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Nutritional status in hospitalized patients: prevalence, déterminants and impact on hospital stay, mortality and costs

Saman Khalatbari Soltani

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Faculté de biologie
et de médecine

Department of Internal Medicine, Lausanne University Hospital

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Thèse de doctorat ès sciences de la vie (PhD)

présentée à la

Faculté de biologie et de médecine
de l'Université de Lausanne

par

Saman Khalatbari Soltani

MSc, University Putra Malaysia, Malaysia

Jury

Prof. Patrice Mathevet, Président
Prof. Gérard Waeber, Directeur de thèse
Prof. Pedro Marques-Vidal, Co-directeur
Prof. Mette Berger, expert
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Manuscripts based on the studies presented in this thesis

Chapter 2

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Chapter 3

Khalatbari-Soltani S, Marques-Vidal P. Impact of nutritional risk screening in hospitalized patients on management, outcome and costs: A retrospective study. *Clinical Nutrition.* 2016 Dec; 35(6):1340-1346.

Chapter 4

Marques-Vidal P, Khalatbari-Soltani S, Sahli S, Coti Bertrand P, Pralong F and Waeber G. Undernutrition is associated with increased financial losses in hospitals. *Clinical Nutrition.* 2017. DOI: http://dx.doi.org/10.1016/j.clnu.2017.02.012.

Chapter 5

Khalatbari-Soltani S, de Mestral C, Waeber G and Marques-Vidal P. Estimation of malnutrition prevalence using administrative data: Not as simple as it seems. *Clinical Nutrition.* 2015;34(6):1276–7.

Chapter 6

Khalatbari-Soltani S, de Mestral C, Waeber G and Marques-Vidal P. Diagnostic accuracy of undernutrition codes in hospital administrative discharge database: improvements needed. Nutrition. 2018. https://doi.org/10.1016/j.nut.2018.03.051

Chapter 7

Khalatbari-Soltani S, de Mestral C, Waeber G, Marques-Vidal P. Large regional disparities in prevalence, management and reimbursement of hospital undernutrition. *European Journal of Clinical Nutrition*.2018. DOI: 10.1038/s41430-018-0149-3.

Chapter 8

Khalatbari-Soltani S, de Mestral C, Marques-Vidal P. Sixteen years trends in reported undernutrition in Switzerland. *Clinical Nutrition*. 2018. doi: 10.1016/j.clnu.2018.01.021

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List of publications

Publication	Author contribution	Status
Khalatbari-Soltani S, Marques-Vidal P. The economic cost of hospital malnutrition in Europe; a narrative review. *Clin Nutr ESPEN*. 2015;10(3):e89–94.	**SKS** performed the literature search, prepared the tables and drafted the manuscript; PMV conceived the study, participated in its design and coordination and helped to draft the manuscript.	Published
Khalatbari-Soltani S, Waeber G, Marques-Vidal P. Estimation of malnutrition prevalence using administrative data: Not as simple as it seems. *Clin Nutr*. 2015;34(6):1276–7.	**SKS** and PMV conceived this letter to the editor; **SKS** wrote the letter; PMV reviewed the letter and provided critical recommendations.	Published
Khalatbari-Soltani S, Marques-Vidal P. Not as bad as you think: a comparison of the nutrient content of best price and brand name food products in Switzerland. *Prev Med Reports*. 2016;3:222–8.	**SKS** analyzed data and wrote the paper; PMV designed research and collected data. PMV has primary responsibility for the final content.	Published
Khalatbari-Soltani S, Marques-Vidal P. Impact of nutritional risk screening in hospitalized patients on management, outcome and costs: A retrospective study. *Clin Nutr*. 2016;35(6):1340–6.	**SKS** and PMV conceived and designed the experiment; **SKS** performed the experiments, analyzed and interpreted the data, and wrote the paper; PMV gave support in the data analyses, interpretation of the data and revised critically the manuscript.	Published
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de Mestral C, **Khalatbari-Soltani S**, Stringhini S, Marques-Vidal P. Fifteen-year trends in the prevalence of barriers to healthy eating in a high-income country. *Am J Clin Nutr*. 2017 Mar;105(3):660–8.	CdM and PMV conceived the paper; CdM analyzed data and wrote paper. PMV supervised the analysis, and had primary responsibility for final content. PMV, **SKS** and SS reviewed the manuscript and provided critical recommendations.	Published
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List of communications

1	Swiss society of Clinical Chemistry, Geneva, Switzerland (2015)		
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2	The 37th European Society for Parenteral and Enteral Nutrition (ESPEN), Lisbon, Portugal (2015)		
		Khalatbari-Soltani, S., & Marques-Vidal, P. (2015b). SUN-PP245: Malnutrition Almost Doubles the Risk of In-Hospital Death in a Swiss University Hospital. Clinical Nutrition, 34, Supplement 1, S114. doi: http://dx.doi.org/10.1016/S0261-5614(15)30396-4	Poster
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3	Swiss Society of General Internal Medicine (SSGIM), Basel, Switzerland (2016)		
		Khalatbari-Soltani, S., & Marques-Vidal, P. FM240: Nutritional risk screening in patients hospitalized in an internal medicine ward: does it impact dietary management.	Oral
		Khalatbari-Soltani, S., & Marques-Vidal, P. P330: Impact of nutritionally 'at-risk' on in-hospital mortality, length of hospital stay and costs among patients hospitalized in an internal medicine ward.	Poster
4	The 38th European Society for Parenteral and Enteral Nutrition (ESPEN), Copenhagen, Denmark (September 2016)		
		Khalatbari-Soltani, S., & Marques-Vidal, P. MON-P158: Underestimation Severity and management according to NRS-2002 in internal medicine department of the Lausanne university hospital. doi: http://dx.doi.org/10.1016/S0261-5614(16)30792-0.	Poster
		Khalatbari-Soltani, S., & Marques-Vidal, P. MON-P157: Monitoring of nutritionally 'at-risk' patients: the theory and the practice. doi: http://dx.doi.org/10.1016/S0261-5614(16)30791-9.	Poster
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Khalatbari-Soltani, S., Waeber G., & Marques-Vidal, P. Diagnostic accuracy of undernutrition in hospital discharge data: improvements needed. — Oral

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3. Research topic: Comparison of nutrient content of different food products in Switzerland

   - **Khalatbari-Soltani S**, Marques-Vidal P. Not as bad as you think: a comparison of the nutrient content of best price and brand name food products in Switzerland. *Prev Med Reports*. 2016;3:222–8.

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Summary

Undernutrition is a frequent condition among hospitalized patients, leading to increased morbidity, mortality, length of hospital stay, and health costs. However, few studies have reported undernutrition prevalence and its management in Switzerland. Indeed, very little information exists for Switzerland regarding the factors associated with undernutrition and its impact on health outcomes and health costs. This project thus aimed to better characterize the prevalence, determinants, management, and consequences of undernutrition among hospitalized patients in Switzerland. To achieve this, five studies were conducted: one literature review, two cross-sectional studies, one diagnostic accuracy study, and one trend analysis. The initial literature review showed that in Europe, undernutrition represents a considerable economic burden, representing as much as 10% of total national health expenditures. The first cross-sectional study was conducted in the Lausanne university hospital and showed that three out of five hospitalized patients are 'at-risk' of undernutrition, but only half of them were nutritionally managed; the study also showed that nutritionally 'at-risk' patients had higher in-hospital mortality and costs, while their reimbursement rates were lower. Further, the diagnostic accuracy study showed that, despite a good specificity (87%), undernutrition-related codes in hospital discharge data had low sensitivity (43%) and positive predictive values (28%), thus precluding adequate evaluation of prevalence rates of undernutrition. The second cross-sectional analysis focused on hospital discharge data for whole Switzerland; it showed considerable regional variations regarding the reporting of undernutrition and its management, highlighting the absence of standardized procedures for the whole country. Analysis of hospital discharge data for whole Switzerland for the period 1998-2014 showed a several-fold increase in the prevalence of reported undernutrition-related codes (e.g. from 0.18% to 2.13% in Ticino and from 0.23% to 5.63% in Mittelland). Nevertheless, in 2014, still 40% of hospitalizations with an undernutrition-related code had no indication of nutritional management. Overall, this project provided some important information regarding the prevalence, determinants, and impact of undernutrition in Swiss hospitals. The results will hopefully serve as reference for future intervention studies.

Résumé

La dénutrition est une condition fréquente parmi les patients hospitalisés, augmentant la morbi-mortalité, la durée du sàjour, et les coûts de la santé. Peu d'études se sont intéressées à la prévalence de la dénutrition et sa prise en charge en Suisse. En fait, il existe très peu d'information concernant les déterminants de la dénutrition et ses conséquences sur la santé et les coûts. L'objectif de ce travail était de mieux caractériser la prévalence, les déterminants, la prise en charge et les conséquences de la dénutrition parmi les patients hospitalisés en Suisse. Pour ce faire, cinq études ont été conduites : une revue de la littérature, deux études transversales, une étude diagnostique et une analyse temporelle. La revue de la littérature a montré qu'en Europe la dénutrition représente un coût financier considérable, pouvant aller jusqu'à 10% des dépenses nationales de santé. La première étude transversale a été conduite à l'hôpital universitaire de Lausanne et a montré que trois patients sur cinq étaient à risque de dénutrition, mais que seulement la moitié bénéficiait d'une prise en charge. Cette étude a également montré que les patients à risque avaient une plus grande mortalité intra-hospitalière et coûtaient plus cher, alors que les taux de remboursement étaient moindres. Par ailleurs, l'étude diagnostique a montré que le codage de la dénutrition avait une bonne spécificité (87%) mais une mauvaise sensibilité (43%) et une valeur prédictive positive faible (28%), ce qui limite l'estimation de la prévalence de la dénutrition par l'utilisation des codes. La seconde étude transversale a porté sur les données de la statistique hospitalière suisse ; elle a montré de grandes disparités régionales concernant le codage et la prise en charge de la dénutrition, dues à l'absence de recommandations au niveau national. Finalement, l'analyse temporelle de la statistique hospitalière suisse pour la période 1998-2014 a montré une augmentation considérable de la fréquence des codes de dénutrition (de 0.18% à 2.13% au Tessin et de 0.23% a 5.63% an Mittelland). Néanmoins, en 2014, encore 40% des hospitalisations ayant un code de dénutrition n'avaient pas de code associé à une intervention nutritionnelle. Dans l'ensemble, ce travail a permis d'obtenir des données concernant la prévalence, les déterminants et l'impact de la dénutrition dans les hôpitaux suisses. Nous espérons que ces résultats pourront servir de référence pour de futures études d'intervention.

“You cannot hope to build a better world without improving the individuals. To that end, each of us must work for our own improvement and, at the same time, share a general responsibility for all humanity, our particular duty being to aid those to whom we think can be most useful”.

Marie Curie

List of Abbreviations

Anatomical therapeutic chemical	ATC
Body mass index	BMI
Centre de soutien à la recherche clinique	CSCR
Charlson comorbidity index	CCI
Chronic obstructive pulmonary disease	COPD
Diagnosis related groups	DRG
Disease related malnutrition	DRM
Enteral nutrition	EN
European society for parenteral and enteral nutrition	ESPEN
Intensive care unit	ICU
International classification of diseases	ICD
Lausanne university hospital/Centre hospitalier universitaire vaudois	CHUV
Length of stay	LOS
Malnutrition screening tool	MST
Malnutrition universal screening tool	MUST
Mini nutrition assessment short form	MNA-SF
Missing at random	MAR
National institute for health and clinical excellence	NICE
Negative predictive value	NPV
Nutrition risk index	NRI
Nutrition risk screening-2002	NRS-2002
Oral nutrition supplement	ONS
Parenteral nutrition	PN
Positive predictive value	PPV
Short nutrition assessment questionnaire	SNAQ
Swiss classification of surgical interventions	CHOP

Chapter 1

Introduction

Definition

Malnutrition refers to a broad term commonly used as a synonym to undernutrition; however, it can also refer to overnutrition. Malnutrition can be defined as "any disorder from a deficiency or excess of one or more essential nutrients" and includes both undernutrition and overnutrition (1). In this thesis, the term "malnutrition" will be used to refer undernutrition, unless otherwise stated.

Undernutrition due to starvation, disease or aging can be defined as "a state resulting from lack of intake or uptake of nutrition that leads to altered body composition and body cell mass, leading to diminished physical and mental function and impaired clinical outcome from disease" (1). Undernutrition is characterized by weight loss, loss of body fat and lean mass with an increase extracellular fluid volume (2).

Undernutrition prevalence

Undernutrition is a highly prevalent problem among hospitalized patients, making it an important public health issue (3). The prevalence of undernutrition ranges between 20% and 50% depending on the diagnostic criteria used and the patient's characteristics (4). In Europe, the prevalence of hospital undernutrition was estimated at 23.7% in Spain (5), 23.8% in the Netherlands (6), 27.3% in Germany (7), and up to 34% in the United Kingdom (8). Worldwide, undernutrition prevalence ranges between 27% and 39% in Asia (9,10), 23% and 42% in Australia (3,11,12), and between 40% and 60% in Latin America (13). In all settings, elderly patients and those who suffering from chronic diseases are more vulnerable to nutritional risk than other patients (14).

In Switzerland, there is little information regarding the nutritional status of hospitalized patients. In 2008, the NutritionDay survey reported that nearly 27% of hospitalized patients in Europe (including Switzerland) were nutritionally 'at-risk' (15). The few studies available for Switzerland reported a prevalence of being undernourished or nutritionally 'at-risk' ranging between 18.2% and 31% (16–18).

Undernutrition screening

Screening all patients at hospital admission is paramount for adequate nutritional management and to have beneficial impacts (19). In the United Kingdom, the United States, the Netherlands and some parts of Denmark, nutrition screening at hospital admission is mandatory; however, this is currently not the case in Switzerland (20).

As the complete nutritional assessment of all admitted patient is not feasible, nutrition screening tools should be simple to administer, reliable, and valid to identify the subset of patients requiring a more thorough nutritional assessment (21). Several nutrition screening tools have been developed but not all are validated. Some tools are country-specific and less frequently applied, such as the Malnutrition Screening tool (MST) (22) in New Zealand and the Short Nutrition Assessment Questionnaire (SNAQ) in the Netherlands (23). Other tools have been endorsed by international nutrition societies. For instance, the European Society for Parenteral and Enteral Nutrition (ESPEN) endorsed the Malnutrition Universal Screening Tool (MUST) (24), the Nutrition Risk Screening-2002 (NRS-2002) (25), and the Mini Nutrition Assessment Short Form (MNA-SF) (26) to be used in community, in hospitals and among institutionalized elderly patients, respectively.

All screening tools recommended by ESPEN are based on simple anamnestic or clinical data (**Table 1**). Briefly, the MUST was developed to detect both undernutrition and obesity in multiple settings such as hospitals and community; it includes information on body mass index, unplanned weight loss and the presence or absence of serious disease (24). The NRS-2002 includes age, recent weight loss, decreased body mass index, reduced dietary intake, and subjective assessment of disease severity (25). The MNA-SF includes anthropometric, medical, lifestyle, dietary, and psychosocial information (26).

The ESPEN guideline indicates that the NRS-2002 should be applied within 48h post-admission, so that ‘at-risk’ patients can be identified, further evaluated and treated (30). Still, implementation of this guideline is far from optimal. For instance, the NutritionDay study reported a screening rate of 43% in western European countries (15); a similar rate (40.3%) was also reported in a cross-sectional, multicenter study in the Netherlands (31). These low screening rates could be due to lack of time, instruction and knowledge (32).

Table 1 Undernutrition risk screening tools

Risk screening tools	Patients population/ Settings	Parameters	Risk of undernutrition	Validity
Malnutrition Universal Screening Tool (MUST)	Adults/ Hospital or community	BMI Weight loss Acute disease	score ≥ 2	SGA: - sensitivity 61%, specificity 79% (4) - sensitivity 72%, specificity 90% (27)
Nutrition Risk Screening -2002 (NRS-2002)	Adults/ Hospital	BMI Recent weight loss Recent poor intake Severity of disease Age	score ≥ 3	SGA: - sensitivity 74%, specificity 87% (27) - sensitivity 62%, specificity 93% (4)
Mini Nutrition Assessment-Short form (MNA-SF)	Elderly/ Community, sub-acute or residential aged cares settings.	BMI Weight change Recent intake Acute disease Mobility Dementia/depression	score ≤ 11	MNA: - sensitivity 90%, specificity 88% (28) - sensitivity 89%, specificity 82% (29)

Abbreviations: BMI, Body mass index; SGA, Subjective Global Assessment; MNA, Mini-Nutritional Assessment.

Undernutrition management

The ESPEN guideline and the National Institute for Health and Clinical Excellence (NICE) recommend that undernourished and 'at-risk' patients should rapidly be referred to nutrition and dietetic services for proper nutritional management (19,33). Nutritional management includes food and nutrition delivery, nutrition counseling, and coordination of nutrition care. Food and/or nutrition delivery includes energy- and nutrient-dense foods, oral nutrition supplements, enteral- and/or parenteral nutrition, and should be adapted to the patient's needs (34). Evidence shows that rapid initiation of nutritional management improves the overall quality of patient care, improves clinical outcomes, and reduces costs (34,35). Nutritional management also reduces complications, length of hospital stay, readmission rate, cost of care, and in some studies, mortality (36–40).

Nevertheless, despite its beneficial effects, nutritional management among undernourished or 'at-risk' patients is still insufficiently implemented (41). Previous multicenter studies conducted in the Netherlands and in Denmark reported that fewer than half of nutritionally 'at-risk' patients received nutritional management (31,42). In Switzerland, nutritional management rate has been reported to be 23.2% (18). Such low implementation rates could be due to lack of clearly defined responsibilities in planning and managing nutritional care, lack of nutritional education or cooperation among hospital staff, lack of time, staff and interest (42,43).

