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1                    **Undernutrition is associated with increased financial losses in hospitals**

2                    **Running head:** cost of hospital undernutrition

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## 31 **Abstract**

32 **Background & aims:** Undernutrition is associated with increased hospital costs. Whether  
33 these increased costs are totally compensated by third payer systems has not been assessed.

34 We aimed to assess the differences between actual and reimbursed hospital costs according to  
35 presence/absence of nutritional risk, defined by a Nutritional risk screening-2002 (NRS-  
36 2002) score  $\geq 3$ .

37 **Methods:** Retrospective study. Administrative data for years 2013 and 2014 of the  
38 department of internal medicine of the Lausanne university hospital. The data included total  
39 and specific costs (i.e. clinical biology, treatments, pathology). Reimbursed costs were based  
40 on the Swiss Diagnosis Related Group (DRG) system.

41 **Results:** 2200 admissions with NRS-2002 data were included (mean age 76 years, 53.9%  
42 women), 1398 (63.6%) of which were considered nutritionally 'at-risk'. After multivariate  
43 adjustment, patients nutritionally 'at-risk' had higher costs (multivariate-adjusted  
44 difference  $\pm$  standard error: 34'206  $\pm$  1246 vs. 22'214  $\pm$  1666 CHF,  $p < 0.001$ ) and higher  
45 reimbursements (26'376  $\pm$  1105 vs. 17'783  $\pm$  1477 CHF,  $p < 0.001$ ). Still, the latter failed to  
46 cover the costs, leading to a deficit between costs and reimbursements of 7831  $\pm$  660 CHF in  
47 patients 'at-risk' vs. 4431  $\pm$  881 in patients 'not at-risk' ( $p < 0.003$ ). Being nutritionally 'at-risk'  
48 also led to a lower likelihood of complete coverage of costs: multivariate-adjusted odds ratio  
49 and 95% confidence interval 0.77 (0.62-0.97). Patients 'at-risk' had lower percentage of total  
50 costs in medical interventions, food, imaging and "other", but the absolute differences were  
51 less than 2%.

52 **Conclusion:** Hospital costs of patients nutritionally 'at-risk' are less well reimbursed than of  
53 patients 'not at-risk'. Better reporting of undernutrition in medical records and better  
54 reimbursement of undernourished patients is needed.

55 **Keywords:** Diagnosis-related groups; costs; reimbursements; hospital undernutrition.

56

## 57 **Introduction**

58           Undernutrition is a common feature among hospitalized patients: in Switzerland, it is  
59 present in slightly less than one out of five patients [1, 2]. Undernutrition leads to increased  
60 in-hospital morbidity and mortality [3], as well as increased hospital costs [4, 5]. In most  
61 European countries, health costs are covered by the government, prepaid private insurances  
62 and the patients themselves [6]. Switzerland has one of the best health systems in the world  
63 [7], which also ranks amongst the most expensive: total health costs for 2013 were estimated  
64 at 9752 US\$ per capita, almost one quarter (22.9%) being paid by the patients [6]. In  
65 Switzerland, hospitals are reimbursed based on the Diagnosis Related Groups (DRG), a  
66 system aimed at making hospital paying more transparent and also at evaluating hospital  
67 performance [8]. The Swiss Diagnosis Related Groups (Swiss DRG) system exists since  
68 2012, is based on its German counterpart and has approximately 1000 different categories  
69 [9]. In a well-managed system, hospital costs should be balanced by reimbursements; hence,  
70 the highest hospital costs due to undernutrition should be covered by higher reimbursements,  
71 provided the adequate DRG codes are indicated. Still, whether this is actually the case has  
72 never been assessed.

73           We have previously shown that being nutritionally ‘at-risk’ was associated with  
74 higher in-hospital mortality and total costs [10]. We now assessed the costs, reimbursements  
75 and corresponding net result (i.e. the difference between costs and reimbursements)  
76 according to presence/absence of nutritional risk. We also assessed the distribution of specific  
77 costs (i.e. related to imaging, laboratory analyses, etc.) according to presence/absence of  
78 nutritional risk. The objective is to know whether patients nutritionally ‘at-risk’ differ from  
79 the others regarding specific costs and if they represent a financial burden for the institution.

## 80 **Materials and methods**

### 81 *Study design*

82 This is a retrospective study using electronic administrative data for years 2013 and  
83 2014 of the department of internal medicine of the Lausanne university hospital. Data from  
84 all adult ( $\geq 18$  years old) hospitalizations who stayed at least one day ( $\geq 24$  hours) in the  
85 department of internal medicine was collected and coded before being handled for analysis.  
86 Data extraction, merging and coding was performed by a specific team of the Lausanne  
87 university hospital and the investigators were blinded to the hospitalizations' identities.

### 88 *Nutritional risk screening and data collection procedure*

89 Nutritional risk screening was defined by the presence of NRS-2002 score in the  
90 electronic medical records. Since January 2013, all data related to nutritional status (including  
91 screening) is available in the patient's electronic file. According to the Lausanne university  
92 hospital guideline, undernutrition risk screening should, whenever possible, include all  
93 patients, and be systematic for patients with chronic obstructive pulmonary disease (COPD)  
94 and heart failure. For the other patients, decision for screening is based on the subjective  
95 evaluation by the health care team. Evaluation should be based on the NRS-2002 of the  
96 Danish Society for Parenteral and Enteral Nutrition [11, 12]. The reason for focusing on  
97 patients with COPD and heart failure is the high prevalence of undernutrition among those  
98 patients [13, 14].

