysis. (See Appendices A and B)

We account for possible nonlinearities in the coding of malnutrition and its treatment by including a complete set of two-way interaction terms for each of the five identified forms of malnutrition (mild, moderate, severe, unspecified, and vitamin) and the three identified treatment modalities (enteral, parenteral and dietician) in the model

Three variables were included to control for patient acuity. Firstly, the patient-specific Weighted Inlier Equivalent Separations (WIES) was used [21]. This is an index of average costs of care per AR-DRG classification used in hospital funding in Victoria. It incorporates weighted per diem payments for excess days of stay above the high outlier boundary ('inlier equivalent' days) and for other cost-increasing factors specific to the episode. Secondly, we used the Charlson co-morbidity index, which predicts the one-year mortality for a patient who may have a range of co-morbid conditions such as heart disease, acquired immune deficiency syndrome or cancer. It has been used in a range of studies to take account of any residual variation in patient severity not captured by the AR-DRG classification [22]. It is a non-proprietary program which has been translated for use with ICD-10 data [23]. Finally, admission to ICU-CCU was included as a dummy variable to control for the higher cost of ICU-CCU admissions. Our purpose was to attribute any remaining variation in cost to variables capturing nutritional status. Age however was not included as an explanatory variable because the construction of the AR-DRG derived WIES index largely accommodates the effect age has on the cost of an admission [24], and to further exclude age factors from the model might have the unintended policy effect of discounting nutritional compromise amongst elderly patients.

Most of our OLS models control for existing treatment costs through including them in our regression analysis—thus the 'malnourished' cost is that over and above any treatment they received (as well as being above expected expenditures for their admitting diagnosis). This assumes that treated patients might have been treated more effectively (say, earlier in their stay), and yielded additional savings, through, for example avoided pressure ulcers or faster recuperation. We used STATA 9.2 SE to analyse our data [25].

RESULTS

Summary statistics are presented to provide an overview of the data we analyse. Table 2 below provides a breakdown of frequencies and mean costs, post exclusion, by classification

of diagnosed and treated malnutrition. Eighty-three percent of the sample is not coded with either a diagnosis or treatment of malnutrition. Approximately 4,800 (1.87%) of inpatients are coded with malnutrition; however 43,000 inpatients receive a nutrition intervention. This is a result of inpatients who consult with a dietician for a range of conditions, including but not limited to malnutrition.

Table 2: Malnutrition by Type- post sample exclusions

Inpatients with;	Observations	Mean cost (S.D)
Nil coded malnutrition	212,408	\$A6,220 (7,942)
Dx-Malnutrition	4,802	\$A12,747 (19,209)
Rx-Malnutrition	43,014	\$A15,720 (22,733)
Dx- or Rx-Malnutrition	44,457	\$A15,506 (22,603)
Total / Mean	256,865	\$A7,827 (12,366)

In Table 3 we present our regression results. We list the coefficients with p-values in parenthesis for five alternative specifications of our model. The last column contains the frequencies. The last two rows present cost estimates derived from each model.

Table 3: Estimate of total cost of inpatient admission, by OLS

Dependent variable -Cost	Model 1	Model 2	Model 3	Model 4	Model 5	Adj. freq.
WFIS		2993.4 (<0.01)	2851.4 (<0.01)		2851.7 (<0.01)	n.a.
Charlson 123, (0/1)		1162.9 (<0.01)	673.5 (<0.01)		670.0 (<0.01)	75,802
Charlson 6, (0/1)		3371.3 (<0.01)	1746.3 (<0.01)		1733.4 (<0.01)	462
ICU_CCU, (0/1)		2390.1 (<0.01)	2112.9 (<0.01)		2110.2 (<0.01)	23,378