Impact on health outcome and costs

Undernutrition complicates patients' outcome and increases morbidity due to impaired immune function, muscle dysfunction, and delayed wound healing; the increase in morbidity further increases length of hospital stay (LOS) (15,44). There is also ample evidence that undernutrition decreases quality of life and increases in-hospital mortality (43–45). For instance, it has been shown that 23% loss of body weight is associated with 70% decrease in physical fitness, 30% decrease in muscle strength and 30% increase in depression (46). Most studies also reported a 40% to 70% increase in LOS in undernourished patients compared to well-nourished patients (7,44,47). Among elderly patients, undernutrition at discharge was a significant independent risk factor for mortality in the subsequent 4.5 years (44).

Undernutrition also carries a considerable economic burden. The estimated excess annual costs of undernutrition have been estimated at £13 billion in the United Kingdom (48) and up to €120 billion in the European Union (49). Still, it is difficult to provide a precise estimation of the actual costs of undernutrition due to the variety of health systems in Europe. In most European countries, health costs are covered by government, prepaid insurances and patients themselves (50). In many countries including Switzerland, health costs are evaluated using the Diagnosis Related Groups (DRG) system for calculating reimbursement or planning health care budgets. A DRG is a statistical system of classifying any inpatient into groups for the purposes of payment based on principle and secondary diagnoses, age, sex, comorbidities, and complications (51).

In Switzerland, the Swiss-DRG system was introduced in January 2012 to facilitate the reimbursement of hospital costs (52) and to evaluate hospital performance by proper recording and documentation (53,54). Hence, complete and precise documentation of all diseases and interventions performed during hospitalization is necessary to obtain an adequate reimbursement of health costs.

Undernutrition reporting

Proper documentation and coding of undernutrition and nutritional intervention procedures is a fundamental step for improving individualized care planning (55,56), disease monitoring, and healthcare costs estimation and reimbursement (57,58). Of note, currently there is no single, universally accepted approach for undernutrition documentation in routine clinical practice (59). Moreover, several studies have shown that undernutrition or being nutritionally ‘at-risk’ is frequently not systematically documented (31,60). A study conducted in one university medical center in Amsterdam reported that nutritional status was documented in only 15.5% of referral letters by the general practitioner (61). Even in the Netherlands, and despite compulsory screening, one study showed that one out of four hospital wards did not document undernutrition in the medical records (62).

Failure to report undernutrition leads to under-estimation of this condition at the national and international levels, thus compromising the adequate evaluation of clinical and public health interventions (63). Possible explanations for the low reporting rates include excessive workload, failure to identify the condition or underrating it relative to others. Indeed, in many countries (including Switzerland), nurses and physicians have little training in nutrition, which is one of the major barriers regarding proper adherence to ‘nutrition programs in hospital’ (43,64–66).

Importantly, proper documentation of undernutrition could impact hospital reimbursement under the DRG-based funding system. Indeed, undernutrition could be considered either as comorbidity or complication. This could potentially change the patient’s DRG group and subsequently increase reimbursement (67–70).

Undernutrition in Switzerland

Switzerland has the second highest and ever increasing per capita health expenditures in the world (71,72). The country consists of 26 cantons, which have a large autonomy regarding health planning. Hence, guidelines regarding undernutrition screening and management are not implemented at the national level. Information regarding the prevalence of undernutrition or being nutritionally ‘at-risk’ among hospitalized patients is scarce; the few available studies report rates varying between 17% and 38%, depending on the method used (16,18,47,73). One study reported a 12.7% frequency of nutritional management among undernourished patients (16). Moreover, there is almost no information regarding trends in undernutrition prevalence; a single study limited to years 1999 and 2008 in a single hospital found no significant differences between the two study periods (69% *vs.* 70%) (74). Finally, to our knowledge, there is no information regarding undernutrition-related costs, and no study had ever been conducted at the national level in Switzerland.

Aim of this thesis

Based on the previous findings, the overall aim of this thesis was to study the prevalence of undernutrition and its impact on hospital outcomes. This aim was further specified into following objectives:

1. To evaluate the impact of (risk of) undernutrition on in-hospital mortality, length of hospital stay and costs.
2. To identify the factors associated with undernutrition screening, prevalence, and management (i.e. nutritional therapies applied);
3. To assess trends in reported undernutrition and its management at discharge among hospitalized patients in whole Switzerland.

For objectives 1 and 2, we used electronic administrative data of the department of internal medicine of the Lausanne university hospital. For objective 3 we used data from the Swiss hospital discharge databases for period 1998 to 2014, provided by the Swiss federal office of statistics (http://www.bfs.admin.ch).

Outline of this thesis

Chapter 2 presents the results of a narrative review on the economic impact of undernutrition. **Chapter 3** presents the results of a cross-sectional study conducted in the internal medicine ward of the Lausanne university hospital regarding the screening and management of undernutrition, and its impact on patients' health outcomes and costs. **Chapter 4** further develops on the economic consequences of undernutrition in the same setting, using actual and not DRG-related costs. These three chapters provide important information for policy makers and stakeholders on the economic importance of hospital undernutrition.

Chapter 5 studies the validity of using undernutrition codes reported in hospital discharge data for assessing the prevalence of undernutrition. **Chapter 6** further develops this topic using data from the cross-sectional study conducted at the Lausanne university hospital. This issue is paramount if one wishes to adequately assess the prevalence of undernutrition using administrative data.

Chapters 7 and 8 expand the scope of the study to whole Switzerland. **Chapter 7** assesses the national and the regional prevalence rates of undernutrition, based on hospital discharge data. **Chapter 8** further expands the analysis by assessing sixteen years trend in reported undernutrition and its management among hospitalized patients in Switzerland.

Chapter 9 wraps up all the information from the previous ones and discusses the public health implications and perspectives.

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Chapter 2

The economic cost of hospital malnutrition in Europe; a narrative review

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Summary

This review paper summarizes available evidence on the impact of being undernourished or nutritionally ‘at-risk’ on length of hospital stay and health costs in Europe, through a comprehensive review which is a basis for the subsequent papers. We conducted a literature search in November 2014 using PubMed and Google Scholar electronic databases. This review showed that undernutrition increased length of hospital stay between 2.4 and 7.2 days. Our results also indicate that undernutrition carries a substantial economic burden, with additional individual costs ranging between 1640 € and 5829 € per hospitalized patient, and an overall cost ranging between 2.1% and 10% of the national health expenditures. Taken together, in comparison to well-nourished patients, being undernourished or nutritionally ‘at-risk’ leads to a longer length of hospital stay and higher costs.

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Review

The economic cost of hospital malnutrition in Europe; a narrative review

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ABSTRACT

Background: Malnutrition among hospitalized patients increases length of stay (LOS) and carries extra hospitalization costs.
Objective: To review the impact of malnutrition on hospital LOS and costs in Europe.
Methods: PubMed and Google Scholar search. All articles from January 2004 until November 2014 were identified. Reference lists of relevant articles were also manually searched.
Results: Ten studies on LOS and nine studies on costs were reviewed. The methods used to assess malnutrition and to calculate costs differed considerably between studies. Malnutrition led to an increased LOS ranging from 2.4 to 7.2 days. Among hospitalized patients, malnutrition led to an additional individual cost ranging between 1640 € and 5829 €. At the national level, the costs of malnutrition ranged between 32.8 million € and 1.2 billion €. Expressed as percentage of national health expenditures, the values ranged between 2.1% and 10%.
Conclusions: In Europe, malnutrition leads to an increase in LOS and in hospital costs, both at the individual and the national level. Standardization of methods and results reported is needed to adequately compare results between countries.
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Introduction

Malnutrition is a highly prevalent problem among hospitalized patients and leads to a considerable adverse health and financial burden [1,2]. Estimates for the worldwide prevalence of malnutrition range between 20 and 50% of hospitalized patients, depending on the population under study and the nutritional screening tools used [3].

Hospital malnutrition is a result of a complex relation between disease, food and nutrition [4]. According to the European Society for Parental and Enteral Nutrition (ESPEN), malnutrition consists of both over- and under-nutrition but in this study only under-nutrition will be considered [3]. Indeed, under-nutrition, also known as disease related malnutrition (DRM), is an urgent public health problem in Europe [5]. Hospital malnutrition has been shown to increase morbidity and LOS, to delay recovery and therefore to result in higher health care and hospital costs [6–8]. Just in Europe, it has been estimated that 20 million patients are at the risk of malnutrition, with an annual cost up to 120 billion € [9,10]. Notwithstanding its impact on health, the economic impact of hospital malnutrition has seldom been studied. In a period where health costs containment is a necessity, better identification of the factors associated with increasing hospitalization costs is paramount to optimize health care delivery. Thus, we aimed to review the impact of hospital malnutrition on LOS and health costs in Europe.

Methods

Literature search strategy

A literature search was conducted in November 2014 using PubMed (MEDLINE) and Google Scholar electronic databases. The

Abbreviation: LOS, length of stay; ESPEN, European Society for Parental and Enteral Nutrition; DRM, disease related malnutrition; NRS, Nutritional Risk Screening; SGA, Subjective Global Assessment; NRI, Nutritional Risk Index; MUST, Malnutrition Universal Screening Tool; BMI, Body Mass Index; DRG, diagnosis-related group.

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search terms used are summarized in supplementary file. All relevant studies published between January 2004 and November 2014 reporting the associations between malnutrition among hospitalized patients and LOS or cost were evaluated. The following key terms included "prevalence", "length of stay", "cost" in combination with "hospital malnutrition" and "hospital undernutrition".

Studies were included if they were a) published from 2004 onwards, as older studies might not correspond to current standards of malnutrition screening and health care delivery and as costs no longer corresponded to current ones; b) conducted among adults (≥18 years old), with no upper age limit; c) conducted in any European country, as universal health coverage is available for most European countries and health expenditures would not be influenced by individual or third party payers; and d) had an English/French/German/Spanish/Portuguese abstract, as other languages could not be assessed by the authors or colleagues. Duplicate publications (i.e. reporting the results of the same study) were excluded.

Data extraction

Titles of articles were analyzed for selecting potentially relevant studies. Then, the abstract and the full text were examined in terms of the eligibility criteria, and the references were also searched for other potential studies not covered by the search strategy.

Data on study characteristics (author, title, country and publication year), study duration, number of patients, prevalence of malnutrition, LOS and/or costs related to malnutrition were extracted by SK, and further confirmed by PMV. Main summary measures were LOS and/or costs related to malnutrition. Both individual (i.e. patient) and overall (i.e. for the whole country) costs were considered. As costs were expressed in different currencies, conversion to Euros (€) was performed using the rates of November 4th, 2014 as indicated in www.xe.com/currencyconverter.

Results

Impact of malnutrition on length of stay

Ten papers were included (selection procedure on Fig. 1). Their main characteristics are summarized in Table 1. Three studies were from Germany [7,11,15], three from Spain [12–14], two from Switzerland [15,16], one from Portugal [6], one from France [17] and one from Norway [18]. Seven studies were multidisciplinary, i.e. conducted in different medical departments [6,11–15,18]; the remaining were conducted in a gastroenterology ward [7], in a cancer center [17] and in an internal medicine department [16]. One article had data on LOS according to malnutrition status, but it was unclear which definition was applied, so it was not included; LOS was 6.3 ± 4.7 for well nourished and 10.6 ± 12.0 for malnourished patients, respectively [19].

Four studies used the Nutritional Risk Screening (NRS-2002) [6,13,14,18], three used the Subjective Global Assessment (SGA) [7,11,12], one used both SGA and NRS-2002 [16], one used the Nutritional Risk Index (NRI) [15] and one study did not report the tools [17]. Prevalence of malnutrition ranged from 19 [7] to 42% [6]. These results are in agreement with a review of malnutrition prevalence in England since 1994 (range 11–45%) [20] and with a collaborative multicentre study including 12 Europe and Middle East countries (32% overall) [21].

In all studies, LOS was significantly longer in malnourished than in well-nourished patients, the differences ranging from 2.4 [12] to 7.2 days [13] (Table 1). Two studies reported a positive association

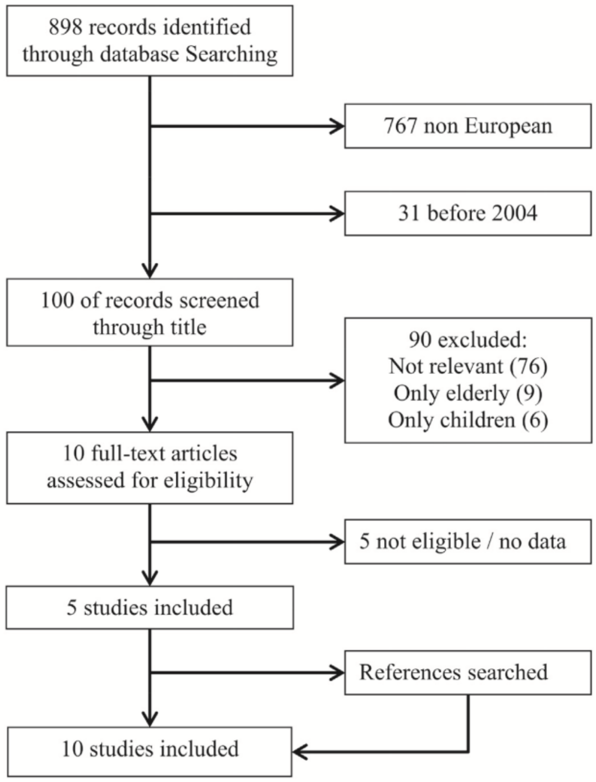

Fig. 1. Selection procedure for the papers on length of stay.

between malnutrition classification (mild, moderate and severe) and prolonged LOS [11,15]. In the Switzerland study in 2004, severe malnourished patients had a five-fold increase of LOS compared to well-nourished patients (25.8 ± 60.6 vs. 5.1 ± 8.2 days, respectively) [15].

No clear trend regarding malnutrition prevalence or its impact on LOS was found within the 10 years period. This unchanged prevalence of malnutrition could be due to the increasing age of hospitalized patients [22], which could also impact LOS. Still, the fact that LOS among malnourished patients did not improve during the period analyzed relative to well nourished patients suggests that nutritional interventions in hospitalized patients are not sufficient.

Impact of malnutrition on hospital costs

Nine papers investigating the economic costs of malnutrition among hospitalized patients were included (**selection procedure on** Fig. 2). Their main characteristics are summarized in Table 2. Except one study conducted in a Gastroenterology Ward [7] all the others were multidisciplinary [6,7,10,13,15,18,23–25]. For nutritional status, one study used the NRI [15], one the SGA [7], four the NRS-2002 [6,13,18,24], two the Malnutrition Universal Screening Tool (MUST) [23,25] and one used Body Mass Index (BMI) and weight loss [10]. Most malnutrition rates ranged from 19 [7] to 44% [10], with the exception of the Croatian study, which reported a much lower prevalence (3.37%) [24]. One paper had data on costs according to malnutrition status, but it was unclear which definition was applied, so it was not included; total costs were 1912 € (no

Table 1
Characteristics of the studies assessing the impact of malnutrition in hospital length of stay.

Author (ref)	Country	N	Nutritional screening tool	Prevalence of malnutrition (%)	Length of stay (days)		
					Mal-nourished	Well-nourished	Difference
Planas et al. [12]	Spain	400	SGA	26.7	7.3 ± 6.2	4.9 ± 5.1	2.4
Kyle et al. [15]	Switzerland	652	NRI	24.0	10.2 ± 16.0*	5.1 ± 8.2	5.1
	Germany	621			25.8 ± 60.6**	9.1 ± 7.7	20.7
					11.8 ± 7.7*		2.7
					17.8 ± 14.7**		8.7
Ockenga et al. [7]	Germany	541	SGA	19.0	11 ± 9	7.7 ± 7	3.3
Pirlich et al. [11]	Germany	1886	SGA	27.4	15*/17**	11	4.6
Nadine et al. [16]	Switzerland	102	SGA & NRS-2002	28.0	9	6	3.0
Amaral et al. [6]	Portugal	469	NRS-2002	42.0	14.7 ± 12.5	7.6 ± 8.3	7.1
Pressoir et al. [17]	France	1545	NR	30.9	19.3 ± 19.4	13.3 ± 19.4	6.0
Burgos et al. [14]	Spain	796	NRS-2002	28.9	10.5 ± 9.5	7.7 ± 7.8	2.8
Alvarez-Hernández et al. [13]	Spain	1597	NRS-2002	23.7	15.2	8.0	7.2
Tangvik et al. [18]	Norway	3271	NRS-2002	29.0	8.32 ± 0.32	5.03 ± 0.12	3.3

N, number of patients; SGA, Subjective Global Assessment; NRI, Nutritional Risk Index; NRS-2000, Nutritional Risk Screening; NR, not reported Normal nutritional status vs. moderate* to severe** malnutrition; All differences between malnourished and well-nourished patients are significant.

standard deviation provided) for well nourished and 2990 € for malnourished patients [19].

Most selected studies reported additional costs, defined as the extra cost involved in treating all malnourished patients in the general population compared to treating the same number of well-nourished individuals [6,7,10,13,18,23,25]. Five studies reported overall costs [10,15,23–25], and four studies reported detailed costs (hospital, diagnosis, therapies and medications costs) [6,7,13,15,18]. Irrespective of the type of costs considered, all studies reported increased hospital costs due to malnutrition (Table 2).