99 Hospitalized patients were interviewed the first day of admission about their  
100 nutritional status, and nutritional risk scoring was performed according to the NRS-2002  
101 criteria. Nutritional risk was scored from 0 to 3; disease severity was scored from 0 to 3, and  
102 an extra score of 1 was added to hospitalizations older than 70 years. The nutritional risk  
103 score is determined due to three different parameters 1) quartile decreased of estimated oral

104 food intake requirements, 2) presence of weight loss more than 5% within the previous 1 to 3  
105 months and 3) low body mass index. The severity of disease was categorized as none, slight,  
106 moderate and severe with the score of 0 to 3, respectively. The scores were added and  
107 hospitalizations with a NRS-2002 score  $\geq 3$  were considered as nutritionally 'at-risk'.

### 108 *Costs and reimbursements*

109 Actual total and specific costs (i.e. related to treatments, medical interventions,  
110 imaging, laboratory analyses, food, intensive care units...) were collected from the hospital  
111 accounting system. Costs were expressed in Swiss Francs (CHF); 1 CHF=1.021 US\$ or 0.919  
112 €([www.xe.com](http://www.xe.com), assessed 29<sup>th</sup> of June, 2016). Specific costs were expressed as percentage of  
113 the total costs. Only specific costs whose median represented at least 1% of total costs were  
114 considered; hence, costs related to anesthesia (median=0); pathology (median=0);  
115 dialysis/transplantation (median=0) and medications (median=0.6) were not considered. Of  
116 note, the costs related to food include neither oral nutritional supplements (ONS), nor enteral  
117 or parenteral nutrition, and costs related to ONS could not be identified from the files.

118 Reimbursements were computed according to the Swiss DRG [9]. We considered 1  
119 DRG point=10'500 CHF (average value for 2014). For each patient, the difference between  
120 costs and reimbursements was also computed. Total costs and reimbursements were used  
121 either as continuous variables or categorized into lower/higher than the 75<sup>th</sup> percentile or  
122 lower/higher than the 90<sup>th</sup> percentile. Coverage of the costs was computed as the ratio of  
123 costs/reimbursements and expressed as percentage, or categorized as complete ( $\geq 100\%$ ) or  
124 less than complete ( $< 100\%$ ).

### 125 *Other variables*

126 Socio-demographic data included age, sex and origin (i.e. coming from home or other  
127 health care facilities). Medical data included International classification of diseases, version

128 10 (ICD-10) codes for the main cause of hospitalization and comorbidities (up to 26), and  
129 vital status at discharge (alive or dead). Main cause of hospitalization was categorized into  
130 infectious, oncologic, endocrine, neuro-psychiatric, cardiologic, pulmonary, digestive, bone  
131 and joint, urologic, and other. The Charlson Index was computed from ICD-10 codes  
132 according to an algorithm defined for Switzerland [15]. Total hospital length of stay (in  
133 internal medicine and other departments) was collected. Data for the medical provision  
134 categories (*groupe de prestations* or GPC), a system assessing the main type of medical  
135 treatment (i.e. intensive care, respiratory system, pain management, infection...) was also  
136 collected.

#### 137 *Exclusion criteria*

138 Hospitalizations were excluded if there was a lack of information on NRS-2002,  
139 costs, sex, age, origin, main diagnosis, or Charlson Index; moreover, patients with main  
140 diagnosis of obstetric and/or gynecological disease were also excluded as they usually  
141 managed in other departments of the hospital.

#### 142 *Statistical analysis*

143 Statistical analyses were performed using Stata version 14.1 for windows (Stata Corp,  
144 College Station, Texas, USA). Descriptive results were expressed as number of participants  
145 (percentage) or as average  $\pm$  standard deviation. Bivariate analyses were performed using chi-  
146 square for categorical variables and Student's t-test or Kruskal-Wallis test for continuous  
147 variables. Associations between variables were assessed using Spearman rank correlation.  
148 For continuous variables, multivariate analysis was performed using analysis of variance and  
149 results were expressed as multivariate-adjusted mean  $\pm$  standard error. Due to the skewness  
150 of the distribution of costs leading to large confidence intervals of the estimates, an analysis  
151 based on quantiles of costs was performed to confirm the findings. For dichotomous  
152 variables, multivariate analysis was performed using logistic regression and the results were

153 expressed as odds ratio (OR) and 95% confidence interval (CI). Sensitivity analyses were  
154 carried out after excluding hospitalizations with extreme costs (>100,000 CHF, N=39) or  
155 related to intensive care (N=85) as the latter are associated with high costs for specific  
156 categories (i.e. emergency, medical interventions). Statistical significance was considered for  
157 a two-sided test with  $p < 0.05$ .

#### 158 *Ethics statement*

159 The study was approved by the Ethics Commission of Canton Vaud ([www.cer-vd.ch](http://www.cer-vd.ch),  
160 decision 428-14, of Dec 2, 2014) and by the board of directors of the Lausanne university  
161 hospital (decision of Dec. 5, 2014).

