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Undernutrition is associated with increased financial losses in hospitals

Running head: cost of hospital undernutrition

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Abstract

Background & aims: Undernutrition is associated with increased hospital costs. Whether these increased costs are totally compensated by third payer systems has not been assessed. We aimed to assess the differences between actual and reimbursed hospital costs according to presence/absence of nutritional risk, defined by a Nutritional risk screening-2002 (NRS-2002) score≥3.

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

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

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

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

Introduction

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

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

Materials and methods

Study design

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

Nutritional risk screening and data collection procedure

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

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

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

Costs and reimbursements

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

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

Other variables

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

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

Exclusion criteria

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

Statistical analysis

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

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

Ethics statement

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

Results

Patient characteristics

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

Characteristics of patients 'not at-risk' and 'at-risk'

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

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

Costs, reimbursements, and net results

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

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

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

Specific costs

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

Discussion

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

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

Availability of nutritional data in medical records

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

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

Costs, reimbursements, and net results

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

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

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

Specific costs

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

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

Limitation of the study

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

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

Conclusion

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

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Statement of authorship

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

Conflict of interest statement

The authors report no conflict of interest.

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Tables

Table 1. Bivariate 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.

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

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.

Table 2. 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.

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

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 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.

	Included	**Excluded**	**p-value**
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 §
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 §
Total costs (CHF)	18’414 [12’698 - 9’983]	15’000 [10’252 - 24’752]	<0.001 §

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 (§) 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.

	Not at-risk	**At-risk**	**p-value**
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 §
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 §

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 (§) 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**
Total costs			
Amount (CHF)	26'152 ± 1378	31'947 ± 1029	0.001
>75th percentile (%)	1 (ref.)	1.80 (1.38 - 2.35)	<0.001
>90th percentile (%)	1 (ref.)	1.80 (1.19 - 2.72)	0.005
Reimbursements			
Amount (CHF)	21'110 ± 1259	24'467 ± 940	0.037
>75th percentile (%)	1 (ref.)	1.23 (0.96 - 1.58)	0.104
>90th percentile (%)	1 (ref.)	1.43 (0.96 - 2.13)	0.080
Difference (cost-reimbursements)			
Amount (CHF)	5043 ± 872	7480 ± 651	0.029
>75th percentile (%)	1 (ref.)	1.56 (1.24 - 1.96)	<0.001
>90th percentile (%)	1 (ref.)	1.71 (1.19 - 2.45)	0.004
Coverage (%)			
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.

	Not at-risk	**At-risk**	**p-value**
N (%)	802 (36.5)	1398 (65.5)	
Total costs			
Amount (CHF)	29'277 ± 905	30'155 ± 675	0.449
>75th percentile (%)	1 (ref.)	1.62 (1.08 - 2.44)	0.019
>90th percentile (%)	1 (ref.)	1.18 (0.66 - 2.12)	0.576
Reimbursements			
Amount (CHF)	24'110 ± 768	22'746 ± 573	0.165
>75th percentile (%)	1 (ref.)	0.86 (0.63 - 1.17)	0.337
>90th percentile (%)	1 (ref.)	0.92 (0.52 - 1.61)	0.758
Difference (costs-reimbursements)			
Amount (CHF)	5167 ± 873	7409 ± 651	0.045
>75th percentile (%)	1 (ref.)	1.45 (1.15 - 1.84)	0.002
>90th percentile (%)	1 (ref.)	1.61 (1.11 - 2.32)	0.012
Coverage (%)			
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**
Total costs [1]			
Amount (CHF)	15'822 [11'046 - 23'953]	19'066 [13'302 - 29'605]	<0.001
>75th percentile (%)	147 (18.9)	372 (28.7)	<0.001
>90th percentile (%)	56 (7.2)	151 (11.6)	0.001
Reimbursements			
Amount (CHF)	10'679 [7739 - 16'958]	12'276 [8988 - 20'024]	<0.001
>75th percentile (%)	166 (21.3)	353 (27.2)	0.003
>90th percentile (%)	54 (6.9)	152 (11.7)	<0.001
Difference (costs-reimbursements)			
Amount (CHF)	4221 [223 - 8455]	5480 [1411 - 10'524]	<0.001
>75th percentile (%)	160 (20.6)	359 (27.7)	<0.001
>90th percentile (%)	55 (7.1)	152 (11.7)	0.001
Coverage (%)			
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**
Total costs [ł]			
Amount (CHF)	20'319 ± 578	24'691 ± 442	<0.001
>75th percentile (%)	1 (ref.)	1.74 (1.38 - 2.21)	<0.001
>90th percentile (%)	1 (ref.)	1.70 (1.20 - 2.40)	0.003
Reimbursements			
Amount (CHF)	16'303 ± 595	18'712 ± 455	0.002
>75th percentile (%)	1 (ref.)	1.34 (1.06 - 1.68)	0.013
>90th percentile (%)	1 (ref.)	1.73 (1.22 - 2.45)	<0.001
Difference (cost-reimbursements)			
Amount (CHF)	4016 ± 420	5980 ± 321	<0.001
>75th percentile (%)	1 (ref.)	1.57 (1.25 - 1.97)	<0.001
>90th percentile (%)	1 (ref.)	2.00 (1.41 - 2.82)	<0.001
Coverage (%)			
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**
Total costs			
Amount (CHF)	20'923 ± 522	24'329 ± 399	<0.001
>75th percentile (%)	1 (ref.)	1.66 (1.28 - 2.14)	<0.001
>90th percentile (%)	1 (ref.)	1.47 (1.02 - 2.14)	0.040
Reimbursements			
Amount (CHF)	16'807 ± 557	18'410 ± 426	0.026
>75th percentile (%)	1 (ref.)	1.23 (0.97 - 1.57)	0.090
>90th percentile (%)	1 (ref.)	1.56 (1.08 - 2.26)	0.017
Difference (cost-reimbursements)			
Amount (CHF)	4116 ± 419	5920 ± 320	<0.001
>75th percentile (%)	1 (ref.)	1.49 (1.18 - 1.88)	<0.001
>90th percentile (%)	1 (ref.)	1.79 (1.25 - 2.55)	<0.001
Coverage (%)			
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**
Total costs			
Amount (CHF)	22'382 ± 281	23'455 ± 214	0.003
>75th percentile (%)	1 (ref.)	1.51 (1.02 - 2.24)	0.038
>90th percentile (%)	1 (ref.)	0.99 (0.58 - 1.71)	0.982
Reimbursements			
Amount (CHF)	18'048 ± 414	17'666 ± 316	0.474
>75th percentile (%)	1 (ref.)	0.96 (0.71 - 1.30)	0.784
>90th percentile (%)	1 (ref.)	1.18 (0.76 - 1.84)	0.453
Difference (cost-reimbursements)			
Amount (CHF)	4334 ± 415	5789 ± 317	0.007
>75th percentile (%)	1 (ref.)	1.34 (1.05 - 1.70)	0.019
>90th percentile (%)	1 (ref.)	1.55 (1.07 - 2.25)	0.022
Coverage (%)			
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.

	Not at-risk (n=802)	**At-risk (n=1398)**	**p-value**
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 [§]	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

[§] 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.

	Not at-risk (n=802)	**At-risk (n=1398)**	**p-value**
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 [§]	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

[§] 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.

	Not at risk (n=778)	**At risk (n=1298)**	**p-value**
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

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