Four studies reported individual data. One study conducted in a gastroenterology ward in Germany reported a 10,268 € additional cost for nutritional support (dietary counseling, special diet, oral supplementation and enteral/parenteral feeding) for a group of 50 randomly selected malnourished patients, leading to an average extra cost of 205 € per patient [7]. A study conducted in Portugal used diagnosis-related group (DRG) codes and LOS to calculate hospitalization costs [6]. Patients at nutritional risk had hospitalization costs which were twice higher than patients not at risk, with an average additional cost of 2687 € [6]. In Spain, costs were calculated based on average hospitalization costs and the nutritional support provided (oral supplementation and enteral/parental feeding). Malnourished patients at admission had an average additional cost of 1409 € compared to well-nourished patients at admission; the difference was even higher (5829 €) between patients well-nourished at admission and malnourished at discharge and well-nourished patients at admission and discharge [13]. Finally, a study conducted in Norway estimated costs based on a mean daily cost for patients ready to discharge and the average LOS in hospital over one year. Malnourished patients had 60% higher costs than well-nourished patients, corresponding to an additional cost of 4745 € per year [18].

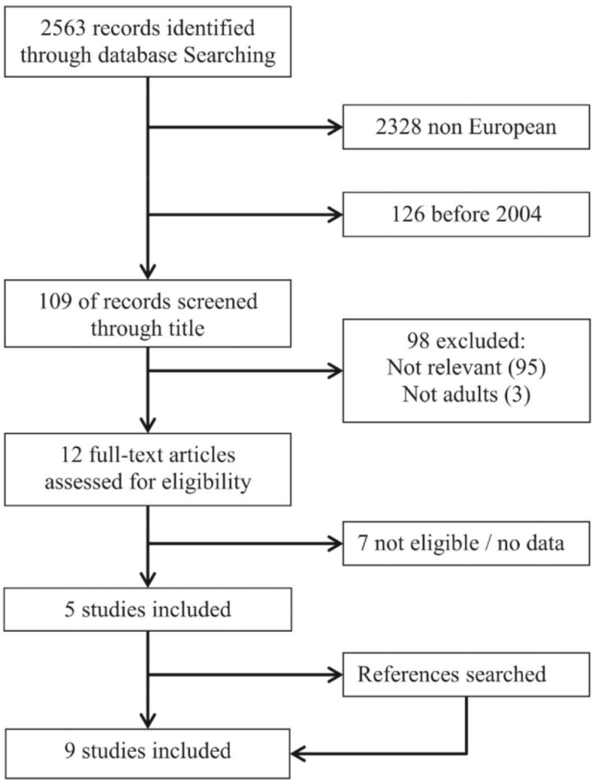

Fig. 2. Selection procedure for the papers on cost of malnutrition.

Five studies reported costs at the national level. In the study conducted in Switzerland and Germany, hospital costs for malnourished patients were 3.1 times higher than for well-nourished patients [15], but no precise values were provided. In the United Kingdom, the annual health care cost of DRM for hospitalized patients was about 3.7 billion £ (4.7 billion €) and the additional cost was almost 3 billion £ (3.8 billion €). In Ireland, the annual total public health and social care costs of malnutrition were estimated at 1.4 billion € (10% of the national health care budget) in all healthcare settings, of which 72 million € (5%) were attributed to hospitalized patients with DRM [23]. In the Netherlands, the total additional costs (prevention, diagnostic, therapy, rehabilitation and care of the disease or treatment under consideration) of DRM were estimated at 1.9 billion € (2.1% of the national health expenditure), of which 1.2 billion € (66%) were attributed to hospital settings [10]. In Croatia, the total direct costs of malnourished patients were estimated at 97.35 million € (3.38% of the national health care budget), of which 32.8 million € (34%) were attributed to hospital malnutrition, leading to an average cost of malnutrition of 1640.48 € per hospitalized patient [24].

Discussion

Our results indicate that malnutrition carries a considerable economic burden, with an additional cost ranging between 1640

Table 2
Characteristics of the studies assessing the impact of malnutrition in hospital costs.

Author	Country	Discipline	N	Nutritional screening tool	Study period	Prevalence (%)[a]	Malnutrition related costs
Individual data							
Ockenga et al. [7]	Germany	Gastroenterology	50	SGA	1 year	19.0	10,268 € additional cost for nutritional support among 50 patients
Amaral et al. [6]	Portugal	Multidisciplinary	469	NRS-2002	11 months	42.0	4890 € for malnourished 2201 € for well-nourished 2687 € additional cost
Alvarez-Hernández et al. [13]	Spain	Multidisciplinary	468	NRS-2002	6 months	24.4	12,237 € for malnourished 6798 € for well-nourished 5829 € additional cost
Tangvik et al. [18]	Norway	Multidisciplinary	3279	NRS-2002	1 year	29.0	15,394 $ for malnourished 9460$ for well-nourished 5934$ (4745 €) additional cost/year
Overall data							
Kyle et al. [15]	Switzerland Germany	Multidisciplinary	652 621	NRI	–	24.0	3.1 times higher in malnourished vs. well-nourished
Elia et al. [25]	United Kingdom	Multidisciplinary	1.29 million	MUST	1 year	28.0	Total cost: 3.7 billion £ (4.7 billion €) Additional cost: 3 billion £ (3.8 billion €) annually
Rice et al. [23]	Ireland	Multidisciplinary	1602	MUST	1 year	36.3	Total cost: 1.4 billion € 10% of the health-care budget 5357 € additional cost of DRM
Freijer et al. [10]	The Netherlands	Multidisciplinary	14 million	BMI < 18.5 OR −18.5<BMI<20 + 3 days of no food intake or less than normal during a week or weight loss of 6 kg in the past 6 months or >3 kg in the past month	1 year	4 to 44	Additional 1.2 billion € in hospital setting 66% of total expenditures on DRM
Benković et al. [24]	Croatia	Multidisciplinary	NR	NRS-2002	1 year	3.37	Total cost: 97.35 million € in one year 3.38% of national health care budget 1640 € average cost per patient

NRI, Nutritional Risk Index; SGA, Subjective Global Assessment; NRS-2002, Nutritional Risk Screening; MUST, Malnutrition Universal Screening Tool; BMI, Body Mass Index; DRM, Disease related malnutrition.
[a] Prevalence of malnutrition.

and 5829 € per hospitalized patient and an overall cost ranging between 2.1 and 10% of the national health expenditures.

Impact of malnutrition on length of stay

Malnutrition led to an increased LOS, ranging from 2.4 to 7.2 days. Relative to well-nourished patients, the average LOS increased by 30–100% in malnourished patients, a value in line with one recent review which also reported 40–70% longer LOS in malnourished patients [26]. This longer LOS is due to the classic adverse effects of malnutrition such as increased risk of infection or pressure ulcer, impaired wound healing, immune suppression and muscle wasting [27], leading to delayed recovery and increased risk of complications [28]. Indeed, increased LOS is one of the major components of the additional costs related to malnutrition [25]. Conversely, the beneficial effects of nutritional intervention on clinical outcomes of malnutrition have been manifold documented [28,29], leading to a significant reduction of LOS and consequently in total costs [30,31]. Thus, early malnutrition intervention may be really beneficial to improve outcomes and health care costs.

Impact of malnutrition on hospital costs

Malnutrition led to an additional increase in costs among hospitalized patients ranging between 1640 [24] and 5829 € [13] per patient. Taken together, malnutrition-related costs represented between 2.1 and 10% of the national health expenditure. However, this large difference between two European countries of similar population size and economic wealth is very likely due to the different statistical models and the assumptions used and not the true burden of disease. Thus, malnutrition among hospitalized patients is a far from trivial condition, leading to a considerable health and economic burden. Moreover, the reported costs are likely to be an underestimate as not all increased treatment costs were included [24].

While the consequences of malnutrition on health have been documented in a large number of studies, the number of studies assessing the economic impact of malnutrition is considerably smaller. It is also important to mention that harmonizing and comparing the results between studies and countries is difficult, due to differences in health care systems, cost calculations and reporting monetary units (£, $, €). For instance, some studies used administrative data [6], while others assessed directly the costs of nutritional therapy [7]; some studies reported total costs while others reported extra costs at admission and/or discharge. Hence, it would be of interest that future studies on the costs of malnutrition use a standard definition of malnutrition and indicate how the differences between well-nourished and malnourished patients were computed. It is also important that studies report their results in a standardized manner: although monetary units (i.e. €) might be important for local health administrators, they might not be of much help for other countries as health costs vary between countries. Thus, other cost-related units could be used, such as LOS, nutrition interventions (i.e. number of nutritional supplements used, enteral/parental nutrition, and consultations by dieticians …) or DRGs. Still, it should be noted that the DRG system changes slightly between countries so that direct comparisons might not be achievable [32]. Further, as some DRGs change according to presence/absence of malnutrition, it would be important to include malnutrition diagnosis codes in the patients' file in order to better evaluate the real economic burden related to malnutrition.

Despite the different methods used to estimate malnutrition-related hospitalization costs, all studies indicate that the total costs of malnutrition are extremely important and largely outweigh those related to obesity [5,25]. Thus, screening at admission and early treatment of malnutrition could lead to considerable health savings [5,31,33]. Indeed, Elia et al. (2005) reported that an investment of 5 million £ (6.4 million €) in nutritional intervention would result in a saving of 50 million £ (63.7 million €) per year, corresponding to a 1% reduction in malnutrition-related costs.

Limitations

This review has several limitations. Firstly, no data were available for many European countries. This was somewhat unexpected for some countries such as Denmark, Sweden and Finland, as their health data management system would facilitate such calculations, at least regarding the costs of nutritional therapy. Thus, it is difficult to determine the impact of malnutrition on medical economic outcomes for a most European countries. Secondly, several definitions of malnutrition were applied, possibly leading to different prevalence rates and thus different costs. Still, our results suggest that malnutrition is associated with increased hospitalization costs irrespective of the definition applied. Thirdly, each study used its own cost assessment method, thus precluding direct comparison of results. Indeed, the heterogeneity of the cost calculations in the individual studies, such as cost of hospitalization vs. cost of nutritional treatment or calculation for a small patient group vs. for a whole country, is a main limitation of this paper. We thus believe that the recommendations for reporting results provided above will facilitate comparison of future studies.

Conclusion

In Europe, the economic impact of hospital malnutrition is considerable, both at the individual and the national level. Standardization of methods and results reported is badly needed to adequately compare results between countries.

Names for PubMed indexing

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Conflict of interest

none.

Competing interests

All authors declare no competing interests.

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The authors' responsibilities were as follows—SKS: performed the literature search, prepared the tables and drafted the manuscript. PMV: conceived the study, participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.clnesp.2015.04.003.

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Supplementary Material

Full electronic search strategy for Length of stay

("malnutrition"[MeSH Terms] OR "malnutrition"[All Fields] OR "undernutrition"[MeSH Terms] OR "undernutrition"[All Fields]) AND ("length of stay"[MeSH Terms] OR ("length"[All Fields] AND "stay"[All Fields]) OR "length of stay"[All Fields])

Full electronic search strategy for cost

("malnutrition"[MeSH Terms] OR "malnutrition"[All Fields] OR "undernutrition"[MeSH Terms] OR "undernutrition"[All Fields]) AND ("economics"[Subheading] OR "economics"[All Fields] OR "cost"[All Fields] OR "costs and cost analysis"[MeSH Terms] OR ("costs"[All Fields] AND "cost"[All Fields] AND "analysis"[All Fields]) OR "costs and cost analysis"[All Fields]).

Chapter 3

Impact of nutritional risk screening in hospitalized patients on management, outcome and costs: A retrospective study

Khalatbari-Soltani S, Marques-Vidal P

Clinical Nutrition. 2016 Dec; 35(6): 1340-1346
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Summary

This research paper describes the implementation of nutritional risk screening in the service of internal medicine of the Lausanne university hospital. The prevalence, determinants, and management of being nutritionally ‘at-risk’ were assessed, together with the impact of being ‘at-risk’ on in-hospital mortality, length of hospital stay and costs. Our study showed that despite an improvement in nutrition risk screening, nutritional management did not follow the same trend. Moreover, our results showed higher in-hospital mortality rate and higher hospitalization costs among patients nutritionally ‘at-risk’ compared to patients ‘not at-risk’. Conversely, this study failed to find longer length of hospital stays among nutritionally ‘at-risk’ patients compared to ‘not at-risk’ patients. In conclusion, undernutrition is highly prevalent among hospitalized patients and increases in-hospital mortality and hospitalization costs. It also shows that implementing only one step of the malnutrition management process is not effective. The main interest of this paper is to provide updated information regarding prevalence and consequences of undernutrition among hospitalized patients, and to stress the need for the implementation of a complete management system of nutritionally ‘at-risk’ patients.

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Original article

Impact of nutritional risk screening in hospitalized patients on management, outcome and costs: A retrospective study

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SUMMARY

Background & aims: Hospitalized patients should be screened for nutritional risk and adequately managed. Being nutritionally 'at-risk' increases in-hospital mortality, length of stay (LOS) and costs, but the impact on actual costs has seldom been assessed. We aimed to determine nutritional risk screening and management in a Swiss university hospital. The impact of being nutritionally 'at-risk' on in-hospital mortality, LOS and costs was also assessed.

Methods: Retrospective analysis of administrative data for years 2013 and 2014 from the department of internal medicine of the Lausanne university hospital (8541 hospitalizations, mean age 72.8 $\pm$ 16.5 years, 50.4% women). Being nutritionally 'at-risk' was defined as a Nutritional risk screening-2002 score $\geq$ 3 and nutritional managements were collected from medical records.

Results: Screening increased from 16.5% in 2013 to 41.9% in 2014 ($p < 0.001$), while prevalence of 'at-risk' patients remained stable (64.6% in 2013 and 62.7% in 2014, $p = 0.37$). Prevalence of 'at-risk' patients was highest in patients with cancer (85.3% in 2013 and 70.2% in 2014) and lowest in patients with disease of skin (42% in 2013 and 44.8% in 2014). Less than half of patients 'at-risk' received any nutritional management, and this value decreased between 2013 and 2014 (46.9% vs. 40.3%, $p < 0.05$). After multivariate adjustment, 'at-risk' patients had a 3.7-fold (95% confidence interval: 1.91; 7.03) higher in-hospital mortality and higher costs (excess 5642.25 $\pm$ 1479.80 CHF in 2013 and 5529.52 $\pm$ 847.02 CHF in 2014, $p < 0.001$) than 'not at-risk' patients, while no difference was found for LOS.

Conclusion: Despite an improvement in screening, management of nutritionally 'at-risk' patients is not totally covered yet. Being nutritionally 'at-risk' affects three in every five patients and is associated with increased mortality and hospitalization costs.

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1. Introduction

Undernutrition is a critical condition among hospitalized patients, both as a cause and consequence of disease [1]. Notwithstanding over three decades of knowledge development, the worldwide prevalence of hospital undernutrition is still high (20–50%) mainly due to difficulties in the identification and adequate management of 'at-risk' patients [2,3]. Undernutrition status tends to deteriorate during hospital stay, worsening patient's outcome and increasing health costs [4,5]. Adequate screening and nutritional therapy have been shown to decrease the rate of nutrition-related complications, to decrease in-hospital mortality and to shorten length of stay (LOS) [6]. According to the European Society for Parenteral and Enteral Nutrition (ESPEN) recommendations, the Nutrition Risk Screening (NRS-2002) should be used for screening undernutrition in all hospitalized patients [1]. Still, even nowadays, proper nutritional risk screening is not performed in many European hospitals [7]; only in some countries like the United Kingdom, the Netherlands and part of Denmark nutritional risk screening is mandatory [8,9].

Switzerland is a small European country with one of the best health systems in the world [10]. Still, screening for nutritionally 'at-risk' patients has been unevenly implemented in hospitals and there is little information regarding prevalence, determinants, management and impact on health outcomes and cost of undernutrition [11]. Such information is important for the adequate

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management of hospital resources, both in Switzerland and similar countries.

In this study we used data from the department of internal medicine of a Swiss university hospital to assess the implementation of nutritional risk screening. We also assessed the prevalence, determinants and management of 'at-risk' patients, and impact of being nutritionally 'at-risk' on in-hospital mortality, LOS and costs.

2. Methods

2.1. Data collection

This is a retrospective study using electronic administrative data of the department of internal medicine of the Lausanne university hospital (CHUV) from January 1st, 2013 to December 31st, 2014. The CHUV is one of the five Swiss university hospitals, with a total staff of 10,000 and a bed capacity of 1642 (www.chuv.ch). In 2013, the department of internal medicine of the CHUV started implementing a nutritional risk screening procedure with the use of NRS-2002; this screening focused mainly, but not exclusively, on patients with heart and/or respiratory failure at admission.

This study included all adult ($\geq$18 years old) patients who stayed for a minimum of one day ($\geq$24 h) in the department of internal medicine of the CHUV.

2.2. Nutritional risk screening and data collection procedure

The patient's nutritional risk status was evaluated by the NRS-2002 [1]. Nutritional screening implementation was defined by the presence of NRS-2002 score in the electronic medical record which contain all the data related to nutritional risk status and managements since January 2013. In brief, according to the CHUV guideline, patients were interviewed by nursing staff at the first 48 h of admission about their nutritional risk status and disease severity according to the NRS-2002 criteria. NRS-2002 score is calculated by adding 'nutritional score' of 0–3 to the 'disease severity score' of 0–3 plus 1 extra score for patients older than 70 years.

The 'nutritional score' is defined by adequacy of dietary intake due to three different parameters 1) quartile decreased of estimated oral food intake requirements, 2) presence of $\geq$5% weight loss within the previous 1–3 months and 3) low body mass index (<18.5 kg/m^2). The 'disease severity score' was categorized as none, slight, moderate and severe with the score of 0–3, respectively. A total NRS-2002 score $\geq$ 3 was considered as nutritionally 'at-risk'.

The nutritional management database of the CHUV included dietary regimen, enteral nutrition (EN) and parenteral nutrition (PN). At the CHUV, all prescriptions given to patients are coded using the Anatomical Therapeutic Chemical (ATC) classification system and procedures are coded according to ICD-9CM. EN was defined as prescribed oral nutrition supplements (ONS) and/or tube feeding according to the ESPEN guideline [12]. PN was defined as any prescription containing the ATC code B05BA (PN solution or premixed multichamber bag containing PN) or as a procedure containing the ICD-9CM code 99.15 (Parenteral infusion of concentrated nutritional substances).