## 162 **Results**

#### 163 *Patient characteristics*

164 Data from 8,538 hospitalizations for years 2013 and 2014 were collected. Of these  
165 5,999 (70.3%) were excluded because of missing data for NRS-2002, and a further 339  
166 (4.0%) because of missing data regarding socio-demographic or financial data, leaving 2,200  
167 (25.8%) hospitalizations for analysis. The characteristics of the included and excluded  
168 patients are summarized in **Supplementary table 1**. Excluded patients were younger, less  
169 frequently women, and had higher in-hospital mortality; excluded patients also had a shorter  
170 length of stay, a lower number of comorbidities, tended to be more frequently in the lowest  
171 category of the Charlson index, and had lower costs than included patients (**Supplementary**  
172 **table 1**).

#### 173 *Characteristics of patients 'not at-risk' and 'at-risk'*

174 The characteristics of patients nutritionally 'not at-risk' and 'at-risk' according to NRS-  
175 2002 classification are summarized in **Supplementary table 2**. Patients 'at-risk' were older,  
176 more frequently women, came less frequently from home, had a longer length of stay, were in



177 the highest category of the Charlson index, had a higher number of comorbidities and a  
178 higher incidence of in-hospital mortality than patients ‘not at-risk’ (**Supplementary table 2**).

179 *Costs, reimbursements, and net results*

180 The total costs, reimbursements and net results according to presence or absence of  
181 nutritional risk are summarized in **Tables 1 and 2**. On bivariate analysis, hospitalizations ‘at-  
182 risk’ had higher total costs, and a higher likelihood of being in the highest quartile or decile  
183 of costs. Hospitalizations ‘at-risk’ also led to higher reimbursements and had a higher  
184 likelihood of being in the highest quartile or decile of reimbursements. Finally,  
185 hospitalizations of nutritionally ‘at-risk’ patients led to higher differences between costs and  
186 reimbursements, were more frequently in the highest quartile or decile of differences between  
187 costs and reimbursements, and had a lower frequency of getting their costs completely  
188 covered (**Table 1**).

189 These findings were further confirmed by multivariate analysis adjusting for sex, age  
190 (continuous), main diagnosis (9 categories), Charlson index category (5 groups), and in-  
191 hospital mortality (**Table 2**). After multivariate adjustment, and compared to patients ‘not at-  
192 risk’, patients ‘at-risk’ led an extra 3400 CHF (95% CI: 1200 to 5600 CHF) loss to the  
193 average difference between costs and reimbursements. Adjusting for number of comorbidities  
194 instead of the Charlson index led to similar findings (data not shown), patients ‘at-risk’  
195 leading an extra 2500 CHF (95% CI: 370 to 4800 CHF) loss to the average difference  
196 between costs and reimbursements. Adjusting simultaneously for the number of  
197 comorbidities, Charlson index and GPC category led to similar conclusions (**Supplementary**  
198 **table 3**); further adjusting for total length of stay also led to similar conclusions  
199 (**Supplementary table 4**).

200 Similar conclusions were obtained in a sensitivity analysis excluding hospitalizations  
201 with total costs >100'000 CHF (N=39) or in intensive care (N=85) (**Supplementary tables 5**  
202 **to 8**), patients 'at-risk' leading an extra 1960 CHF (95% CI: 900 to 3000 CHF) loss to the  
203 average difference between costs and reimbursements. Finally, an inverse association  
204 between percentage of costs covered and length of stay was found in the overall sample  
205 (Spearman  $r=-0.146$ ,  $p<0.001$ ) and after excluding hospitalizations in intensive care or with  
206 total costs >100'000 CHF (Spearman  $r=-0.175$ ,  $p<0.001$ ).

### 207 *Specific costs*

208 The specific costs according to presence or absence of nutritional risk are summarized  
209 in **Supplementary tables 9 and 10**. On bivariate analysis, patients 'at-risk' had a higher  
210 percentage of costs related to units (housing) and a lesser percentage related to medical  
211 interventions, laboratory analyses and other (**Supplementary table 9**). Multivariate analysis  
212 showed that patients 'at-risk' had lower percentage of costs in medical interventions, food,  
213 imaging and other ( $p<0.05$ ), but all absolute differences were less than 2% (**Supplementary**  
214 **table 10**). Sensitivity analysis excluding hospitalizations in intensive care or with total costs  
215 >100'000 CHF showed that patients 'at-risk' had lower percentage of costs in medical  
216 interventions, food, imaging and other ( $p <0.05$ ) (**Supplementary table 11**).

## 217 **Discussion**

218 In this study we show that patients nutritionally 'at-risk' have higher costs but also  
219 higher reimbursements than patients 'not at-risk'. Still, the higher reimbursement of patients  
220 nutritionally 'at-risk' fails to completely cover the excess costs among 'at-risk' patients.  
221 Thus, patients nutritionally 'at-risk' have a wider gap between costs and reimbursements (i.e.  
222 lead to greater losses for the hospital) than patients 'not at-risk'. We also show that the

223 distribution of the main specific costs (expressed as percentage of total costs) does not vary  
224 considerably between ‘at-risk’ and ‘not at-risk’ patients.