Dummy variables for the diagnosis of

Mild, (0/1)	4106.2	6196.0	3703.1	2519.4	2990.7	235
	(<0.01)	(<0.01)	(<0.01)	(0.35)	(0.10)	
Moderate, (0/1)*	2541.8	3891.7	1578.9	2705.9	3983.7	260
	(<0.01)	(<0.01)	(<0.01)	(0.23)	(<0.01)	
Severe, (0/1)*	7889.9	6059.3	3503.3	14020.7	6214.5	324
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)	
Unspecified, (0/1)*	5419.2	1734.7	-581.7	1526.5	623.4	2,482
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(0.09)	
Vitamin deficiency, (0/1)*	4294.7	2635.3	1963.9	3167.3	2053.0	1,501
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)	

Dummy variables for the treatment of

Nutritional consult, (0/1)*			3034.9	7238.6	3071.2	39,241
			(<0.01)	(<0.01)	(<0.01)	
Enteral therapy, (0/1)*			6594.1	31861.5	6498.2	3,118
			(<0.01)	(<0.01)	(<0.01)	
Parenteral therapy, (0/1)*			16412.4	49859.1	16243.0	655
			(<0.01)	(<0.01)	(<0.01)	

Interaction terms

Nutritionist & Mild-malnutrition, (0/1)*			-5009.9	760.4		
			(0.07)	(0.69)		
Nutritionist & Moderate-malnutrition, (0/1)*			-6515.8	-2391.8		210
			(0.01)	(0.14)		
Nutritionist & Severe-malnutrition, (0/1)*			-16097.2	-2711.9		221
			(<0.01)	(0.05)		
Nutritionist & Unspecified-malnutrition,			-3833.0	-1858.5		259
			(<0.01)	(<0.01)		
Nutritionist & Vitamin deficiency, (0/1)*			-2651.0	-273.5		1,774
			(<0.01)	(0.52)		
Enteral Rx & Mild-malnutrition, (0/1)*			-16264.7	-1472.4		547
			(0.01)	(0.73)		
Enteral Rx & Moderate-malnutrition,(0/1)*			-17161.6	-7862.9		4
			(<0.01)	(<0.01)		
Enteral Rx & Severe-malnutrition,(0/1)*			-4029.7	-3791.0		13
			(0.19)	(0.07)		
Enteral Rx & Unspecified-			-8146.5	960.4		22
			(<0.01)	(0.17)		
Enteral Rx & Vitamin deficiency, (0/1)*			-364.1	648.5		179
			(0.85)	(0.63)		
Parenteral Rx & Mild-malnutrition, (0/1)*			16181.4	2656.9		36
			(0.02)	(0.58)		
Parenteral Rx & Moderate-malnutrition,			dropped	dropped		
			(n.a)	(n.a)		
Parenteral Rx & Severe-malnutrition,(0/1)*			-26602.2	-12147.2		3
			(<0.01)	(<0.01)		

Parenteral Rx & Unspecified-				-6963.8 (<0.01)	1500.4 (0.15)	8
Parenteral Rx & Vitamin deficiency,(0/1)*				-17797.5 (<0.01)	-1591.0 (0.52)	73
Constant term	7733.3 (<0.01)	1873.5 (<0.01)	1747.5 (<0.01)	6219.9 (<0.01)	1744.5 (<0.01)	10
<i>R</i> -squared	0.0032	0.593	0.606	0.153	0.606	
Joint F-test for 5 diagnostic dummy variables	F(4,256859) = 87.0	F(4,256855) = 140.4	F(5,256852) = 1008.7	F(5,256842) = 2520.8	F(5,256838) = 914.0	
Joint F-test for 3 treatment dummy variables			F(3,256852) = 2681.8	F(3,256842) = 14477.7	F(3,256838) = 2553.2	
Joint F-test for 15 interaction dummy variables				F(14,256842) = 17.3	F(14,256838) = 5.1	
Cost of Malnutrition = $\sum[(Dx-mal)(Freq.)]$ (\$2004)	\$24,078945	\$12,692135	\$3,919781	\$14,381074	\$8,380891	
Pro-rata adjustment sample 78% of pop. (\$2004)	\$30,870442	\$16,271968	\$5,025360	\$18,437274	\$10,744731	