2.3. Other variables

Socio-demographic data included age, sex, marital status and coming from home or other healthcare facilities. Clinical variables included main diagnosis and vital status at discharge (alive or dead). Main diagnoses (the most relevant diagnosis for the hospitalization at discharge according to the responsible physician) were categorized in groups according to the 10th International Classification of Diseases and related health problems (ICD-10). Main diagnosis groups are indicated in Supplementary Table 1. Only main diagnosis were used regardless any subsidiary diagnosis except for disease of circulatory system (Ischemic heart disease and Heart Failure) and pulmonary diseases (Pneumonia and Chronic obstructive pulmonary disease).

LOS was calculated according to the official Swiss Diagnosis-related group (DRG) guidelines, available at swissdrg.org/assets/pdf/Tarifdokumente/SwissDRG_Falldefinitionen_Version_5_2013_f_def.pdf. According to the "midnight rule", a patient who is admitted at the hospital before midnight and who stays at the hospital at midnight is considered as having spent a night at the hospital. Briefly, LOS is computed using the following formula:

[date of discharge − date of admission]/24 − hours of administrative leave/24.

The dates of discharge and admission include hours and minutes, and the number of hours of administrative leave (i.e. periods during which the patient is allowed to leave the hospital; only periods of $\geq$8 h are taken into account) is rounded to the lowest value. Calculations are made using hours as the primary unit and the values were provided to us by the hospital administration. According to the guidelines, only LOS of at least 24 h can be considered as hospital treatment; thus, our inclusion criteria included a minimum stay of 24 h.

Contrary to other studies that used DRG costs [13–15], total cost was defined as the actual costs. The cost of each patient's expenditures was extracted from the hospital billing system; this system considers costs related to anesthesia, surgery (including occupation of surgical wards), imagiology (X-rays, MRI, echography), clinical chemistry, pathology, ICU-related costs, medical care, external consultations (i.e. a specialist outside the internal medicine ward who is asked to examine the patient), administrative tasks, food (no-therapeutical), blood products (i.e. transfusions), drugs (including enteral and parenteral nutrition), medical material (catheters,…), transport, etc. Summation of all the costs was done to estimate the actual cost of patient care.

Due to anonymization constraints, only month and year of admission and discharge were available; hence, it was not possible to calculate readmissions within 30 days after discharge as two admissions occurring in the same month could not be sorted.

2.4. Statistical analysis

Statistical analyses were performed using Stata version 14 for windows (Stata Corp, College Station, Texas, USA). Descriptive results were expressed as number of participants (percentage) or as mean ± standard deviation (SD). Bivariate analyses were performed using chi-square or Fisher's exact test for qualitative variables and Student's t-test, analysis of variance or Kruskal–Wallis test for quantitative variables. Multivariate analysis was performed using logistic regression including sex, age, year, coming from home and main diagnosis in the model; the results were expressed as odds ratio (OR) and 95% confidence interval (CI). Statistical significance was assessed for a two-sided test with $p < 0.05$.

2.5. Ethics

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 CHUV board of directors (decision of Dec. 5, 2014). Only routinely collected data was used. Patients were not asked to provide informed written consent and no intervention was performed. All information was extracted and anonymized before being handled for analysis.

3. Results

3.1. Study population

Overall, data from 8541 hospitalizations was analyzed. In 2013, the mean age was 72.7 ± 16.4 years and 50% were women, and in 2014 the mean age was 73.0 ± 16.6 years and 50.7% were women. The main characteristics, prevalence and determinants of nutrition screening and being nutritionally 'at-risk' are summarized in Table 1.

3.2. Nutritional risk screening

Between 2013 and 2014, total nutrition risk screening increased from 670/4077 (16.5%) to 1869/4464 (41.9%) of hospitalizations (p-value < 0.001). While in 2013 no consistent differences were found regarding patients screened and not screened except for older age, in 2014 screening was significantly higher among women and patients aged ≥80 years. Prevalence of screening was at least 12.2% in all disease categories in 2013, and this value increased to 31.9% in 2014 (Fig. 1). Patients discharged with cancer or disease of the circulatory system had a higher prevalence of screening, but no difference was found regarding prevalence of screening according to main diagnosis categories between 2013 and 2014 (Table 1).

Multivariate analysis showed that patients aged ≥80 years or coming from home had higher likelihood to be screened [Odds ratio (95% CI): 1.81 (1.56; 2.10) and 1.30 (1.07; 1.58), respectively]. Compared to patients with a main diagnosis of cancer, patients with pneumonia, disease of digestive, genitourinary or blood systems had lower odds of screening [Odds ratio (95% CI): 0.96 (0.75; 1.24); 0.70 (0.55; 0.88); 0.68 (0.51; 0.91); 0.62 (0.44; 0.88), respectively], while no difference was found for the other diseases (Fig. 1).

3.3. Nutritional status on admission and its determinants

The implementation of the screening procedure resulted in a 2.7 fold increase in the number of patients 'at-risk' in year 2014 compared to 2013; conversely, the prevalence of 'at-risk' patients remained stable: 433/670 (64.6%) in 2013 and 1172/1869 (62.7%) in 2014 (Table 1). Prevalence of 'at-risk' patients was highest in patients with cancer (85.3% in 2013 and 70.2% in 2014) and lowest in patients with disease of skin (42% in 2013 and 44.8% in 2014).

Multivariate analysis showed that women and patients aged ≥80 years had a higher likelihood of being nutritionally 'at-risk' [Odds ratio (95% CI): 1.23 (1.02; 1.48); 4.67 (3.57; 6.09), respectively] while patients who came from home had lower odds of being nutritionally 'at-risk': 0.52 (0.35; 0.76); compared to patients with cancer, patients discharged with another diagnosis had a lower odds of being nutritionally 'at-risk' (Fig. 2).

3.4. Nutritional managements among patients at risk

Fewer than half of the patients considered as nutritionally 'at-risk' received at least one type of nutritional management (46.9% in 2013 and 40.3% in 2014, p-value < 0.05). Also, approximately one in six of the patients considered 'not at-risk' received at least one type of nutritional management (13.5% in 2013 and 16.3% in 2014, Table 2). The most frequent management was EN, followed by dietary regimen alone and PN. There were no significant differences between year 2013 and 2014 regarding dietary regimen and PN, but prevalence of EN decreased significantly in 2014 compared to 2013 (Table 2).

Table 1
Number and main characteristics of all hospitalizations (eligible), hospitalizations where nutritional risk screening was performed (screened) and hospitalizations with a positive ('at-risk') nutritional screening, department of internal medicine of the CHUV, 2013 and 2014.

	Eligible		p-Value	Screened (yes)		p-Value	At-risk (yes)		p-Value
	2013	2014		2013	2014		2013	2014	
N	4077	4464		670	1869	<0.001	433	1172	0.37
Women	2037 (49.9)	2264 (50.7)	0.48	328 (49.0)	1019 (54.5)	<0.05	232 (53.6)	672 (57.3)	0.17
Age categories									
18–59	809 (19.8)	879 (19.7)	0.23	107 (16.0)	269 (14.4)	<0.05	42 (9.7)	117 (9.1)	0.02
60–79	1544 (37.8)	1620 (36.3)		255 (38.0)	628 (33.6)		162 (37.4)	353 (30.1)	
80+	1724 (42.3)	1965 (44.0)		308 (46.0)	972 (52.0)		229 (52.9)	702 (59.9)	
Living in a couple[a]	1638 (41.4)	1830 (42.2)	0.48	257 (39.7)	717 (39.2)	0.82	162 (38.5)	422 (36.9)	0.56
Coming from home	3794 (93.1)	4103 (91.9)	<0.05	622 (92.8)	1750 (93.6)	0.47	393 (90.8)	1088 (92.8)	0.16
Main diagnosis									
Cancer	409 (10.0)	505 (11.3)	<0.05	61 (9.1)	225 (12.1)	0.70	52 (12.0)	158 (13.5)	0.85
Infection	330 (8.1)	346 (7.7)		47 (7.0)	137 (7.3)		32 (7.4)	85 (7.3)	
Pulmonary disease	224 (5.5)	266 (6.0)		38 (5.7)	113 (6.1)		26 (6.0)	76 (6.5)	
Pneumonia	397 (9.7)	352 (7.9)		58 (8.6)	129 (6.9)		38 (8.8)	85 (7.3)	
COPD	149 (3.6)	159 (3.5)		19 (2.9)	62 (3.3)		13 (3.0)	40 (3.4)	
Digestive system	361 (8.8)	397 (8.9)		56 (8.4)	130 (7.0)		39 (9.0)	81 (6.9)	
Endocrine, nutritional and metabolic	140 (3.4)	141 (3.2)		21 (3.1)	52 (2.8)		13 (3.0)	36 (3.1)	
Circulatory system	346 (8.5)	367 (8.2)		57 (8.5)	152 (8.1)		26 (6.0)	90 (7.7)	
Ischemic heart disease	126 (3.1)	123 (2.7)		23 (3.4)	57 (3.1)		13 (3.0)	30 (2.5)	
Heart failure	341 (8.4)	334 (7.5)		57 (8.5)	153 (8.2)		39 (9.0)	91 (7.7)	
Symptoms, abnormal findings + injury	448 (11.0)	572 (12.8)		90 (13.4)	283 (15.2)		58 (13.4)	171 (14.6)	
Genitourinary system	162 (4.0)	199 (4.5)		23 (3.4)	68 (3.65)		17 (3.9)	36 (3.1)	
Blood	115 (2.8)	138 (3.1)		14 (2.1)	44 (2.35)		8 (1.8)	27 (2.3)	
Nervous system	94 (2.3)	83 (1.8)		20 (3.0)	39 (2.1)		11 (2.5)	24 (2.0)	
Skin	55 (1.3)	64 (1.4)		12 (1.8)	29 (1.6)		5 (1.2)	13 (1.1)	
Musculoskeletal system	119 (2.9)	154 (3.5)		20 (3.0)	66 (3.5)		9 (3.0)	44 (3.8)	
Rehabilitation	261 (6.4)	264 (5.9)		54 (8.1)	130 (7.0)		34 (7.8)	85 (7.2)	

COPD, Chronic obstructive pulmonary disease.
[a] 3% of observations had missing data. Results are presented as number of hospitalizations and (column percentage). Between-year comparisons performed by chi-square.

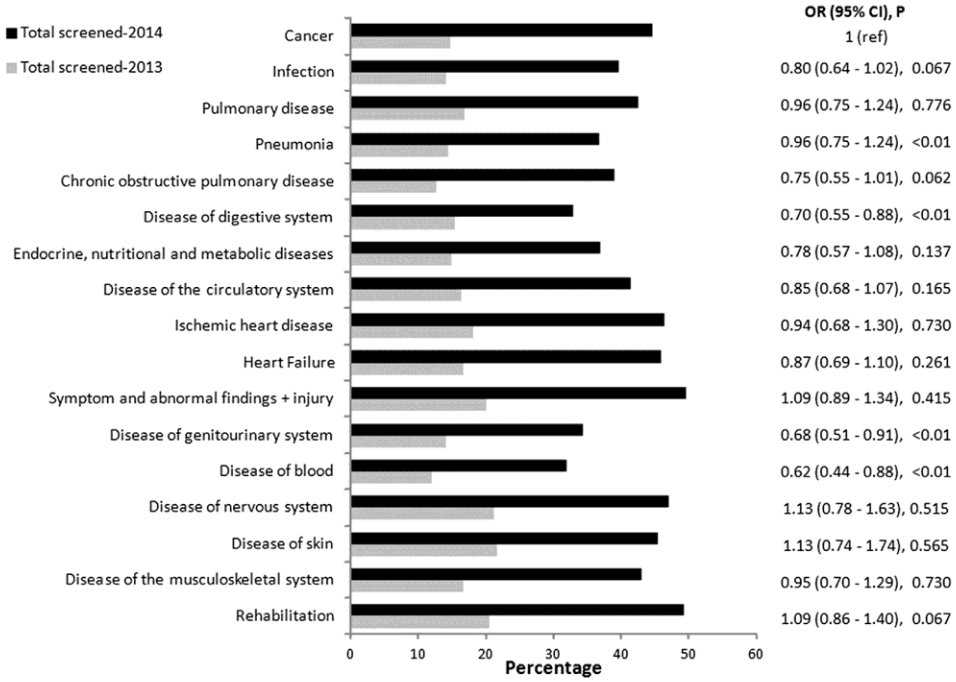

Fig. 1. Prevalence of nutrition screening among adult patients hospitalized in the department of internal medicine of the CHUV for years 2013 and 2014. Results are shown according to the main disease at discharge and expressed as percentage and as multivariate-adjusted (sex, age, year and coming from home or elsewhere) Odds ratio (OR) and 95% confidence interval (CI). P, p-value testing the OR against unity.

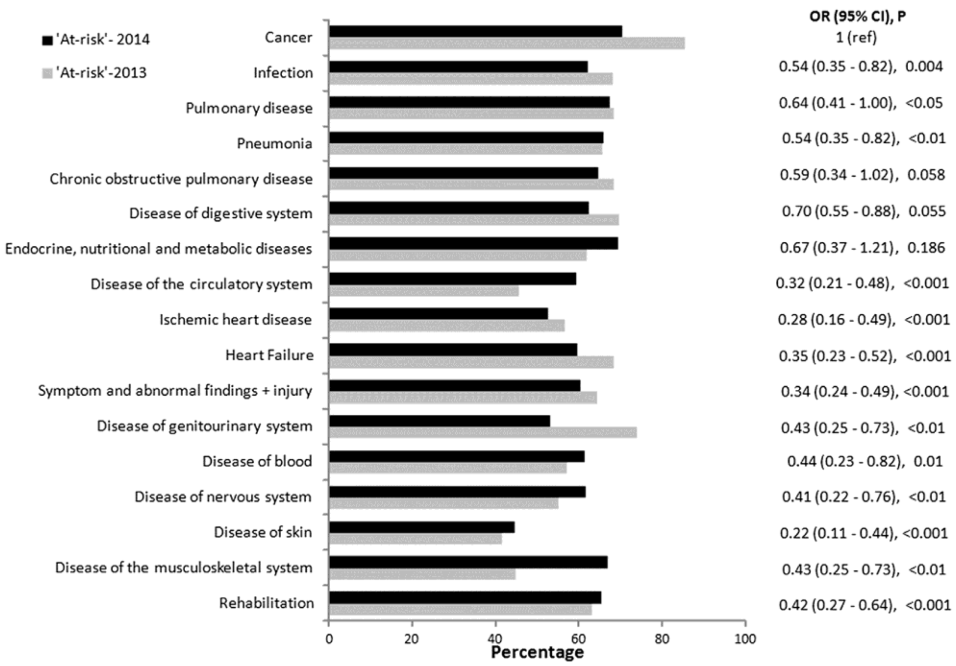

Fig. 2. Prevalence of being nutritionally 'at-risk' among adult patients hospitalized in the department of internal medicine of the CHUV for years 2013 and 2014. Results are shown according to the main disease at discharge and expressed as percentage of screened patients and as multivariate-adjusted (sex, age, year and coming from home or elsewhere) Odds ratio (OR) and 95% confidence interval (CI). P, p-value testing the OR against unity.

Table 2
Nutrition management of nutritionally 'not at-risk' and 'at-risk' adult patients in the department of internal medicine of the CHUV, 2013 and 2014.

	2013		2014		p-Value At-risk
	Not at risk	At-risk	Not at risk	At-risk	
N (row %)	237 (35.4)	433 (64.6)	697 (37.3)	1172 (62.7)	0.37
Dietary regimen	10 (4.2)	37 (8.6)	19 (2.7)	103 (8.8)	0.87
Enteral nutrition	29 (12.2)	196 (45.3)	106 (15.2)	458 (39.1)	<0.05
Parenteral nutrition	1 (0.4)	4 (0.9)	0 (0)	9 (0.8)	0.75†
Overall	32 (13.5)	203 (46.9)	114 (16.3)	473 (40.3)	<0.05

'At-risk' status defined by a NRS-2002 > 3. Results are presented as number of patients and (column percentage). Between-year comparisons by chi-square or Fisher's exact test (†). Overall number of patients is lower than the sum of all managements due to the fact that several patients received multiple managements (i.e. dietary regimen + enteral nutrition).

3.5. *Impact on in-hospital mortality, length of stay and costs*

The impact of being nutritionally 'at-risk' on in-hospital mortality, LOS and costs is summarized in Table 3. In-hospital mortality was higher in patients who were nutritionally 'at-risk' in year 2014 but not in 2013. Multivariate analysis confirmed those findings: in 2014, patients 'at-risk' of undernutrition had a 3.7-fold higher risk of dying than patients 'not at-risk'.

Patients 'at-risk' had a longer LOS than patients 'not at-risk' in 2013 and 2014, but this difference was no longer significant after multivariate adjustment. Similarly, after multivariate adjustment, the likelihood of being above the 90^{th} percentile of LOS did not differ between 'at-risk' and 'not at-risk' patients (Table 3).

Patients 'at-risk' had higher healthcare costs compared to patients 'not at-risk' in both years, and these findings were further confirmed after excluding patients whose costs were higher than 100,000 CHF: compared to 'not at-risk' patients, 'at-risk' patients had an excess cost of 5642.25 ± 1479.8 CHF in 2013 and 5529.52 ± 847.02 CHF in 2014.

4. Discussion

This study showed that nutrition screening improved between 2013 and 2014 in the department of internal medicine of the CHUV; however, nutritional management is not totally covered yet. Patients nutritionally 'at-risk' have higher in-hospital mortality and hospitalization costs than patients 'not at-risk', while no differences were found for LOS.