#### 225 *Availability of nutritional data in medical records*

226         Only one quarter (26%) of medical records had data for NRS-2002. This value is  
227 higher than reported in a Brazilian study (18.8%) [16] but lower than in a Canadian (33%)  
228 [17] or an Argentinean (38.8) studies [18]. Possible reasons are that the health care team fails  
229 to identify nutrition risk [19], the information is not collected [20] possibly due to time  
230 constraints [21], or it is collected but not inserted in the electronic file [22]. Given the  
231 considerable health and economic impact of undernutrition risk among hospitalized patients,  
232 inclusion of nutritional data in the electronic files should be made compulsory.

233         Excluded patients had higher mortality but were younger and had lower number of  
234 comorbidities and a shorter length of stay than included ones. The younger age is due to  
235 lower screening rates among young patients [10], while the shorter length of stay could be  
236 due to the higher mortality and to the less complex disease. Our results suggest that health  
237 care teams select the patients based on their clinical status as indicated in the hospital  
238 guidelines, but avoid specific patients with end-of-life situations.”

#### 239 *Costs, reimbursements, and net results*

240         Being nutritionally ‘at-risk’ was associated with higher total costs, a finding in  
241 agreement with the literature [4, 23]. For instance, in a previous review, we showed that,  
242 compared to well-nourished patients, patients at risk of undernutrition had higher  
243 hospitalization costs, ranging between 1640 and 5829€per patient [5]. Similarly, an  
244 Australian study conducted among COPD patients showed that patients with an  
245 undernutrition code in their medical records had a total cost which was almost double than  
246 those who were well-nourished (AUD \$23,652 vs. 12,362) [24]. This difference could partly

247 be due to an increased length of stay, although the higher costs among patients nutritionally  
248 'at-risk' persisted in the sensitivity analyses even after adjusting for total length of stay.  
249 Interestingly, the reimbursements obtained from nutritionally 'at-risk' patients were higher  
250 than the reimbursements of patients 'not at-risk'; thus, one would expect that this increase in  
251 reimbursements would lead to a similar coverage of costs for both nutritionally 'at-risk' and  
252 'not at-risk' patients, but actually it was not the case, coverage rate being significantly lower  
253 among nutritionally 'at-risk' patients, a finding also reported by others [25, 26]. Possible  
254 explanations include the fact that coverage rates decrease with increasing length of stay or  
255 that undernutrition is frequently underreported in hospital discharge data [27, 28], thus  
256 leading to an inadequate DRG classification [25]. Therefore, it can be speculated that a better  
257 reporting of undernutrition might lead to increase reimbursement [29]. Still, presence of an  
258 undernutrition code in the discharge data does not forcibly lead to a different DRG code [26],  
259 and the impact of a better reporting of undernutrition on reimbursements remains to be  
260 evaluated. Finally, prompt screening and management of patients 'at-risk' of undernutrition  
261 might lead to cost savings of 1000 €per patient [30].

262 An intervention aimed at better screening, management and reporting of  
263 undernutrition is currently ongoing at the department of internal medicine, and the results will  
264 be analyzed in 2017.

#### 265 *Specific costs*

266 Few studies assessed the distribution of hospital costs for nutritionally 'at-risk' and  
267 'not at-risk' patients [31, 32]. In a community setting, Benković et al. estimated that, among  
268 patients with undernutrition, the share of total health costs for medications, hospitalizations,  
269 community nursing and (par)enteral nutrition was 42.6%, 33.7%, 13.1% and 6.7%,  
270 respectively, but no comparison with adequately nourished patients was performed [32]. In  
271 one hospital setting in Spain, patients with undernutrition had higher costs for hospital stay,

272 oral and artificial nutrition, and medicines [31]. These findings are partly in agreement with  
273 our results, where patients nutritionally ‘at-risk’ had a higher share of total costs associated  
274 with intensive care. Interestingly, expressing the costs as percentage of the total showed that  
275 Spanish patients with undernutrition also had a lower share of oral nutrition (1.1% vs. 1.7%),  
276 similar to our findings. Contrary to the Spanish study which evaluated artificial nutrition as  
277 representing almost 22% of total costs [31], it was not possible to quantify the specific cost of  
278 therapeutic or artificial nutrition in our study, as costs related to costs related to ONS, enteral  
279 and parenteral nutrition are not identifiable. Overall, our results suggest that the distribution  
280 of the different types of hospital costs between nutritionally ‘at-risk’ and ‘not at-risk’ patients  
281 varies, patients ‘at-risk’ having a higher share related to intensive care. Still, the absolute  
282 differences between ‘at-risk’ and ‘not at-risk’ patients were modest, never exceeding 2%.  
283 Hence, it can be inferred that being nutritionally ‘at-risk’ does not influence particularly one  
284 type of hospital costs; rather, it tends to increase all types of costs.