Notes: 1. (*) coefficient is for discrete change of dummy variable from 0 to 1

2. The reported frequencies were adjusted to ensure the dummy variables are mutually exclusive. See appendices A and B.

As hypothesised, control variables and treatment, variables generally predict significantly higher costs of care. Recorded malnutrition has a significant positive effect on cost. The *R*-squared in Model 1 demonstrates that malnutrition, alone, explains only a small component of cost. The inclusion of explanatory covariates, in particular the WIES index, in Models 2, 3 and 4 increases their explanatory power, the *R*-squared is approximately 0.6. In Model 3 we include three dummy variables for the treatment of malnutrition, to control for existing treatment costs—thus the ‘malnourished’ cost is that over and above any treatment received. Note however in Models 1, 2 and 3 the coefficients for Mild-malnutrition are greater than Moderate-malnutrition and in Model 3 the coefficient for Unspecified-malnutrition is negative. Model 4 documents the capacity of malnutrition (diagnosis, treatment and interaction terms) to explain cost. Estimates from the rejected models are presented to demonstrate the sensitivity of our model to the inclusion of other plausible explanatory factors.

Model 5 is our preferred specification. The inclusion of a full set of interaction terms generates an expected hierarchy of costs (e.g., Charlson score, degrees of malnutrition, etc.) in all related sets of dummy variables. Model 5 estimated the cost of malnutrition in the Victorian public hospital system for 2004, to be \$A8.4 million. The 44 hospitals which contributed data to the Cost Weights Study Dataset (CWSD) in 2003-04, comprised 78% of the total number of inpatient admissions in Victoria during that period[26]. A *pro rata*

adjustment implies that the cost of malnutrition to the Victorian public hospital system is \$A10.7 million (\$2004).

To support our inclusion of two sets of dummy variables for the diagnosis and treatment of malnutrition we jointly test two null hypotheses. First, five dummy variables for the diagnosis of malnutrition are jointly equal to zero and secondly three dummy variables for treatment of malnutrition are jointly equal to zero. Using an *F*-Test (with significance ≤ 0.05) we conclude that we can retain both sets of dummy variables in the regression.

Our econometric models do not appear to be symptomatic of multicollinearity because in general they produce a high R-squared with most explanatory variables remaining statistically significant. [27] We nevertheless conduct a formal test for multicollinearity using Stata's 'collin' command, which computes several summary measures of multicollinearity including a condition number. Multicollinearity may be problematic if the condition number, which equals the square root of the largest eigenvalue divided by the smallest eigenvalue, is greater than 20. [28] The condition number for Model 5 was equal to 8.4, which allayed any residual concerns that multicollinearity may have compromised our results.

DISCUSSION

Our cost estimate of untreated malnutrition in the Victorian inpatient population is the first time that the patient-level CWSD has been used for this purpose. Our raw data indicates that the prevalence of malnutrition in the Victorian public hospital system is only 1.87% of all admissions and costs \$A10.7 million per annum. Importantly our analysis controls for the level of patient acuity. The sensitivity analysis shows that if the admitting diagnosis is not controlled for, cost estimates for malnutrition 'increase' by approximately 71%.

Administrative data sets are known to underestimate the prevalence of inpatient malnutrition [2, 4, 7]. The Australian literature has published inpatient malnutrition rates between 34.7% and 42.3% [1, 2, 6] and less than 1% of inpatients who were identified as malnourished were documented as such in the medical record [2]. We therefore suggest that a cost estimate of \$A10.7 million forms a lower bound on the true cost of coded malnutrition to the Victorian hospital system.

A twenty-fold *pro rata* adjustment of costs estimates, based on these rates obtained from the literature would produce biased estimates, as we suspect the under reporting of malnutrition is not uniform [1, 2]. Recall, that the ICD-10-AM codes Mild-, Moderate- and Severe-malnutrition are assigned when the patient's BMI lies between one and two, two and three, or greater than three standard deviations below the community mean, respectively. If our sample of 256,865 inpatients had a normally distributed BMI, the expected numbers of

inpatients with Mild-, Moderate- and Severe-malnutrition would be 34,908, 5,497 and 360 respectively. While the coding of Severe-malnutrition appears relatively complete, the coding of Mild-malnutrition maybe substantially under-represented.