4.1. *Nutritional risk screening*

Nutritional risk screening more than doubled between 2013 and 2014. Still, in 2014, screening was performed in less than half of admitted patients, in contrast with the generally accepted standards and guidelines [1]. Nevertheless, the 42% screening rate observed in 2014 is in line with the NutritionDay study which reported a 43% screening rate in western European countries (including Switzerland) [4] and with a cross-sectional multicenter study which reported a 40.3% screening rate in the Netherlands [16]. Further, according to one study conducted in Scandinavia, nutrition screening rates were as low as 40% in Denmark, 21% Sweden and 16% in Norway [17]. Possible explanations for this low screening rate are lack of sufficient nutrition-related education, clearly defined responsibilities and time of the medical team [18], and it would be of interested to replicate this study in the forthcoming years in order to confirm if the observed increase in screening has been maintained. As being nutritionally 'at-risk' is highly prevalent and commonly under-recognized and/or undertreated, universal screening is paramount among in-hospital patients at admission.

4.2. *Nutritional status on admission and its determinants*

Three in every five screened patients were 'at-risk' (64.6% in 2013 and 62.7% in 2014), a finding in agreement with previous studies [2,3] but higher than other studies conducted in Switzerland (18.2% and 27.8%) [11,19], Brazil (48.1%) [20] or

Table 3
Impact of being nutritionally 'at-risk' on in-hospital mortality, length of stay and costs for patients admitted in the department of internal medicine of the CHUV, 2013 and 2014.

	2013		p-Value	2014		p-Value
	Not at risk	At-risk		Not at risk	At-risk	
N	228	402		685	1084	
In-hospital mortality						
Bivariate	9 (3.8)	31 (7.2)	0.08	12 (1.7)	88 (7.5)	0.001
Multivariate, OR (95% CI)[a]	1 (ref.)	1.57 (0.65–3.79)	0.30	1 (ref.)	3.67 (1.91–7.03)	0.001
Length of stay (days)						
Bivariate, mean ± SD	12.9 ± 9.8	16.0 ± 13.6	0.01	13.3 ± 10.2	16.7 ± 14.3	0.001
Multivariate, mean ± SE[a]	14.1 ± 0.9	15.2 ± 0.6	0.319	14.8 ± 0.5	15.6 ± 0.4	0.155
LOS > 90th percentile						
Bivariate	23 (9.7)	56 (12.9)	0.215	68 (9.75)	186 (15.9)	0.001
Multivariate, OR (95% CI)[a]	1 (ref.)	0.86 (0.46–1.61)	0.64	1 (ref.)	1.13 (0.80–1.60)	0.50
Actual costs (CHF)						
Bivariate, mean ± SD	20,707.7 ± 17,433.4	31,300.5 ± 39,597.8	0.001†	23,535.0 ± 24,754.9	33,649.1 ± 51,594.7	0.001†
Multivariate, mean ± SE[a]	19,672.7 ± 2313.0	31,566.3 ± 1656.3	0.001	21,670.3 ± 1681.2	34,419.3 ± 1282.85	0.001
Actual costs (CHF) (<100,000)						
Bivariate, mean ± SD	20,006.1 ± 13,785.5	25,726.2 ± 18,206.2	0.001†	20,541.2 ± 14,355.0	25,868.7 ± 18,683.5	0.001†
Multivariate, mean ± SE[a]	19,888.8 ± 1154.7	25,531 ± 839.4	0.001	20,291.8 ± 656.2	25,821.3 ± 505.8	0.001

NRS-2002, nutrition risk screening 2002; CI, confidence interval; SD, standard deviation; SE, standard error. 'At-risk' status defined by a NRS-2002 > 3.
[a] Adjusting for year, sex, marital status and main disease categories. Statistical analysis by chi-square and logistic regression for in-hospital mortality and LOS > 90th percentile, and by Kruskal–Wallis (†) or analysis of variance for length of stay and actual costs.

Denmark (23%) [21]. Several explanations might be put forward for the higher prevalence observed in this study; first, the CHUV guideline regarding nutrition risk screening emphasizes screening of high risk patients (i.e. patients with heart failure or respiratory failure), leading to a positive selection bias; second, patients in our study were older (72.8 ± 16.5 years) than those included in the Brazilian study (51.3 ± 18.0 years) and it has been shown that risk of being nutritionally 'at-risk' increases with age [11,22–24].

The prevalence of being nutritionally 'at-risk' was highest among patients with cancer or pulmonary disease, in accordance with another study where cancer patients had an almost three-fold higher undernutrition rate than non-cancer patients [20]. Importantly, prevalence of being nutritionally 'at-risk' was above 10% in all main diagnosis categories, which is in line with the results reported by one Norwegian [25] and one multicenter [3] studies. Thus, our results strengthen the recommendation that nutritional risk screening should be performed in all hospitalized patients, as the prevalence of 'at-risk' status is high irrespective of the main diagnosis considered. Still, in the absence of adequate screening capacities, focusing on patients with cancer, COPD and endocrine, nutritional and metabolic diseases might be the best option.

4.3. Nutritional managements

Evidence shows that management of undernourished or nutritionally 'at-risk' patients should be initiated immediately to improve clinical outcomes [6]. In this study, less than half of the nutritionally 'at-risk' patients received at least one type of nutritional managements during their hospitalization. Still, this low management rate is in accordance with two observational multicenter studies conducted in the Netherlands [21] and Denmark [16], where fewer than half of all 'at-risk' patients received nutritional managements. Further, the management rates observed in our study are higher than in Brazil (10.1% of patients on EN) [20], the Netherlands (27.9% of patients receiving ONS) [26] or another Swiss study (23.2% of patients receiving nutritional management) [19]. Overall, our results suggest that, despite being far from optimal, the nutritional management rates among 'at-risk' patients observed in this study are comparable or even slightly better than reported in the literature; notwithstanding, improvements should be made so that all 'at-risk' patients might benefit from an adequate nutritional management. Finally, the fact that the proportion of 'at-risk' patients benefiting from nutritional managements decreased from 46.9% in 2013 to 40.3% in 2014 might be due to the lack of capacity to respond to the increased number of patients 'at-risk' in 2014 and should be monitored in future studies.

4.4. Impact on in-hospital mortality, length of stay and costs

Being nutritionally 'at-risk' significantly increased in-hospital mortality, a finding in line with other studies [3,19,21] which shows the importance of adequate management of such patients in order to reduce fatal events.

On bivariate analysis, 'at-risk' patients showed a significant higher LOS than 'not at-risk' patients, a finding also in accordance with previous studies [3,5,21]. One study conducted in Switzerland reported a two-fold increase in LOS among undernourished patients compared to well-nourished patients (10.2 ± 16.0 vs. 5.1 ± 8.2 days, respectively) [27], and another Swiss study reported a stepwise increase in LOS from 6 days among patients with NRS-2002 < 3 to 10 days among patients with NRS-2002 ≥ 3 [19]. Conversely, after multivariate adjustment, no significant association was found between nutritional risk status and LOS, although LOS tended to be one day higher among 'at-risk' compared to 'not at-risk' patients. Although significant association between being nutritionally 'at-risk' and increased LOS has been reported by several studies [3,5,21], most of these studies were not adjusted for possible confounding factors such as age, sex, social factors such as living alone or lack of social/family support, and main diagnosis category, which could explain the weaker association in our study.

After excluding extreme expenditures, being nutritionally 'at-risk' was associated with approximately 5500 CHF (€ 5085 as of December 2015) higher actual healthcare costs, which is consistent with our previous review where being undernourished led to an additional cost ranging between 1640 € and 5829 € [5]. In addition, another study also showed that early nutrition therapy for 'at-risk' patients is highly cost-effective compared to delayed nutrition therapy [28]. As LOS did not differ significantly between 'at-risk' and 'not at-risk' groups, it is unlikely that these extra costs are solely due to an increase in LOS. Thus, it will be of interest to further assess the different types of health expenditures (i.e. related to treatments, X-rays, nutritional support…) among nutritionally 'at-risk' patients in Switzerland.

Overall, our results indicate that the increase in nutritional screening which occurred between 2013 and 2014 at the department of internal medicine of the CHUV was not followed by a similar improvement in nutritional management. Thus, future actions should aim at improving nutritional management of nutritionally 'at-risk' patients, by issuing institutional guidelines and by implementing a more thorough training and collaboration between doctors, nurses and dieticians. Automatic notifications to the department of clinical nutrition of the presence of an 'at-risk' patient could also be implemented, in order to better quantify the resources used/needed to manage in-hospital malnutrition and their impact on health outcomes and cost. Moreover, future studies should allow a better characterization of the costs specifically associated with being nutritionally 'at-risk'.

4.5. Strengths and limitations

This study was built on real-life data from the CHUV; namely, all adult hospitalizations occurring in years 2013 and 2014 were included and costs were evaluated based on actual expenditures and not on DRG-related codes.

Some limitations should also be acknowledged. First, there is no standard procedure regarding nutritional screening for all hospitals in Switzerland, so these findings might not be applicable in other hospitals. Still, our results provided a baseline frame for further comparisons. Second, the analysis was limited to a single department, and it is possible that nutritional screening might be performed differently in other departments. Still, some studies also rely on data from single departments [26,29,30]. Finally, due to the selection process in the hospital guideline, a possible selection bias might occur, i.e. diagnoses with a high prevalence of 'at-risk' patients (such as heart failure and COPD) being selected. Although this procedure might increase the prevalence of patients 'at-risk', it would not influence neither their management nor the effect of being 'at-risk' on outcomes.

4.6. Conclusion

Between 2013 and 2014, the increase in nutritional risk screening at the department of internal medicine was not followed by a similar increase in nutritional management of 'at-risk' patients. Being nutritionally 'at-risk' affects three in every five patients and is associated with increased mortality and hospitalization costs. Implementation of adequate nutritional care and evaluation of its impact on health outcomes and expenditures are needed.

Conflict of interest

None of the authors has a conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.clnu.2016.02.012.

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Supplementary Material

Supplementary Table 1 10th International Classification of Diseases and related health problems (ICD-10) codes used.

Main diagnosis	**ICD-10 codes**
Cancer	C00-D09
Infection	A00-B00
Pulmonary disease	J00-J99
Pneumonia	J12-18
Chronic obstructive pulmonary	J40-J47
Disease of digestive system	K00-K93
Endocrine, Nutritional and metabolic diseases	E00-E90
Disease of the circulatory system	I00-I99
Ischemic heart disease	I20-I25
Heart Failure	I50
Symptom and abnormal findings + injury	R00-R99; S00-S99
Disease of genitourinary system	N00-N99
Disease of blood	D50-D89
Disease of nervous system	G00-G99
Disease of skin	L00-L99
Disease of the musculoskeletal	M00-M99
Rehabilitation	Z50.80-Z50.89

Chapter 4

Undernutrition is associated with increased financial losses

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Summary

This research paper describes the difference between actual and reimbursed hospital costs among nutritionally 'at-risk' and 'not at-risk' hospitalized patients. Overall, our results show that nutritionally 'at-risk' patients have higher costs and also higher reimbursements than 'not at-risk' patients. Still, the amount of reimbursements for 'at-risk' patients failed to completely cover the extra costs, leading to lower coverage rates and higher net financial losses for the hospitals. Our results also showed that the differences between 'at-risk' and 'not at-risk' patients were evenly distributed between the various types of hospital costs, showing that there is no specific cost type that is particularly increased among 'at-risk' patients. Although, the impact of precise documentation of nutritional status on reimbursements remains to be evaluated, our results highlight the need for proper documentation of undernutrition in hospital discharge data to avoid undermining hospital finances. Thus, we conclude that being nutritionally 'at-risk' increases all types of costs and leads to lower reimbursement rates than being 'not at-risk'. This study provides important information regarding economic consequences of hospital undernutrition status as a public health concern.

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Original article

Undernutrition is associated with increased financial losses in hospitals

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SUMMARY

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 $\geq$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 $\pm$ standard error: 34,206 $\pm$ 1246 *vs.* 22,214 $\pm$ 1666 CHF, $p < 0.001$) and higher reimbursements (26,376 $\pm$ 1105 *vs.* 17,783 $\pm$ 1477 CHF, $p < 0.001$). Still, the latter failed to cover the costs, leading to a deficit between costs and reimbursements of 7831 $\pm$ 660 CHF in patients 'at-risk' vs. 4431 $\pm$ 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.

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1. 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,

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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 was to know whether patients nutritionally 'at-risk' differed from the others regarding specific costs and if they represented a financial burden for the institution.

2. Materials and methods

2.1. 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 h) 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.

2.2. 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 patients 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 1–3 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'.

2.3. 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%).

2.4. 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.

2.5. 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 are usually managed in other departments of the hospital.

2.6. 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 and medical interventions). Statistical significance was considered for a two-sided test with $p < 0.05$.

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2.7. Ethics statement

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

3. Results

3.1. Patient characteristics

Data from 8538 hospitalizations for years 2013 and 2014 were collected. Of these 5999 (70.2%) 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 2200 (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.

3.2. 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’.

3.3. 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).

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.

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’ had an extra 3400 CHF (95% CI: 1200–5600 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’ having an extra 2500 CHF (95% CI: 370–4800 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); as did further adjusting for total length of stay (Supplementary Table 4).

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 [11,142–24,748]	19,982 [13,684–33,785]	<0.001
>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 [7802–18,186]	13,346 [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 [187–8655]	5651 [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]	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.

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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 5–8), patients 'at-risk' having an extra 1960 CHF (95% CI: 900–3000 CHF) loss to the average difference between costs and reimbursements. Also, 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, $p < 0.001$).

3.4. 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 with total costs >100,000 CHF or in intensive care showed that patients 'at-risk' had lower percentage of costs in medical interventions, food, imaging and other ($p < 0.05$) (Supplementary Table 11).

4. 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.

4.1. 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 guideline, but avoid specific patients with end-of-life situations."

4.2. Costs, reimbursements, and net results

Being nutritionally 'at-risk' was associated with higher total costs, a finding in agreement with the literature [4,23]. 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 in our study the higher costs among patients nutritionally 'at-risk' persisted in the sensitivity analyses after adjusting for total length of stay. Interestingly, the reimbursements obtained from nutritionally 'at-risk' patients were higher than those 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. Actually it was not the case, coverage rates 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], leading to an inadequate DRG classification [25]. Thus, it can be speculated that a better reporting of undernutrition might lead to increased 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.

4.3. 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. [32] 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. 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.

4.4. Limitation of the study

This paper has several limitations worth acknowledging. Firstly, only patients from the department of internal medicine of a

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university hospital were included. Hence, 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 elsewhere. 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 or the coverage of the costs. Fourthly, due to legal constraints, it was not possible to obtain the identification of the patients, which would have allowed their follow-up and assessing 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.

5. Conclusion

Patients nutritionally ‘at-risk’ have higher costs and higher reimbursements than patients ‘not at-risk’. Still, 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

The authors report no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.clnu.2017.02.012.

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Supplementary Materials

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

	Included	**Excluded**	**p-value**
N (%)	2 200 (25.8)	6 338 (74.2)	
Age (years)	75.6 ± 15.5	71.9 ± 16.7	<0.001
Women (%)	1 186 (53.9)	3 114 (49.1)	<0.001
Coming from home (%)	2 053 (93.3)	5 841 (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[1]
Charlson index (%)			
0	932 (42.4)	2 914 (46.0)	0.003
1	275 (12.5)	689 (10.9)	
2	343 (15.6)	1 020 (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[1]
Total costs (CHF)	18 414 [12 698 - 9 983]	15 000 [10 252 – 24 752]	<0.001[1]

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 [1] student's t-test of Kruskal-Wallis test for continuous variables.

Supplementary Table 2 Socio-demographic and clinical characteristics of including hospitalizations 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)	1 298 (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)	1 288 (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[1]
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[1]

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 [1] 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=1 398)	**p-value**
Total costs			
Amount (CHF)	26 152 ± 1 378	31 947 ± 1 029	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 ± 1 259	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)	5 043 ± 872	7 480 ± 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)	1 398 (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)	5 167 ± 873	7 409 ± 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=1 298)	**p-value**
Total costs			
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 [7 739 – 16 958]	12’276 [8 988 – 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 – 8 455]	5480 [1 411 – 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=1 298)	**p-value**
Total costs			
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)	4 016 ± 420	5 980 ± 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=1 298)	**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)	4 116 ± 419	5 920 ± 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=1 298)	**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)	4 334 ± 415	5 789 ± 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=1 398)	**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 [1]	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

[1] 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=1 398)	**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 [1]	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

[1] 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) [1]	**At risk** (n=1 298) [1]	**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 [2]	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

[1] Hospitalizations in intensive care (n=85) or with costs over 100'000 CHF (n=39) were excluded. [2] 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.

Chapter 5

Estimation of malnutrition prevalence using administrative data: Not as simple as it seems

Khalatbari-Soltani S, Marques-Vidal P, Waeber G

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Summary

The aim of this study was to assess the validity of using undernutrition codes reported in hospital discharge data for assessing the prevalence of undernutrition. Our study highlights that results from objectively assessed undernutrition are not actively coded in administrative discharge databases. This leads to a substantial under-estimation and under-recognition of undernutrition prevalence among hospitalized patients. This study was the first to use the support of the newly created *Centre de Soutien à la Recherche Clinique* (CSCR) of the Lausanne university hospital (CHUV), and it pioneered data extraction from a large number of databases available at the CHUV.