#### 285 *Limitation of the study*

286 This paper has several limitations worth acknowledging. Firstly, only patients from  
287 the department of internal medicine of a university hospital were included, so our results  
288 might not be extrapolated to other departments or to peripheral hospitals. Also, the DRG  
289 system and level of reimbursement varies between countries [33], so the results obtained for  
290 Switzerland might not be applicable in other countries. Still, they provide a framework for the  
291 evaluation of the economic impact of undernutrition in hospitals, and it would be of interest  
292 to replicate this study in other settings or other countries. Secondly, it was not possible to  
293 obtain the value of the DRG point for 2013, so the value for 2014 was used instead. The  
294 higher value of DRG for year 2014 in comparison to year 2013, led to an overestimation of  
295 the amounts reimbursed and a probable underestimation of the difference between costs and  
296 reimbursements. Thirdly, the number of patients with NRS-2002 data was small, and they

297 differed significantly from the patients without information for nutritional risk. Hence, a  
298 possible selection bias cannot be ruled out, more severe patients benefiting from nutrition risk  
299 screening. Still, this selection bias would not influence the reimbursement of the costs, or the  
300 coverage of the latter. Fourthly, due to legal constraints, it was not possible to obtain the  
301 identification of the patients, which would have allowed their follow-up and thus other  
302 assessments such as the impact of risk of undernutrition on readmissions. Finally, it was not  
303 possible to characterize the “Other” types of cost, and costs related to medicines were  
304 underestimated as only “expensive” drugs (i.e. some types of chemotherapy, biological  
305 equivalents) were considered.

### 306 *Conclusion*

307 Patients nutritionally ‘at-risk’ have higher costs and higher reimbursements than  
308 patients ‘not at-risk’, but reimbursements fail to adequately cover the excess costs due to  
309 undernutrition, leading to higher financial losses for the hospitals.

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### 312 **Statement of authorship**

313 PMV made most of the statistical analyses and wrote most of the article; SS provided  
314 data; SK-S wrote part of the manuscript; PC, FP and GW revised the article for important  
315 intellectual content. PMV had primary responsibility for final content.

### 316 **Conflict of interest statement**

317 The authors report no conflict of interest.

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406 **Tables**

407 **Table 1.** Bivariate analysis of the costs, reimbursements and net balance for participants  
 408 nutritionally ‘not at-risk’ and ‘at-risk’ according to the NRS-2002 criteria, department of  
 409 internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Not at-risk</b>	<b>At-risk</b>	<b>p-value</b>
N (%)	802 (36.5)	1398 (65.5)	
<b>Total costs</b>			
Amount (CHF)	16'171	19'982	<0.001
	[11'142 – 24'748]	[13'684 – 33'785]	
>75 <sup>th</sup> percentile (%)	140 (17.5)	410 (29.3)	<0.001
>90 <sup>th</sup> percentile (%)	49 (6.1)	171 (12.2)	<0.001
<b>Reimbursements</b>			
Amount (CHF)	11'114	13'346	
	[7802 – 18'186]	[8988 – 25'351]	<0.001
>75 <sup>th</sup> percentile (%)	162 (20.2)	388 (27.8)	<0.001
>90 <sup>th</sup> percentile (%)	49 (6.1)	157 (11.2)	<0.001
<b>Difference (costs-reimbursements)</b>			
Amount (CHF)	4239	5651	
	[187 - 8655]	[1244 – 11'232]	<0.001
>75 <sup>th</sup> percentile (%)	157 (19.6)	393 (28.1)	<0.001
>90 <sup>th</sup> percentile (%)	54 (6.7)	166 (11.9)	<0.001
<b>Coverage (%)</b>			
Amount	72.2 [53.7 - 97.9]	69.9 [52.1 - 93]	0.084
Complete	191 (23.8)	283 (20.2)	0.050

410 Results are expressed as number of patients (percentage) for categorical variables and as  
411 median [interquartile range] for continuous variables. Between-group comparisons performed  
412 using chi-square for categorical variables and Kruskal-Wallis test for continuous variables.

413 **Table 2.** Multivariate analysis of the costs, reimbursements and net balance for participants  
 414 nutritionally ‘not at-risk’ and ‘at-risk’ according to the NRS-2002 criteria, department of  
 415 internal medicine of the Lausanne university hospital, 2013-2014.

	Not at-risk	At-risk	p-value
N (%)	802 (36.5)	1398 (65.5)	
<b>Total costs</b>			
Amount (CHF)	22'214 ± 1666	34'206 ± 1246	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	2.10 (1.66 - 2.66)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	2.36 (1.66 - 3.36)	<0.001
<b>Reimbursements</b>			
Amount (CHF)	17'783 ± 1477	26'376 ± 1105	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.53 (1.22 - 1.92)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.96 (1.37 - 2.79)	<0.001
<b>Difference (costs-reimbursements)</b>			
Amount (CHF)	4431 ± 881	7831 ± 660	0.003
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.72 (1.37 - 2.15)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	2.09 (1.48 - 2.95)	<0.001
<b>Coverage (%)</b>			
Amount	82.6 ± 1.6	78.6 ± 1.2	0.044
Complete	1 (ref.)	0.77 (0.62 - 0.97)	0.026

416 Results are expressed as odds ratio (95% confidence interval) for categorical variables and as  
 417 multivariate-adjusted mean ± standard error for continuous variables. Between-group  
 418 comparisons performed using logistic regression for categorical variables and analysis of  
 419 variance for continuous variables. Adjustment performed on sex, age (continuous), main  
 420 diagnosis (9 categories), Charlson index category (5 groups), and in-hospital mortality.