Although some uncertainty surrounds the prevalence of coded malnutrition in the medical record, we have greater confidence in our estimates of cost per inpatient coded with malnutrition. We find that controlling for the severity of the underlying condition, recorded malnutrition is estimated to add \$A1745 per admission. The adjusted *R*-squared of our regression was 0.6056. The joint level of significance of dummy variables used to identify malnutrition and treatment were tested and found to be statistically significant. Most of the variation in cost is explained by the WIES term, which weights the admitting condition based on its DRG. When the regression was recalculated without the inclusion of malnutrition, treatment and their interaction terms the adjusted *R*-squared was 0.5921 indicating that while the correlation between malnutrition and cost is statistically significant, malnutrition and its treatment explains less than 1% of the observed variation in cost. These results are plausible. The large sample size has enabled the detection of a small but nevertheless statistically significant and financially relevant effect that coded malnutrition has on the cost of an inpatient admission.

It is clear that this is not an epidemiologically-based estimate of prevalence, and that identification and coding of malnutrition in Victorian hospitals is not well-developed. Taking the example of the three severity codes for protein-energy malnutrition (Mild, Moderate and Severe-malnutrition), it is unlikely that the less severe forms would present in fewer numbers than the more severe category. Yet in our study, the prevalence of these different levels of malnutrition was roughly the same (around 275 cases in each group), which suggests considerable under-diagnosis for milder forms of malnutrition.

Our estimates of the incremental effect of coded malnutrition on the cost of an inpatient stay appear more robust, although cost estimates may be biased when the sample is non-representative. We suspect we have obtained a near complete ascertainment of inpatients with Severe- and Vitamin-malnutrition. The under-reporting of cases of Moderate- and Mild-malnutrition may bias these costs upwards due to identification of only the most obvious cases; but this will also bias downward our estimates of the total costs of malnutrition because the costs of treating clinical sequelae of under-recognised malnutrition will be absorbed by other variables in the model. The inclusion of interaction terms ensures that our cost estimates for Severe-, Moderate- and Mild-malnutrition are progressively decreasing, which is consistent with our expectations. There is therefore, a clear case for the continued development of administrative data sets such as the CWSD to ensure that research into public health issues can fully utilise this potentially valuable data resource.

CONCLUSION

In this paper, we conduct a secondary analysis of the Victorian Cost Weights Dataset to estimate the cost of coded malnutrition in Victorian hospitals. We control for admitting diagnosis, clinical history and any recorded treatment of malnutrition. Total cost was estimated by summing the product of the coefficients and frequency of five dummy variables, which identified malnutrition. We find that even with evident undercoding of inpatient malnutrition, this comorbidity entails significant additional costs.

It is important to clarify that our findings do not imply neglect in the treatment of malnutrition. Rather, the findings suggest that, as hospital managers seek to improve the quality of care and decrease costs, comorbidities such as malnutrition are obvious targets for intervention. We recognise firstly that cost-of-illness studies cannot be used in isolation to guide decisions on resource allocation; priority setting should be driven by a comparison of incremental gains with incremental costs. Secondly, we recognise that inpatient treatment costs are a sub-set of the total costs of malnutrition; other important costs not integrated into our cost-of-illness study include outpatient costs of malnutrition and quality of life decrements incurred by patients. Our research however, utilises an inexpensive and accessible source of data to identify that this under-appreciated comorbidity, imposes a non-trivial cost on the Victorian hospital system. Furthermore, the treatment of malnutrition routinely entails relatively low cost and non-invasive interventions such as nutritional supplements and consultation. In communication with a local teaching hospital the per diem cost of intervention via a nutritional consult, enteral feeds and TPN were estimated as \$A21.75, \$A8.40 and \$A137.60 respectively (M. Banks, personal communication, 2008.). The economic evaluation of interventions such as these offers an enticing direction for future research.