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Letter to the Editor

Estimation of malnutrition prevalence using administrative data: Not as simple as it seems

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ICD code

Dear Editor,

Malnutrition is a common finding among hospitalized patients, leading to increased morbidity and higher length of stay and costs [1]. Several studies have assessed the prevalence of malnutrition using hospital discharge data, i.e. using international classification of diseases (ICD) codes. Nowadays, most hospital data is available in electronic format, including prealbumin, a marker of malnutrition [2]. Whether malnutrition defined by low prealbumin levels is actively reported in discharge data has seldom been assessed. Thus, we assessed the prevalence of malnutrition according to four definitions: 1) any ICD-10 code E40 to E46; 2) ICD-10 code R63 or R64; 3) prealbumin levels <15 mg/dL (measurements performed in 996 patients devoid of liver disease or infection) and 4) any one of the previous three. We used data from 2002 to 2013 from the Department of Internal Medicine of the Lausanne University Hospital, Switzerland (32,850 patients aged ≥18 years).

Prevalence (95% confidence interval – CI) of malnutrition using the entire sample was 2.7% (2.5–2.9); 1.7% (1.6–1.9); 2.0% (1.8–2.2) and 6.1% (5.9–6.4) for definitions 1, 2, 3 and 4, respectively. These findings are in agreement with other studies conducted in the United States and Spain, which reported 3.2% and 1.4% malnutrition diagnosis at discharge according to ICD-9 codes [3,4]. No differences in prevalence were found between genders or age groups using definitions 1 and 2, while higher prevalence were found in men using definition 3 and in younger patients using definitions 3 and 4 (Table 1). Among the 996 patients for whom prealbumin was measured, 656 [65.9% (62.8–68.8)] had prealbumin levels <15 mg/dL, but of these 656 patients with possible malnutrition, only 56 (8.5%) were reported as malnourished in discharge data (definition 1) and only 17 (2.6%) were considered as malnourished according to definition 2. These findings are in accordance with the literature [4,5], showing that results from objective nutritional assessments are rarely translated into ICD codes at discharge. This underreporting of malnutrition has considerable consequences for health planning, as health statistics and most public health decisions are based solely on hospital discharge data.

Table 1
Malnutrition prevalence according to gender and age groups. Results are expressed as number of hospitalizations and (%).

	Malnutrition definition			
	ICD-10 code E40 to E46	ICD-10 code R63 or R64	Prealbumin <15 mg/dL	All
Gender				
Women	450 (2.8)	298 (1.9)	286 (1.8)	993 (6.2)
Men	432 (2.6)	269 (1.6)	370 (2.2)	1027 (6.2)
**P*-value	0.265	0.104	0.004	0.990
Age group				
30–59	226 (2.9)	142 (1.8)	174 (2.2)	509 (6.5)
60–69	166 (3.0)	94 (1.7)	151 (2.7)	393 (7.1)
70–79	201 (2.6)	109 (1.5)	177 (2.3)	473 (6.2)
80–89	221 (2.4)	172 (1.9)	127 (1.4)	503 (5.5)
90+	68 (2.5)	50 (1.8)	27 (1.0)	142 (5.3)
**P*-value	0.131	0.219	<0.001	<0.001

ICD, International Classification of Diseases. **P*-value for between group comparisons using Chi-square test.

We conclude that the prevalence and determinants of hospital malnutrition vary significantly according to the definition applied. Results from objectively assessed malnutrition are not actively coded, leading to a considerable underestimation of malnutrition prevalence in hospital discharge data. Professionals filling the discharge letter should be more sensitized towards malnutrition.

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Conflict of interest

None.

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Chapter 6

Diagnostic accuracy of undernutrition codes in hospital administrative discharge database: improvements needed

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Abstract

Background & Aims: Hospital administrative databases are widely used for disease monitoring. Undernutrition is highly prevalent among hospitalized patients, but the diagnostic accuracy of undernutrition coding in administrative data is poorly known. This study examined the diagnostic accuracy of undernutrition coding in administrative hospital discharge database.

Methods: Retrospective cross-sectional study using administrative data for years 2013-14 from the Internal medicine unit of the Lausanne university hospital (n=2 509). Two reference diagnoses were defined: 'confirmed' undernutrition by a Nutrition Risk Screening-2002 score (NRS-2002) ≥3 *plus* a body mass index (BMI) <18.5 kg/m^2, and 'probable' undernutrition by an NRS-2002 ≥3 *plus* any prescribed nutritional management *plus* a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years). Missing BMI values were imputed.

Results: Of the 2 509 eligible patients, 262 (10.4%) were classified as 'confirmed' and 631 (25.2%) as 'probable' undernutrition. Sensitivity, specificity, negative and positive predictive values (and corresponding 95% confidence intervals) for undernutrition codes using 'confirmed' undernutrition were 43.0 (37.0 - 49.3); 87.2 (85.8 - 88.6); 92.9 (91.7 - 94.0) and 28.2 (23.8 - 32.8), respectively. The corresponding values using both 'confirmed' and 'probable' undernutrition were 30.0 (27.2 - 32.9); 93.4 (92.0 - 94.6); 66.7 (64.7 - 68.7) and 75.1 (70.6 - 79.3), respectively. Similar findings were obtained after stratifying for sex or age groups or restricting the analysis to patients with non-missing BMI data.

Conclusions: Undernutrition codes in hospital discharge data have good specificity but its sensitivity and positive predictive values are low.

Introduction

Prevalence of undernutrition among hospitalized patients is high, ranging between 20 to 60% (1–3). Undernutrition is associated with increased morbidity and mortality, longer hospital stay, decreased quality of life, and increasing health care costs (1,2,4–6). Hence, routine nutritional risk screening of hospitalized patients has been recommended by national and international organizations (7–9). Reliable data of the prevalence and management of undernourished patients are also needed to adequately assess the public health importance of this condition (8,10).

In recent years, the importance of hospital administrative discharge databases for disease monitoring and health policies planning has increased considerably (11,12). Hence, adequate reporting of undernourished patients using the corresponding International Classification of Diseases (ICD) codes is necessary (8). Still, it has been shown that undernutrition or being nutritionally 'at-risk' is frequently under-reported (13–15). Failure to report undernutrition would minimize the importance of this condition at the national or regional level (12) and would compromise the adequate evaluation of clinical and public health interventions (16). Further, if administrative discharge databases are to be used in public health, their diagnostic accuracy, assessed by common metrics such as sensitivity and specificity of the reported conditions, should be high. Still, to our knowledge, only one study conducted in Danish hospitals assessed the diagnostic accuracy of undernutrition coding in hospital administrative data (17). The reported positive predictive values (PPVs) were 70.9% using both 'definite' (screened-confirmed) and 'probable' (clinically-confirmed) undernutrition as reference, and decreased to a worrying 11.0% when using only 'definite' undernutrition as reference. Whether these findings also apply to other settings is currently unknown, and there is a scarcity of information regarding the diagnostic accuracy of undernutrition coding in hospital administrative discharge databases.

Therefore, the aim of this study was to estimate the diagnostic accuracy of undernutrition codes in hospital administrative discharge databases in Switzerland. Given the previous evidence of under-reporting of this condition (13–15), we hypothesized that the sensitivity and positive predictive values of undernutrition coding would be low.

Methods

Study setting

This is a retrospective study based on electronic administrative data from the Internal medicine unit of the Lausanne university hospital (CHUV) for years 2013 and 2014. The CHUV is one of the five Swiss university hospitals (www.chuv.ch) and the Internal medicine unit of the CHUV is the largest in Switzerland, with over 4,000 admissions per year.

Data extraction and variables definitions

The following data were extracted from the hospital records: date of hospital admission and discharge; sex; age; body mass index (BMI); main diagnosis at discharge, and comorbidities. Age was categorized into 18-59, 60-79 and 80+ years. Main diagnosis at discharge was classified into eight categories according to the ICD-10 codes (**Supplementary Table 1)**. The Charlson Comorbidity Index (CCI) (18) was computed from ICD-10 codes according to an algorithm defined for Switzerland (19); patients were dichotomized into low (CCI <2) and high (CCI ≥2) comorbidity status (20).

Data from the Nutrition Risk Screening-2002 (NRS-2002) score was collected. NRS-2002 is one of the most popular nutrition screening tools in health care settings and it includes weight loss, diminished energy or nutritional intake, BMI and disease severity (21,22). Briefly, during the first day of admission NRS-2002 score were calculated based on nutritional status (0 to 3 score) plus 0 to 3 score of disease severity categories (none, slight, moderate, and severe), and an extra score of 1 for hospitalized patients older than 70 years (21). Nutritional risk was categorized into low (NRS-2002 <3), medium (NRS-2002= 3-4), and high (NRS-2002 >4) (22).

Nutritional management was defined as having at least one of the following: a) enteral nutrition; b) parenteral nutrition; c) oral nutritional supplementation, or d) specific dietary regimen as recorded in patient's dietary file.

Undernutrition codes

As both diagnosis of undernutrition and being 'at-risk' of undernutrition should have their own ICD codes (8), we searched for all ICD-10 codes related to nutritional status in adults: E12 (malnutrition-related diabetes mellitus); E40 (kwashiorkor); E41 (nutritional marasmus);

E42 (marasmic kwashiorkor); E43 (unspecified severe protein-energy malnutrition); E44 (protein-energy malnutrition of moderate and mild degree); E46 (unspecified protein-energy malnutrition); R63 (symptoms and signs concerning food and fluid intake) and R64 (cachexia). Positive coding of undernutrition was defined as presence of at least one of the aforementioned codes in the hospital administrative discharge database.

Undernutrition status

We defined 'confirmed' undernutrition (gold standard) as an NRS-2002 score ≥3 *plus* a BMI <18.5 kg/m^2 as suggested in the European and American Society of Parenteral and Enteral Nutrition and the Academy of Nutrition and Dietetics recommendations (8,23). 'Probable' undernutrition was defined as an NRS-2002 ≥3 *plus* any prescription of nutritional management/support *plus* a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years). The criteria for both 'confirmed' and 'probable' undernutrition were based on the previously established definitions (8,23–25). If the above mentioned criteria were not met, patients were considered as not undernourished. Consequently, three categories of undernutrition were defined: 'confirmed', 'probable' and 'no evidence'. These categories are comparable, but not strictly similar to those used in a previous study which assessed the diagnostic accuracy of undernutrition coding (17).

Inclusion and exclusion criteria

Patients were considered as eligible if they were aged 18 years and older. Exclusion criteria were a) absence of NRS-2002 data; b) length of stay <24 hours and c) outlier BMI data (BMI <13 or >50 kg/m^2).

Statistical analysis

Statistical analyses were performed using Stata 14.1 (Stata Corp, College Station, TX, USA). Descriptive results were expressed as average ± standard deviation (SD) or standard error (SE) for continuous data or as number of participants (%) for categorical data. Bivariate comparisons were performed using student's t-test for continuous data or chi-square for categorical data.

Diagnostic accuracy of ICD-10 codes for nutritional status was assessed by calculating sensitivity, specificity, PPV, negative predictive values (NPVs) and their 95% confidence intervals (CIs). Two reference diagnoses (gold standards) were used: 1) 'confirmed' undernutrition only, and 2) 'confirmed' and 'probable' undernutrition together. Diagnostic accuracy was computed for the whole sample and also stratifying by year of admission, sex, and age groups to determine whether the validity differs between categories. As a nutrition screening program has been implemented since 2013 (1), it was hypothesized that diagnostic accuracy would change between 2013 and 2014.

In our database, 22% (544/2509) of the patients had missing values for BMI. To avoid statistical power reduction and possible selection bias by excluding these patients, we used multiple imputations to fill out missing BMI values. We assumed that BMI data were missing at random (MAR) and used predictive mean matching to impute the missing BMI values. Twenty imputed data sets were generated and analyzed (26). The imputation model included sociodemographic variables (age, sex, and marital status); coming from home or other health care centers; main diagnosis; having NRS-2002 ≥3; having any nutritional management/support and CCI. We assessed the validity of our imputation model by comparing the distributions of complete data with three imputed data sets. The averages and standard deviations were 24.83 ± 5.69 kg/m^2 for the complete dataset (patients with non-missing BMI data) and 24.72 ± 5.65, 24.78 ± 5.65 and 24.75 ± 5.69 kg/m^2 for the three imputed datasets. The very small differences in this summary measures suggested that MAR assumption and the imputed model were fit properly. For the sensitivity analysis, we used a complete case analysis approach, i.e. including only patients with non-missing BMI data.

Ethics

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 CHUV board of directors (decision of Dec. 5, 2014). Information extracted from routinely collected data and anonymized before being handled for analysis.

Results

Sample selection and characteristics

Of the initial 8 541 patients, 6 032 (70.6%) were excluded. The reasons for exclusion are summarized in **Supplementary Figure 1** and the characteristics of the included and excluded patients are summarized in **Supplementary Table 2**. Excluded patients were more likely to be admitted to the hospital in year 2013, men, aged 80 years or higher, having circulatory system disease or respiratory system disease (Supplementary Table 2).

Prevalence of reported 'confirmed' and 'probable' undernutrition

Out of the 2 509 included hospitalizations, 1588 (63.3%) had an NRS-2002 ≥3; 400 (15.9%) had an ICD-10 code for undernutrition; 262 (10.4%) were classified as 'confirmed' and 631 (25.2%) were classified as 'probable' undernutrition. The characteristics of the patients according to 'confirmed', 'probable' and 'no evidence' of undernutrition are presented in **Table 1**. Patients in 'confirmed' and 'probable' undernutrition categories were more frequently women, were older, received more frequently nutritional management and had more frequently an NRS-2002 score of 3 or 4 (Table 1). These results were the same considering complete case analysis **(Supplementary Table 3**).

Diagnostic accuracy of undernutrition codes

The results of the diagnostic accuracy of undernutrition codes using 'confirmed' undernutrition as reference, overall and stratified by admission year, sex and age groups are displayed in **Table 2**. Less than half of 'confirmed' undernourished cases were reported as such in the administrative database (113/262; 43.1%). Overall, undernutrition codes had poor sensitivity and PPV, and good specificity and NPV. Stratification by admission year showed that number of patients categorized in 'confirmed' undernutrition in year 2014 were higher in comparison to year 2013, although the percentage remained almost the same. There were no differences between year of admission, sex and age groups except NPV which was higher among men. The results were the same considering complete-case analyses (n=1969 patients with reported BMI) **(Supplementary Table 4**).

Table 3 shows the results of the diagnostic accuracy of undernutrition codes using both 'confirmed' and 'probable' undernutrition as reference. Addition of 'probable' to 'confirmed' undernutrition resulted in an overall decrease in sensitivity and NPVs and an increase in specificity and PPVs. There were no variations in results stratified by year of admission, sex or age groups. Overall, undernutrition codes in the administrative discharge database had very high specificity and reasonable PPVs.

The results of the sensitivity analysis restricting the sample to patients with reported BMI (n=1969) are shown in **Supplementary Table 5**. Compared to the results from the imputed data, sensitivity, specificity, and PPVs were similar, while NPVs were higher.

Table 1 Characteristics of the study sample based on nutritional status categories, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014.

Characteristics	**No evidence** n=1 616 (64.4) [3]	**Confirmed** [1] n=262 (10.4) [3]	**Probable** [2] n=631 (25.2) [3]
Age (years), *mean* ± *S.E*	74.3 ± 0.4	76.1 ± 1.2	78.6 ± 0.5
Women, *n (%)*	834 (51.6)	168 (64.1)	335 (53.1)
Age category, *n (%)*			
18-59	262 (16.2)	41 (15.6)	63 (10.0)
60-79	578 (35.8)	75 (28.6)	216 (34.2)
Above 80	776 (48.0)	146 (55.8)	352 (55.8)
Main diagnosis, *n (%)*			
Cancer	115 (7.1)	35 (13.3)	108 (17.1)
Infectious diseases	111 (6.9)	17 (6.5)	54 (8.5)
Rehabilitation	140 (8.7)	25 (9.5)	39 (6.2)
Respiratory system diseases	254 (15.7)	48 (18.3)	106 (16.8)
Digestive system diseases	111 (6.9)	21 (8.0)	53 (8.4)
Circulatory system diseases	359 (22.2)	29 (11.1)	108 (17.1)
Symptoms, abnormal findings & injury	258 (15.9)	35 (13.4)	80 (12.7)
Other	268 (16.6)	52 (19.9)	83 (13.2)
Any nutritional management, *n (%)*	143 (8.8)	156 (59.4)	513 (81.3)
NRS-2002 categories, *n (%)*			
Medium risk (3-4)	608 (37.6)	170 (64.9)	462 (73.2)
High risk (>4)	87 (5.4)	92 (35.1)	169 (26.8)
Charlson comorbidity index ≥2, *n (%)*	674 (41.7)	117 (44.6)	336 (53.2)

Abbreviations: S.E, standard error; NRS-2002, nutrition risk screening 2002.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2.

[2] 'probable' undernutrition defined as an NRS-2002≥3 *plus* any prescription of nutritional management/support *plus* a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years).

Results are expressed as average ± standard error or as number of patients (column %) except for [3] where prevalence is expressed as number of patients (row %).

Table 2 Diagnostic accuracy of undernutrition codes in hospital administrative discharge database using 'confirmed' undernutrition as reference, overall and stratified by admission year, gender and age groups, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014.