421

## Supplementary tables

**Supplementary table 1.** Socio-demographic and clinical characteristics of excluded and included patients, department of internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Included</b>	<b>Excluded</b>	<b>p-value</b>
N (%)	2200 (25.8)	6338 (74.2)	
Age (years)	75.6 ± 15.5	71.9 ± 16.7	<0.001
Women (%)	1186 (53.9)	3114 (49.1)	<0.001
Coming from home (%)	2053 (93.3)	5841 (92.2)	0.076
In-hospital mortality (%)	120 (5.5)	439 (6.9)	0.016
Length of stay (days)	14 [9 - 21]	11 [7 - 17]	<0.001 <sup>§</sup>
Charlson index (%)			
0	932 (42.4)	2914 (46.0)	0.003
1	275 (12.5)	689 (10.9)	
2	343 (15.6)	1020 (16.1)	
3	146 (6.6)	324 (5.1)	
4+	504 (22.9)	1391 (22.0)	
Number of comorbidities	5 [3 - 6]	4 [3 - 6]	<0.001 <sup>§</sup>
Total costs (CHF)	18'414	15'000	
	[12'698 - 9'983]	[10'252 - 24'752]	<0.001 <sup>§</sup>

Results are expressed as number of patients (percentage) for categorical variables and as mean ± standard deviation or as median [interquartile range] for continuous variables. Between-group comparisons performed using chi-square for categorical variables and student's t-test of Kruskal-Wallis (<sup>§</sup>) test for continuous variables.

**Supplementary table 2:** Socio-demographic and clinical characteristics of including patients according to nutritional status as assessed by NRS-2002, department of internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Not at-risk</b>	<b>At-risk</b>	<b>p-value</b>
N (%)	778 (37.5)	1298 (62.5)	
Age (years)	71.4 ± 16.1	78.1 ± 14.6	<0.001
Women (%)	381 (47.5)	805 (57.6)	<0.001
Coming from home (%)	765 (95.4)	1288 (92.1)	0.003
In-hospital mortality (%)	16 (2.0)	104 (7.4)	<0.001
Length of stay (days)	12 [8 - 19]	15 [10 - 23]	<0.001 <sup>§</sup>
Charlson index (%)			
0	387 (48.3)	545 (39.0)	<0.001
1	92 (11.5)	183 (13.1)	
2	130 (16.2)	213 (15.2)	
3	45 (5.6)	101 (7.2)	
4+	148 (18.5)	356 (25.5)	
Number of comorbidities	4 [3 - 6]	5 [3 - 7]	<0.001 <sup>§</sup>

Results are expressed as number of patients (percentage) for categorical variables and as mean ± standard deviation or as median [interquartile range] for continuous variables. Between-group comparisons performed using chi-square for categorical variables and student's t-test or Kruskal-Wallis (<sup>§</sup>) test for continuous variables.

**Supplementary table 3:** Multivariate analysis of the costs, reimbursements and difference for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014.

	Not at-risk (n=802)	At-risk (n=1398)	p-value
<b>Total costs</b>			
Amount (CHF)	26'152 ± 1378	31'947 ± 1029	0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.80 (1.38 - 2.35)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.80 (1.19 - 2.72)	0.005
<b>Reimbursements</b>			
Amount (CHF)	21'110 ± 1259	24'467 ± 940	0.037
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.23 (0.96 - 1.58)	0.104
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.43 (0.96 - 2.13)	0.080
<b>Difference (cost-reimbursements)</b>			
Amount (CHF)	5043 ± 872	7480 ± 651	0.029
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.56 (1.24 - 1.96)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.71 (1.19 - 2.45)	0.004
<b>Coverage (%)</b>			
Amount	82.8 ± 1.6	78.5 ± 1.2	0.032
Complete	1 (ref.)	0.75 (0.60 - 0.94)	0.013

Results are expressed as odds ratio (95% confidence interval) for categorical variables and as multivariate-adjusted mean ± standard error for continuous variables. Between-group comparisons performed using logistic regression for categorical variables and analysis of variance for continuous variables. Adjustment performed on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), number of comorbidities (continuous), medical provision category (16 groups) and in-hospital mortality.



**Supplementary table 4.** Multivariate analysis of the costs, reimbursements and net balance for participants nutritionally ‘not at-risk’ and ‘at-risk’ according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Not at-risk</b>	<b>At-risk</b>	<b>p-value</b>
N (%)	802 (36.5)	1398 (65.5)	
<b>Total costs</b>			
Amount (CHF)	29'277 ± 905	30'155 ± 675	0.449
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.62 (1.08 - 2.44)	0.019
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.18 (0.66 - 2.12)	0.576
<b>Reimbursements</b>			
Amount (CHF)	24'110 ± 768	22'746 ± 573	0.165
>75 <sup>th</sup> percentile (%)	1 (ref.)	0.86 (0.63 - 1.17)	0.337
>90 <sup>th</sup> percentile (%)	1 (ref.)	0.92 (0.52 - 1.61)	0.758
<b>Difference (costs-reimbursements)</b>			
Amount (CHF)	5167 ± 873	7409 ± 651	0.045
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.45 (1.15 - 1.84)	0.002
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.61 (1.11 - 2.32)	0.012
<b>Coverage (%)</b>			
Amount	82.8 ± 1.6	78.6 ± 1.2	0.035
Complete	1 (ref.)	0.74 (0.59 - 0.94)	0.011

Results are expressed as odds ratio (95% confidence interval) for categorical variables and as multivariate-adjusted mean ± standard error for continuous variables. Between-group comparisons performed using logistic regression for categorical variables and analysis of variance for continuous variables. Adjustment performed on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), number of comorbidities (continuous), medical provision category (16 groups), in-hospital mortality and total length of stay.