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Appendix A: Research variables - Malnutrition

ICD-10-AM Descriptions	ICD-10-AM	Freq.	Percentage	Adj. freq.
Mild protein-energy malnutrition	E441	235	0.091	235
Moderate protein-energy malnutrition	E440	260	0.101	260
<i>Kwashiorkor</i>	E40	1	0.000	
<i>Nutritional marasmus</i>	E41	36	0.014	
<i>Marasmic kwashiorkor</i>	E42	1	0.000	
<i>Unspecified sever protein-energy malnutrition</i>	E43	286	0.111	
Severe protein-energy malnutrition	E40-E43	324	0.126	324
<i>Unspecified protein-energy malnutrition</i>	E46	1,640	0.638	
<i>Symptoms and Signs; Abnormal weight loss</i>	R634	859	0.334	
Total unspecified protein-energy malnutrition	E46 + R634	2,499	0.973	2,482
<i>Vitamin A deficiency, unspecified</i>	E509	1	0.000	
<i>Wernicke's encephalopathy</i>	E512	19	0.007	
<i>Other manifestations of thiamine deficiency</i>	E518	1	0.000	
<i>Thiamine deficiency - unspecified</i>	E519	4	0.002	
<i>Riboflavin deficiency</i>	E530	1	0.000	
<i>Deficiency of other B group vitamins</i>	E538	681	0.265	
<i>Vitamin B deficiency unspecified</i>	E539	10	0.004	
<i>Ascorbic acid deficiency</i>	E54	8	0.003	
<i>Vitamin D unspecified</i>	E559	461	0.179	
<i>Deficiency of Vitamin K</i>	E561	19	0.007	
<i>Deficiency of other vitamins</i>	E568	3	0.001	
<i>Vitamin deficiency , unspecified</i>	E569	3	0.001	
<i>Dietary calcium deficiency</i>	E58	3	0.001	
<i>Dietary zinc deficiency</i>	E60	8	0.003	
<i>Iron deficiency</i>	E611	259	0.101	
<i>Magnesium deficiency</i>	E612	6	0.002	
<i>Vanadium deficiency</i>	E616	1	0.000	
<i>Other specified nutritional deficiencies</i>	E638	11	0.004	
<i>Nutritional deficiency, unspecified</i>	E639	20	0.008	
<i>Lack of Adequate food</i>	Z594	7	0.003	
<i>Inappropriate diet and eating habits</i>	Z724	18	0.007	
Total vitamin malnutrition	E509 to Z724	1,544	0.601	1,501

Appendix B: Research variables – Treatment

ICD-10-AM Descriptions	ICD-10-AM	Freq.	Percentage	Adj. freq.
<i>Oral Nutritional Support</i>	96096-00	0	0.000	
<i>Therapeutic diet support</i>	96095-00	0	0.000	
Treatment with oral supplements		0	0.000	
<i>Percutaneous endoscopic jejunostomy tube [PEJ]</i>	30478-05	37	0.014	
<i>Removal of gastrostomy tube</i>	30478-08	31	0.012	
<i>Initial insertion of PEG</i>	30481-00	367	0.143	
<i>Repeat insertion of PEG tube</i>	30482-00	112	0.044	
<i>Insertion of Percutaneous non-endoscopic gastrostomy</i>	30483-00	17	0.007	
<i>Insertion of feeding jejunostomy tube</i>	31462-00	169	0.066	
<i>Laparoscopic insertion of feeding jejunostomy tube</i>	90306-00	6	0.002	
<i>Irrigation of gastrostomy or enterostomy</i>	92073-00	2	0.001	
<i>Enteral Infusion</i>	92191-00	2,531	0.985	
Treatment with enteral intervention		3,272	1.274	3,118
<i>Parenteral Infusion</i>	92192-00	655	0.255	
<i>Parenteral nutritional support</i>	96098-00	0	0.000	
Treatment with parenteral intervention		655	0.255	655
<i>Nutritional Dietary assessment</i>	96026-00	16	0.006	
<i>Nutritional Counselling or education</i>	96067-00	124	0.048	
<i>Allied Health intervention, Dietetics</i>	95550-00	42,511	16.550	
Treatment with dietary consult		42,651	16.604	39,241

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