	Total cases	**Confirmed** [1]	**Reported** [2]	**Sensitivity**	**Specificity**	**Negative predictive value**	**Positive predictive value**
All	2 509	262 (10.4)	113 (43.1)	43.0 (37.0 - 49.3)	87.2 (85.8 - 88.6)	92.9 (91.7 - 94.0)	28.2 (23.8 - 32.8)
Admission, year							
2013	661	73 (11.0)	33 (45.2)	46.0 (34.2 - 58.1)	84.6 (81.4 - 87.4)	92.7 (90.1 - 94.7)	26.8 (19.3 - 35.5)
2014	1 848	189 (10.2)	80 (42.3)	42.0 (34.9 - 49.4)	88.1 (86.5 - 89.7)	93.0 (91.7 - 94.2)	28.7 (23.5 - 34.5)
Sex							
Women	1 337	168 (12.5)	67 (39.9)	39.7 (32.3 - 47.6)	88.2 (86.2 - 90.0)	91.1 (89.3 - 92.7)	32.5 (26.1 - 39.4)
Men	1 172	94 (8.0)	46 (48.9)	48.9 (38.5 - 59.4)	86.2 (84.0 - 88.2)	95.1 (93.5 - 96.3)	23.6 (17.8 - 30.2)
Age groups, years							
18-59	366	41 (11.2)	18 (43.9)	44.6 (29.1 - 61.0)	89.0 (85.0 - 92.2)	92.8 (89.3 - 95.4)	33.5 (21.3 - 47.7)
60-79	869	75 (8.6)	37 (49.3)	49.2 (37.5 - 60.9)	85.3 (82.6 - 87.6)	94.6 (92.7 - 96.2)	24.0 (17.5 - 31.5)
Above 80	1 274	146 (11.4)	58 (39.7)	39.5 (31.5 - 47.9)	88.1 (86.1 - 89.9)	91.8 (90.0 - 93.4)	30.0 (23.6 - 37.0)

Results are expressed as number of patients (row %), and as percentage (95% confidence interval) for diagnostic accuracy.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2.

[2] Reported undernutrition defined as presence of at least one of the International Classification of Diseases 10th revision codes for undernutrition.

Table 3 Diagnostic accuracy of undernutrition codes in hospital administrative discharge database using both 'confirmed' and 'probable' undernutrition as reference, overall and stratified by admission year, gender and age groups, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014.

	Total cases	Confirmed & probable [1]	Reported [2]	Sensitivity	Specificity	Negative predictive value	Positive predictive value
All	2 509	1002 (39.9)	301 (30.0)	30.0 (27.2 - 32.9)	93.4 (92.0 - 94.6)	66.7 (64.7- 68.7)	75.1 (70.6 - 79.3)
Admission, year							
2013	661	279 (42.2)	94 (33.7)	33.6 (28.1 - 39.5)	92.1 (88.9 - 94.6)	65.4 (61.2 - 69.5)	75.7 (67.2 - 83.0)
2014	1 848	723 (39.1)	207 (28.6)	28.6 (25.3 - 32.0)	93.8 (92.3 - 95.2)	67.2 (64.8 - 69.5)	74.9 (69.3 - 79.9)
Sex							
Women	1 337	565 (42.2)	157 (27.7)	27.7 (24.1 - 31.6)	93.7 (91.8 - 95.3)	63.9 (61.0 - 66.7)	76.5 (70.1 - 82.1)
Men	1 172	437 (37.3)	144 (32.9)	32.9 (28.5 - 37.5)	93.0 (90.9 - 94.8)	70.0 (67.0 - 72.9)	73.7 (67.0 - 79.7)
Age groups, years							
18-59	366	104 (28.4)	37 (35.6)	35.0 (25.9 - 45.0)	93.3 (89.6 - 96.0)	78.3 (73.3 - 82.7)	67.6 (53.5 - 79.7)
60-79	869	318 (36.6)	106 (33.3)	33.2 (28.1 - 38.7)	91.2 (88.5 - 93.4)	70.3 (66.8 - 73.6)	68.6 (60.6 - 75.8)
Above 80	1 274	580 (45.5)	158 (27.2)	27.3 (23.7 - 31.1)	95.2 (93.3 - 96.6)	61.0 (58.1 - 63.9)	82.5 (76.3 - 87.6)

Results are expressed as number of patients (row %), and as percentage (95% confidence interval) for diagnostic accuracy.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2; 'probable' undernutrition defined as an NRS-2002≥3 plus any prescription of nutritional management/support plus a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years).

[2] Reported undernutrition defined as presence of at least one of the International Classification of Diseases 10th revision codes for undernutrition.

Discussion

In this study we showed that the accuracy of undernutrition codes in a hospital administrative database has a good specificity but a low sensitivity and PPV. Our findings question the use of currently available administrative data for estimating the prevalence and impact of undernutrition in a hospital setting.

Diagnostic accuracy of undernutrition codes

In our study, undernutrition codes in the hospital administrative discharge database had a relatively good PPV when both 'confirmed' and 'probable' undernutrition categories were used. Conversely, the PPV using only 'confirmed' undernutrition was noticeably lower, which could be due to the low prevalence of 'confirmed' undernutrition in our study (5). Our results are comparable to the only study investigating the accuracy of ICD-10 coding for undernutrition in the Danish National registry, reported a PPV of 70.9% for both 'definite' (screened-confirmed) and 'probable' (clinically-confirmed) undernutrition and a PPV of 11.0% when only 'definite' undernutrition was used as reference (17). Our results are also in line with a study showing that ICD-10 codes of obesity have very low sensitivity (7.75%), high specificity (99%) and moderate PPV (66%) (27). These findings suggest that diagnostic accuracy of undernutrition codes varies according to the reference (gold standard) used, but its PPV is very low when the more stringent definition of undernutrition is used as reference. For instance, if 'confirmed' undernutrition is considered as the reference, approximately half of the true undernourished patients will be missed while three quarters of the patients reported as undernourished will be false positives. If 'confirmed' and 'probable' undernutrition is considered as the reference, then two thirds of the true undernourished patients will be missed, but only one quarter of the patients reported as undernourished will be false positives. Moreover, our results showed that there was no improvement of undernutrition coding over time, against the awareness increment of the health consequences of hospitalized undernutrition (28).

Coding inaccuracy and difference in validity could be due to factors related to documentation quality of physicians, coder's experience, ICD-10 coding system and type of administrative databases (29–31). The low accuracy of undernutrition codes could also be explained by lack of clear criteria for undernutrition diagnosis, in addition to the variation of cut-offs in different validated nutrition screening tools (8).

Consequences for public health

Hospital administrative database is frequently used for establishing health policies (12). Hence, the validity of the data must be high so that adequate decisions can be taken. Still, previous studies assessing the accuracy of ICD-9 and ICD-10 codes showed that each database has its own unique set of drawbacks (12,17,27,29,31). Undernutrition reporting using ICD-10 codes had limited diagnostic performance in correctly identifying patients with 'confirmed' undernutrition. Conversely, our results also show that, absence of an ICD-10 code for undernutrition is reliable information as it has a high specificity and a high NPV.

Our results allow the assessment of correction coefficients enabling the estimation of the "true" prevalence of undernutrition based on administrative discharge database. These coefficients are computed as PPV divided by sensitivity and their values are 0.66 and 2.50 for 'confirmed' and 'confirmed plus probable' undernutrition, respectively. That is, for each 100 patients with reported undernutrition, there would actually be 66 patients with 'confirmed' undernutrition and 250 patients with 'confirmed *plus* probable' undernutrition. Interestingly, the lower prevalence of 'confirmed' undernutrition is in agreement with one study which showed that using both positive nutrition screening score and BMI<18.5 kg/m^2 underestimates being undernourished or 'at-risk' of undernutrition (1). Overall, our results suggest that reliability of hospital administrative discharge database should be tested before it can be used to estimate the prevalence or the public health impact of a given condition.

Study limitations

Our study has some limitation worth acknowledging. First, it was limited to one university hospital, so results might not be generalizable to other hospitals. However, our results are similar to those multicenter studies (17,27), which shows that results from one setting, in the absence of big national databases, could still be a valuable framework to evaluate prevalence and diagnostic accuracy of undernutrition codes; in addition, this is the first study in Switzerland that provide an estimated magnitude of under/over estimation of "true" undernutrition prevalence. Second, although our study included a large sample (n=2509), many patients (70.6%) were excluded from the analyses, mostly due to lack of NRS-2002 data. Third, there were no data available regarding recent weight loss during the last three weeks and reduced muscle strength or weakening, thus precluding the exact duplication of the 'probable' undernutrition category reported in a previous study (17). Still, the diagnostic accuracy results for undernutrition obtained in our study were similar.

Conclusion

Undernutrition codes in hospital administrative discharge database have good specificity but its sensitivity and positive predictive values are low.

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Supplementary Materials

Supplementary Table 1 International Classification of Diseases 10th revision codes used to categorize the main diagnosis at discharge, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014.

Main diagnosis	**Codes**
Cancer	C00-D09
Infectious diseases	A00-B00
Rehabilitation	Z50.80-Z50.89
Respiratory system diseases	J00-J99
Digestive system diseases	K00-K93
Circulatory system diseases	I00-I99
Symptoms, abnormal findings & injury	R00-R99; S00-S99
Other	E00-E90; N00-N99; D50-D89; G00-G99; L00-L99; M00-M99

Supplementary Table 2 Comparison between excluded and included patients, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014.

Characteristics	**Included** n = 2 509 (29.4) [1]	**Excluded** n = 6 032 (70.6) [1]	**p-value**
Admission year			<0.001
2013	661 (26.4)	3 416 (56.6)	
2014	1 848 (73.7)	2 616 (43.4)	
Women	1 337 (53.3)	2 964 (49.1)	<0.001
Age category			<0.001
18-59	366 (14.6)	1 322 (21.9)	
60-79	869 (34.6)	2 295 (38.1)	
Above 80	1 274 (50.8)	2 415 (40.0)	
Main diagnosis			<0.001
Cancer	282 (11.2)	632 (10.5)	
Infection	183 (7.3)	493 (8.2)	
Rehabilitation	179 (7.1)	346 (5.7)	
Respiratory system diseases	408 (16.3)	1 139 (18.9)	
Digestive system diseases	185 (7.4)	573 (9.5)	
Circulatory system diseases	497 (19.8)	1 140 (18.9)	
Symptoms, abnormal findings & injury	372 (14.8)	648 (10.7)	
Others	403 (16.1)	1 061 (17.6)	
Charlson comorbidity index ≥2	1 127 (44.9)	2 601 (43.1)	0.12

Results are expressed as number of patients (column %) except for [1] where prevalence is expressed as number of patients (row %). Between-group comparisons performed using chi-square test.

Supplementary Table 3 Characteristics of the study sample based on nutritional status categories, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014 (complete-case analysis).

Characteristics	**No evidence** n=1 590 (63.4) [3]	**Confirmed** [1] n=186 (7.4) [3]	**Probable** [2] n=733 (29.2) [3]	**p-value**
Age (years), *mean* ± *S.D*	72.2 ± 16.6	78.4 ± 14.0	75.3 ± 17.6	n.a.
Women, *n (%)*	820 (51.6)	124 (66.67)	393 (53.6)	<0.001
Age category, *n (%)*				<0.001
18-59	271 (17)	28 (15.1)	67 (9.1)	
60-79	575 (36.2)	55 (29.6)	239 (32.6)	
Above 80	744 (46.8)	103 (55.4)	427 (58.3)	
Main diagnosis, *n (%)*				<0.001
Cancer	142 (8.9)	24 (12.9)	116 (15.8)	
Infectious diseases	109 (6.9)	9 (4.8)	65 (8.9)	
Rehabilitation	110 (6.9)	21 (11.3)	48 (6.6)	
Respiratory system diseases	249 (15.7)	34 (18.3)	125 (17.1)	
Digestive system diseases	109 (6.9)	12 (6.5)	64 (8.7)	
Circulatory system diseases	351 (22.1)	21 (11.3)	125 (17.1)	
Symptoms, abnormal findings & injury	246 (15.5)	26 (14.0)	100 (13.6)	
Other	274 (17.2)	39 (21.0)	90 (12.3)	
Any nutritional management, *n (%)*	143 (9.0)	111 (59.7)	558 (76.1)	0.001
NRS-2002 categories, *n (%)*				*n.a.*
Medium risk (3-4)	582 (36.6)	112 (60.2)	546 (74.5)	
High risk (>4)	87 (5.5)	74 (39.8)	187 (25.5)	
Charlson comorbidity index ≥2, *n (%)*	673 (42.3)	81 (43.6)	373 (50.9)	<0.001

Abbreviations: S.D, standard deviation; NRS-2002, nutrition risk screening 2002; n.a, not applicable.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2.

[2] 'probable' undernutrition defined as an NRS-2002≥3 *plus* any prescription of nutritional management/support *plus* a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years).

Results are expressed as average ± standard deviation or as number of patients (column %) except for [3] where prevalence is expressed as number of patients (row %). Between-group comparisons performed using chi-square test.

Supplementary Table 4 Diagnostic accuracy of undernutrition codes in hospital administrative discharge database using 'confirmed' undernutrition as reference, overall and stratified by admission year, gender and age groups, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014 (complete-case analysis).

	Total	**Confirmed** [1]	**Reported** [2]	**Sensitivity**	**Specificity**	**Negative predictive value**	**Positive predictive value**
All	1 969	186 (9.45)	94 (50.5)	50.5 (43.1 - 57.9)	88.1 (86.5 - 89.5)	94.5 (93.3 - 95.5)	30.6 (25.5 - 36.1)
Admission, year							
2013	436	43 (9.8)	26 (60.5)	60.5 (44.4 - 75.0)	86.0 (82.2 - 89.3)	95.2 (92.4 - 97.2)	32.1 (22.2 - 43.4)
2014	1 533	143 (9.3)	68 (47.6)	47.6 (39.1 - 56.1)	88.6 (86.8 - 90.3)	94.3 (92.9 - 95.5)	30.1 (24.2 - 36.5)
Sex							
Women	1 042	124 (11.9)	55 (44.3)	44.4 (35.4 - 53.5)	89.5 (87.4 - 91.4)	92.3 (90.3 - 93.9)	36.4 (28.8 - 44.6)
Men	927	62 (6.7)	39 (62.9)	62.9 (49.7 - 74.8)	86.5 (84.0 - 88.7)	97.0 (95.6 - 98.1)	25.0 (18.4 - 32.6)
Age groups, years							
18-59	277	28 (10.1)	15 (53.6)	53.6 (33.9 - 72.5)	88.8 (84.2 - 92.4)	94.4 (90.7 - 97.0)	34.9 (21.0 - 50.9)
60-79	682	55 (8.1)	32 (58.2)	58.2 (44.1 - 71.3)	85.8 (82.8 - 88.4)	95.9 (93.9 - 97.4)	26.4 (18.8 - 35.2)
Above 80	1 010	103 (10.2)	47 (45.6)	45.6 (35.8 - 55.7)	89.4 (87.2 - 91.3)	93.5 (91.7 - 95.1)	32.9 (25.2 - 41.2)

Results are expressed as number of patients (row %), and as percentage (95% confidence interval) for diagnostic accuracy.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2.

[2] Reported undernutrition defined as presence of at least one of the International Classification of Diseases 10th revision codes for undernutrition.

Supplementary Table 5 Diagnostic accuracy of undernutrition codes in hospital administrative discharge database using both 'confirmed' and 'probable' undernutrition as reference, overall and stratified by admission year, gender and age groups, Internal medicine unit of the Lausanne university hospital, for years 2013 and 2014 (complete-case analysis).

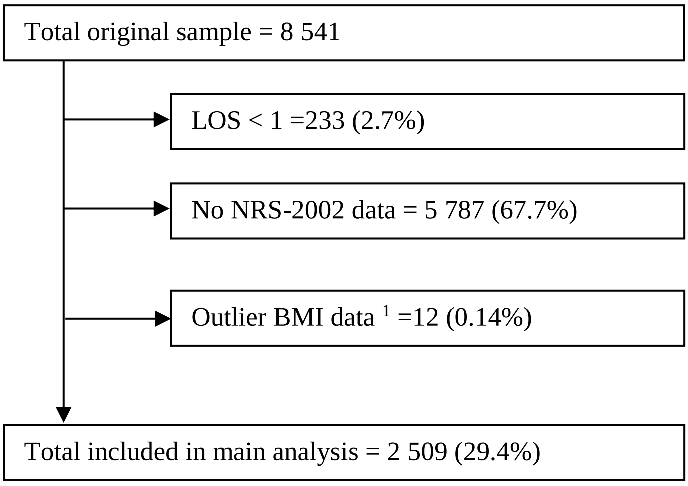
	Total	**Confirmed & probable** [1]	**Reported** [2]	**Sensitivity**	**Specificity**	**Negative predictive value**	**Positive predictive value**
All	1 969	638 (32.4)	217 (34.0)	34.0 (30.3 - 37.8)	93.2 (91.8 - 94.5)	74.7 (72.5 - 76.7)	70.7 (65.2 - 75.7)
Admission, year							
2013	436	146 (33.5)	60 (41.1)	41.1 (33.0 - 49.5)	92.8 (89.1 - 95.5)	75.8 (71.0 - 80.1)	74.1 (63.1 - 83.2)
2014	1 533	492(32.1)	157 (31.9)	31.9 (27.8 - 36.2)	93.4 (91.7 - 94.8)	74.4 (71.9 - 76.7)	69.5 (63.0 - 75.4)
Sex							
Women	1 042	363 (34.8)	106 (29.2)	29.2 (24.6 - 34.2)	93.4 (91.2 - 95.1)	71.2 (68.1 - 74.1)	70.2 (62.2 - 77.4)
Men	927	275 (29.7)	111 (40.4)	40.4 (34.5 - 46.4)	93.1 (90.1 - 94.9)	78.7 (75.7 - 81.6)	71.2 (63.4 - 78.1)
Age groups, years							
18-59	277	71 (25.6)	30 (42.3)	42.3 (30.6 - 54.6)	93.7 (89.5 - 96.6)	82.5 (77.0 - 87.1)	69.8 (53.9 - 82.8)
60-79	682	208 (30.5)	79 (38.0)	38.0 (31.4 - 45.0)	91.1 (88.2 - 93.5)	77.0 (73.3 - 80.4)	65.3 (56.1 - 73.7)
Above 80	1 010	359 (35.5)	108 (30.1)	30.1 (25.4 - 35.1)	94.6 (92.6 - 96.2)	71.0 (67.9 - 74.1)	75.5 (67.6 - 82.3)

Results are expressed as number of patients (row %), and as percentage (95% confidence interval) for diagnostic accuracy.