**Supplementary table 5:** Bivariate analysis of costs, reimbursements and net balance for hospitalizations nutritionally 'not at-risk' and 'at-risk', according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014.

Hospitalizations in intensive care (n=85) or with costs over 100'000 CHF (n=39) excluded.

	Not at-risk (n=778)	At-risk (n=1298)	p-value
<b>Total costs<sup>†</sup></b>			
Amount (CHF)	15'822 [11'046 - 23'953]	19'066 [13'302 - 29'605]	<0.001
>75 <sup>th</sup> percentile (%)	147 (18.9)	372 (28.7)	<0.001
>90 <sup>th</sup> percentile (%)	56 (7.2)	151 (11.6)	0.001
<b>Reimbursements</b>			
Amount (CHF)	10'679 [7739 - 16'958]	12'276 [8988 - 20'024]	<0.001
>75 <sup>th</sup> percentile (%)	166 (21.3)	353 (27.2)	0.003
>90 <sup>th</sup> percentile (%)	54 (6.9)	152 (11.7)	<0.001
<b>Difference (costs-reimbursements)</b>			
Amount (CHF)	4221 [223 - 8455]	5480 [1411 - 10'524]	<0.001
>75 <sup>th</sup> percentile (%)	160 (20.6)	359 (27.7)	<0.001
>90 <sup>th</sup> percentile (%)	55 (7.1)	152 (11.7)	0.001
<b>Coverage (%)</b>			
Amount	72 [53.8 - 97.9]	69.5 [51.8 - 91.6]	0.042
Complete	184 (23.7)	254 (19.6)	0.027

Results are expressed as number of patients (percentage) for categorical variables and as median [interquartile range] for continuous variables. Between-group comparisons performed using chi-square for categorical variables and Kruskal-Wallis test for continuous variables.

**Supplementary table 6:** Multivariate analysis of the costs, reimbursements and difference for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014. Hospitalizations in intensive care (n=85) or with costs over 100’000 CHF (n=39) excluded.

	Not at-risk (n=778)	At-risk (n=1298)	p-value
<b>Total costs †</b>			
Amount (CHF)	20’319 ± 578	24’691 ± 442	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.74 (1.38 - 2.21)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.70 (1.20 - 2.40)	0.003
<b>Reimbursements</b>			
Amount (CHF)	16’303 ± 595	18’712 ± 455	0.002
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.34 (1.06 - 1.68)	0.013
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.73 (1.22 - 2.45)	<0.001
<b>Difference (cost-reimbursements)</b>			
Amount (CHF)	4016 ± 420	5980 ± 321	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.57 (1.25 - 1.97)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	2.00 (1.41 - 2.82)	<0.001
<b>Coverage (%)</b>			
Amount	82.3 ± 1.6	78.2 ± 1.2	0.041
Complete	1 (ref.)	0.76 (0.60 - 0.96)	0.020

Results are expressed as odds ratio (95% confidence interval) for categorical variables and as multivariate-adjusted mean ± standard error for continuous variables. Between-group comparisons performed using logistic regression for categorical variables and analysis of variance for continuous variables. Adjustment performed on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), and in-hospital mortality.

**Supplementary table 7:** Multivariate analysis of the costs, reimbursements and difference for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014. Hospitalizations in intensive care (n=85) or with costs over 100’000 CHF (n=39) excluded.

	Not at-risk (n=778)	At-risk (n=1298)	p-value
<b>Total costs</b>			
Amount (CHF)	20’923 ± 522	24’329 ± 399	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.66 (1.28 - 2.14)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.47 (1.02 - 2.14)	0.040
<b>Reimbursements</b>			
Amount (CHF)	16’807 ± 557	18’410 ± 426	0.026
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.23 (0.97 - 1.57)	0.090
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.56 (1.08 - 2.26)	0.017
<b>Difference (cost-reimbursements)</b>			
Amount (CHF)	4116 ± 419	5920 ± 320	<0.001
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.49 (1.18 - 1.88)	<0.001
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.79 (1.25 - 2.55)	<0.001
<b>Coverage (%)</b>			
Amount	82.4 ± 1.6	78.1 ± 1.2	0.037
Complete	1 (ref.)	0.75 (0.60 - 0.95)	0.017

Results are expressed as odds ratio (95% confidence interval) for categorical variables and as multivariate-adjusted mean ± standard error for continuous variables. Between-group comparisons performed using logistic regression for categorical variables and analysis of variance for continuous variables. Adjustment performed on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), number of comorbidities (continuous), medical provision category (16 groups) and in-hospital mortality.

**Supplementary table 8:** Multivariate analysis of the costs, reimbursements and difference for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014. Hospitalizations in intensive care (n=85) or with costs over 100’000 CHF (n=39) excluded.

	Not at-risk (n=778)	At-risk (n=1298)	p-value
<b>Total costs</b>			
Amount (CHF)	22’382 ± 281	23’455 ± 214	0.003
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.51 (1.02 - 2.24)	0.038
>90 <sup>th</sup> percentile (%)	1 (ref.)	0.99 (0.58 - 1.71)	0.982
<b>Reimbursements</b>			
Amount (CHF)	18’048 ± 414	17’666 ± 316	0.474
>75 <sup>th</sup> percentile (%)	1 (ref.)	0.96 (0.71 - 1.30)	0.784
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.18 (0.76 - 1.84)	0.453
<b>Difference (cost-reimbursements)</b>			
Amount (CHF)	4334 ± 415	5789 ± 317	0.007
>75 <sup>th</sup> percentile (%)	1 (ref.)	1.34 (1.05 - 1.70)	0.019
>90 <sup>th</sup> percentile (%)	1 (ref.)	1.55 (1.07 - 2.25)	0.022
<b>Coverage (%)</b>			
Amount	82.2 ± 1.6	78.3 ± 1.2	0.058
Complete	1 (ref.)	0.76 (0.60 - 0.96)	0.021

Results are expressed as odds ratio (95% confidence interval) for categorical variables and as multivariate-adjusted mean ± standard error for continuous variables. Between-group comparisons performed using logistic regression for categorical variables and analysis of variance for continuous variables. Adjustment performed on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), number of comorbidities (continuous), medical provision category (16 groups), in-hospital mortality and total length of stay.

**Supplementary table 9:** Bivariate analysis of specific costs for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’ according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Not at-risk (n=802)</b>	<b>At-risk (n=1398)</b>	<b>p-value</b>
Units (housing)	34.8 [26.0 - 43.5]	38.4 [28.8 - 46.3]	<0.001
Medical interventions	16.6 [13.3 - 20.1]	15.1 [12.3 - 18.2]	<0.001
Food <sup>§</sup>	6.0 [5.0 - 6.9]	5.9 [4.9 - 6.8]	0.201
Imaging	2.4 [0.9 - 5.8]	2.4 [0.9 - 4.7]	0.174
Laboratory analyses	4.5 [3.0 - 6.6]	4.3 [2.9 - 6.1]	0.027
Intensive care unit	5.4 [3.0 - 11.3]	4.8 [2.7 - 11.7]	0.252
Other	14.8 [11.0 - 18.6]	13.0 [9.6 - 16.5]	<0.001

<sup>§</sup> Excluding nutritional therapy. Only positions representing a median >1% of total costs are indicated. Results are expressed as % of total costs and as median [interquartile range].

Between-group comparisons performed using Kruskal-Wallis test.

**Supplementary table 10:** Multivariate analysis of specific costs for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014.

	<b>Not at-risk (n=802)</b>	<b>At-risk (n=1398)</b>	<b>p-value</b>
Units (housing)	35.6 ± 0.4	36.0 ± 0.3	0.461
Medical intervention	16.8 ± 0.2	15.9 ± 0.1	<0.001
Food <sup>§</sup>	6.0 ± 0.1	5.7 ± 0.1	<0.001
Imaging	4.1 ± 0.2	3.7 ± 0.1	0.023
Laboratory analyses	5.1 ± 0.1	5.1 ± 0.1	0.991
Intensive care unit	8.9 ± 0.4	10.3 ± 0.3	0.005
Other	15.0 ± 0.2	13.3 ± 0.1	<0.001

<sup>§</sup> Excluding nutritional therapy. Only positions representing a median >1% of total expenditures are indicated. Results are expressed as % of total costs and as multivariate-adjusted mean ± standard error. Between-group comparisons performed using analysis of variance adjusting on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), and in-hospital mortality.

**Supplementary table 11:** Multivariate analysis of specific costs for hospitalizations nutritionally ‘not at-risk’ and ‘at-risk’, according to the NRS-2002 criteria, department of internal medicine of the Lausanne university hospital, 2013-2014. Hospitalizations in intensive care or with expenditures over 100’000 CHF excluded.

	<b>Not at risk (n=778)</b>	<b>At risk (n=1298)</b>	<b>p-value</b>
Units (housing)	36.1 ± 0.4	37.1 ± 0.3	0.073
Medical intervention	16.9 ± 0.2	16.1 ± 0.1	0.003
Food §	6.1 ± 0.1	5.9 ± 0.1	0.004
Imaging	4.0 ± 0.1	3.6 ± 0.1	0.036
Laboratory analyses	5.0 ± 0.1	5.1 ± 0.1	0.564
Intensive care unit	8.6 ± 0.4	8.9 ± 0.3	0.490
Other	15.2 ± 0.2	13.8 ± 0.1	<0.001

<sup>†</sup> Hospitalizations in intensive care (n=85) or with costs over 100’000 CHF (n=39) were excluded. <sup>§</sup> excluding nutritional therapy. Only positions representing a median >1% of total expenditures are indicated. Results are expressed as % of total costs and as multivariate-adjusted mean ± standard error. Between-group comparisons performed using analysis of variance adjusting on sex, age (continuous), main diagnosis (9 categories), Charlson index category (5 groups), and in-hospital mortality.