[1] 'Confirmed' undernutrition defined as having an NRS-2002 score ≥3 and a BMI <18.5 kg/m^2; 'probable' undernutrition defined as an NRS-2002≥3 plus any prescription of nutritional management/support plus a BMI ≥18.5 and <20 kg/m^2 if age <70 years (<22 kg/m^2 if age ≥70 years).

[2] Reported undernutrition defined as presence of at least one of the International Classification of Diseases 10th revision codes for undernutrition.

Supplementary Figure 1 Participant selection procedure



Abbreviations: LOS, Length of hospital stay; NRS-2002, nutrition risk screening; BMI, Body mass index.

[1] BMI<13 or >50 kg/m^2 were considered as outliers

Chapter 7

Large regional disparities in prevalence, management and reimbursement of hospital undernutrition

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Abstract

Background & aims: Undernutrition is a frequent condition among hospitalized patients, with a significant impact on patient's outcome and on hospital costs. Whether undernutrition is reported similarly at the national level has seldom been assessed. We aimed to 1) assess regional differences within Switzerland regarding undernutrition prevalence, management, and cost reimbursement, and 2) identify the factors associated with reporting of undernutrition status and its management.

Methods: Observational cross-sectional study including routine statistics from the Swiss hospital discharge databases for years 2013 and 2014 (seven administrative regions). All adults aged ≥20 with length of hospital stay of at least 1 day were included. Reported undernutrition was defined based on the International Classification of Diseases (ICD)-10 codes. Nutritional management and "reimbursable" undernutrition codes were also assessed.

Results: Of the initial 1 784 855 hospitalizations, 3.6% had reported undernutrition, the prevalence ranging between 1.8% (Ticino) and 4.6% (Mittelland). Use of the different undernutrition-related ICD-10 codes also varied considerably across regions. Multivariable analysis showed a two-fold variation in reported undernutrition: multivariable-adjusted odds ratio and 95% confidence interval relative to Eastern Switzerland: 2.31 (2.23 - 2.38) for Mittelland and 0.74 (0.70 - 0.79) for Ticino. Over half (59.6%) of hospitalizations with reported undernutrition also included information on undernutrition management, the prevalence ranging between 28.6% (Ticino) and 67.2% (Zürich), these findings were further confirmed by multivariable adjustment. Only one third (36.8%) of undernutrition-related codes were reimbursable, the prevalence ranging between 8.3% (Ticino) and 50.7% (Zürich).

Conclusion: In Switzerland, there is considerable regional variation regarding reporting of undernutrition prevalence, management, and cost reimbursement. Undernutrition appears to be insufficiently managed and valued.

Introduction

Undernutrition is a common condition among hospitalized patients, which adversely affects health outcomes. Undernutrition increases length of hospital stay (LOS), morbidity, mortality, and hospital costs (1). Still, hospital undernutrition tends to be under-diagnosed and improperly addressed (2, 3).

Studies at the national level assessing undernutrition prevalence among adult hospitalized patients are scarce. In the Netherlands, two multicenter studies reported undernutrition prevalence levels of 14% and 32% among half a million and 12 883 hospitalized patients, respectively (4, 5). One nationally representative study in the United States reported that 3.4% of hospital discharges had undernutrition-related codes (6). A study conducted in the United Kingdom reported that 25% of patients screened at admission were at medium or high risk of undernutrition (7). Studies regarding the economic impact of undernutrition at the national level are also scarce (8, 9), and indicate that undernutrition is a costly condition. Hence, adequate reporting of nutritional status of patients and its management in hospital discharge data is important for public health (to calculate proper rates and to evaluate performance of hospitals), allocation of resources (i.e. an increase in the number of undernourished patients should be counteracted by an increase in the number of clinical nutrition professionals), and hospital reimbursement rates (10).

Switzerland is a small European country with universal health coverage based on mandatory individual health insurance (11). The country consists of 26 cantons, which have a large autonomy regarding health planning. Hence, guidelines regarding undernutrition screening and management are not implemented at the national level, although efforts have been made for such harmonization for reimbursement purposes (12). Several studies regarding prevalence and cost of undernutrition have been conducted in specific settings (1, 13), but none at the national level. Thus, the primary aim of this study was to assess any geographical differences regarding prevalence of reported undernutrition, management, and cost reimbursement. The secondary aim was to assess the factors associated with reporting of undernutrition status and its management.

Methods

Study sample

Data from the Swiss hospital discharge database for years 2013 to 2014 were used. The database was provided by the Swiss federal office of statistics (http://www.bfs.admin.ch); it covers 98% of public and private hospitals within Switzerland and includes all stays for each hospital. The main cause for hospitalization and the comorbidities are coded using the International Classification of Diseases 10th revision (ICD-10) of the World Health Organization. The procedures are coded using the Swiss classification of surgical interventions (CHOP) (http://www.bfs.admin.ch), which also includes non-surgical interventions such as dietary management.

Eligibility criteria were as follows: adult patients (aged ≥20 years), length of hospital stay >1 day, not having any codes related to pregnancy, childbirth and the puerperium (i.e. ICD-10 codes beginning with letter "O") as main diagnosis, having complete demographic data and information on main diagnosis and mortality. As it was not possible to identify patients, the results relate to the number of discharges and not to the number of patients. Due to Swiss data protection legislation, ages were provided in categories, hence, it was not possible to include hospitalizations for patients aged 18 or 19.

Prevalence and management of undernutrition

Presence of undernutrition was assessed by searching all ICD-10 codes related to nutritional status: E12 (malnutrition-related diabetes mellitus), E40 (kwashiorkor), E41 (nutritional marasmus), E42 (marasmic kwashiorkor), E43 (unspecified severe protein-energy malnutrition), E44 (protein-energy malnutrition of moderate and mild degree), E46 (unspecified protein-energy malnutrition), R63 (R63.0: anorexia, R63.3: feeding difficulties and mismanagement; R63.4: abnormal weight loss, and R63.6: insufficient intake of food and water due to self-neglect) and R64 (cachexia).

Presence of nutritional management was assessed by searching all CHOP codes related to enteral nutrition (96.6 and 96.35), parenteral nutrition (99.15), nutritional advice and therapy (89.0A.32) and multimodal nutritional therapy (89.0A.4*, where *=any number). Multimodal nutritional therapy can be coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file.

Presence of "reimbursable" undernutrition was assessed by searching specific associations of undernutrition-related ICD-10 (E43 and E44) and nutritional management CHOP codes (12).

Demographic and socioeconomic variables

The following variables were extracted: administrative region, year of hospital discharge, sex (male/female), nationality (Swiss/non-Swiss), age group (categorized into 20-39, 40-64 and ≥65 years), main diagnosis at discharge and comorbidities (based on ICD-10 codes, see Supplemental Table 1) and stay in an intensive care unit (ICU, yes/no). Administrative region was categorized into Eastern, Léman, Mittelland, Northwest, Zürich, Central and Ticino based on similar linguistic and cultural characteristics, as previously done (14). Severity of disease was assessed using the Swiss version of the Charlson Comorbidity Index (CCI) and dichotomized into low (CCI<2) and high (CCI≥2) comorbidity status (15).

Statistical analysis

Statistical analyses were performed using Stata 14 (Stata Corp, College Station, TX, USA). Bivariate analyses were performed using Chi-square test for categorical variables. Results were expressed as number of participants (percentage) or as average ± standard deviation. Multivariable analysis was performed using logistic regression and results were expressed as Odds ratio (OR) and 95% confidence interval (CI). All models were adjusted for year of admission, sex, age categories, nationality, main disease categories, ICU stay, and CCI category.

Hospital discharges were further weighted based on sex and age categories distribution of the Swiss population for 2013 and 2014; data were downloaded from the Swiss federal office of statistics. To reduce the likelihood of type I error due to the high number of tests performed, we considered statistical significance for two-sided tests at $p<0.01$. We present the results only for undernutrition-related ICD-10 codes with prevalence ≥2%, which we arbitrarily set as the clinically relevant cutoff.

Code availability

Stata code used in the statistical analysis can be provided upon request.

Ethics statement

The hospital discharge data provisions are part of a Swiss government mandate and no agreement from an ethics committee is necessary. All data were anonymized prior to being used.

Results

Sample selection and characteristics

Of the initial 2 404 545 hospitalizations, 1 784 855 (74.2%) were included in the analysis (**Supplemental Figure 1**). Excluded hospitalizations were more likely to be of younger adults, women, Swiss, no ICU stay, low CCI and patients from Léman, Mittelland and Zürich (**Supplemental Table 2**). **Table 1** summarizes the demographic and clinical characteristics of the included hospitalizations by administrative region. Hospitalizations in Ticino were older (≥65 years), Léman and Ticino had slightly higher proportion of women and non-Swiss hospitalizations. Central Switzerland had the highest proportion of ICU stay and Ticino had the highest proportion of hospitalization with CCI≥2 (Table 1). Results from the raw data (un-weighted) as a sensitivity analysis showed no differences in comparison with the aforementioned results (**Supplemental Table 3**).

Prevalence and determinants of reported undernutrition

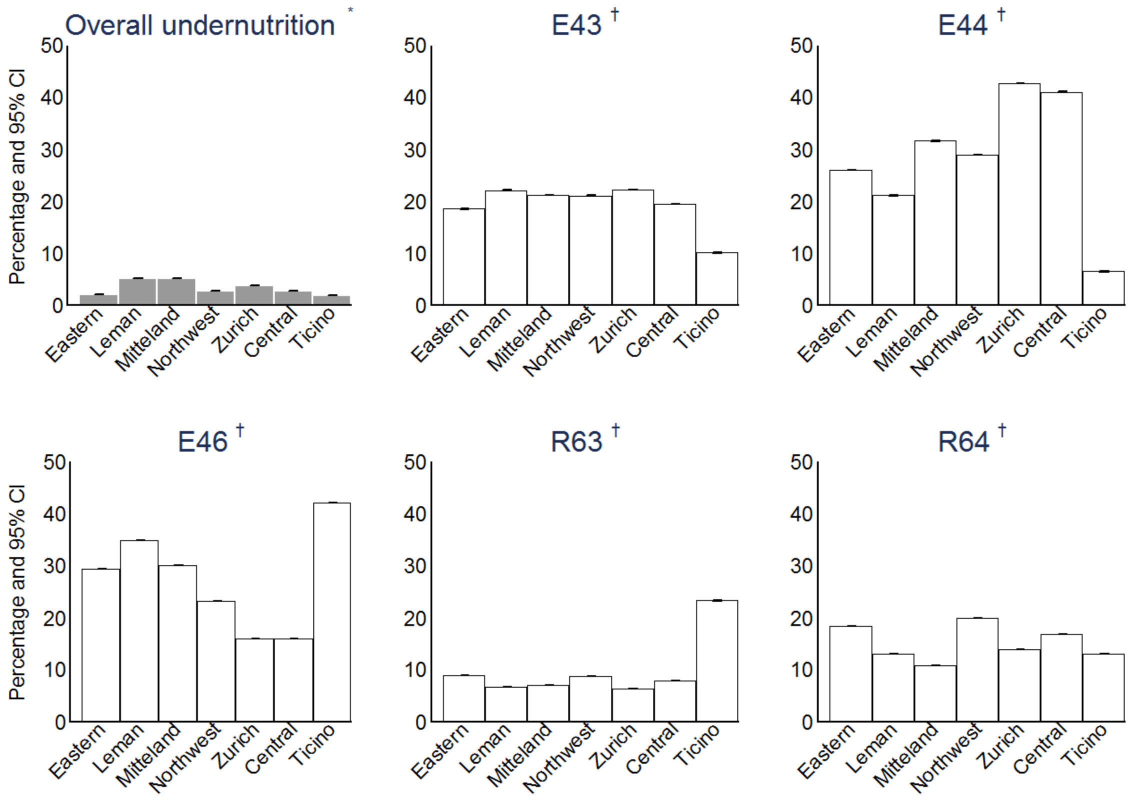
Of the 1 784 855 hospitalizations, 64 243 (3.6%) had undernutrition reported in their discharge files, the prevalence ranging between 1.8% in Ticino to 4.7% in Mittelland (**Figure 1**). The distribution of the most frequent ICD-10 codes for undernutrition (E43, E44, E46, R63 and R64) is shown in Figure 1. Overall, the use of the different codes greatly differed between regions. Code E43 (unspecified severe protein-energy malnutrition) was seldom used in Ticino, code E44 (protein-energy malnutrition of moderate and mild degree) was mostly used in Zürich and Central Switzerland, code E46 (unspecified protein-energy malnutrition) was mostly used in Ticino and Léman, code R63 (symptoms and signs concerning food and fluid intake) was mostly used in Ticino and code R64 (cachexia) was mostly used in Northwest and Eastern Switzerland.

Table 1 Demographic and clinical characteristics of the study population by administrative region, Swiss hospital discharge database, 2013-2014.

Characteristics	**Eastern** (n=272 977)	**Léman** (n=298 815)	**Mittelland** (n=339 629)	**Northwest** (n=342 134)	**Zürich** (n=306 359)	**Central** (n=133 121)	**Ticino** (n=91 820)	**p-value**
Age group, *years*								<0.001
20-39	14.5	13.7	12.6	12.7	16.4	15.2	7.9	
40-64	52.4	47.4	48.5	49.9	50.4	52.9	44.3	
Above 65	33.1	38.9	39.9	37.4	33.2	31.9	47.8	
Sex								<0.001
Man	49.1	46.0	47.0	47.6	48.0	50.4	45.6	
Woman	50.9	54.0	53.0	52.4	52.0	49.6	54.4	
Nationality								<0.001
Swiss	81.9	72.6	89.3	80.8	79.9	84.5	73.0	
Non-Swiss	18.1	27.4	10.7	19.2	20.1	15.5	26.9	
Main diagnosis								<0.001
Malignant	7.3	9.4	8.3	8.7	9.4	7.5	9.9	
Circulatory system	11.7	11.4	12.4	12.0	11.0	9.9	12.6	
Respiratory system	5.5	6.2	5.4	5.8	4.8	5.6	6.9	
Digestive system	10.7	9.2	10.3	10.0	11.2	11.5	9.9	
Infectious	2.5	2.5	3.2	3.0	2.9	3.1	3.0	
Mental & nervous system	13.3	13. 5	12.2	12.2	12.1	11.9	11.6	
Miscellaneous	49.0	47.8	48.2	48.3	48.6	50.5	46.1	
Intensive care unit								<0.001
No	94.5	91.5	93.8	93.5	91.6	91.1	92.4	
Yes	5.5	8.5	6.2	6.5	8. 4	8.9	7.6	
Charlson Index								<0.001
0-1	79.9	75.1	74.5	76.3	75.6	78.3	71.7	
2+	20.1	24.9	25.5	23.7	24.4	21.7	28.3	

Results are expressed as column weighted percentage. Between-group comparisons performed using chi-square test. Results are weighted based on sex and age categories distribution of the Swiss population for years 2013 and 2014.

Figure 1 Prevalence of reported undernutrition, overall and according to the most frequent undernutrition-related International Classification of Diseases 10th revision codes, by administrative region, Swiss hospital discharge database, 2013-2014.



Codes: E43, unspecified severe protein-energy undernutrition; E44, protein-energy malnutrition of moderate and mild degree; E46, unspecified protein-energy malnutrition; R63, includes R63.0 (anorexia), R63.3 (eating difficulties and mismanagement), R63.4 (abnormal weight loss), and R63.6 (insufficient intake of food and water due to self-neglect); R64, cachexia.

[*] Overall prevalence of reported undernutrition using all hospitalizations (n=1 784 855) as denominator.

[†] Proportion of undernutrition-related ICD-10 codes using hospitalizations with reported undernutrition (n=64 243) as denominator.

Results from the multivariable analysis of the factors associated with prevalence of undernutrition (overall and according to the most frequent undernutrition codes) are shown in **Table 2**. Hospitalizations occurring in 2014, of patients aged ≥65 years, of women, of Swiss nationality, including an ICU stay, having higher CCI and infectious disease as main cause were more likely to have undernutrition reported. Compared with Eastern Switzerland, all other regions (except Ticino) had a higher likelihood of reporting undernutrition. These results were consistent for ICD-10 codes E43, E44, R63 and R64, while Zürich, Northwest, and Central Switzerland were less likely to report code E46 (Table 2). Sensitivity analysis based on raw data did not change the results (**Supplemental Table 4**).

Prevalence and determinants of undernutrition management

Of the 64 243 hospitalizations with reported undernutrition, 35 024 (54.5%) reported undernutrition management, the proportions ranging between 28.6% in Ticino and 67.2% in Zürich (**Figure 2**). In all regions, the most prevalent nutritional management was a dietitian consultation, followed by enteral nutrition, parenteral nutrition and multimodal interventions (Figure 2). Multivariable analysis showed that being hospitalized in 2014, presenting with digestive system, infectious, or malignancy as main cause for hospitalization, having ICU stay, and having higher CCI were associated with a higher likelihood of receiving any nutritional management (**Table 3**). The analysis also showed that reporting of any nutritional management and its different types varied between regions. Compared to Eastern Switzerland, Zürich and Central Switzerland had a higher and Léman, Northwest and Ticino a lower likelihood of reporting any nutritional management. All regions (except Central Switzerland) had lower odds of reporting dietitian consultations than Eastern Switzerland. Zürich, Mittelland and Léman had a higher and Ticino a lower likelihood of reporting enteral nutrition. All regions had higher odds of reporting parenteral nutrition than Eastern Switzerland. Finally, all regions (except Ticino) had a higher likelihood of reporting multimodal management than Eastern Switzerland (Table 3). Sensitivity analysis based on raw data did not change the results (**Supplemental Table 5**).

Table 2 Multivariable analysis of the factors associated with undernutrition prevalence and by different undernutrition codes from the International Classification of Diseases 10th revision, Swiss hospital discharge database, 2013-2014.

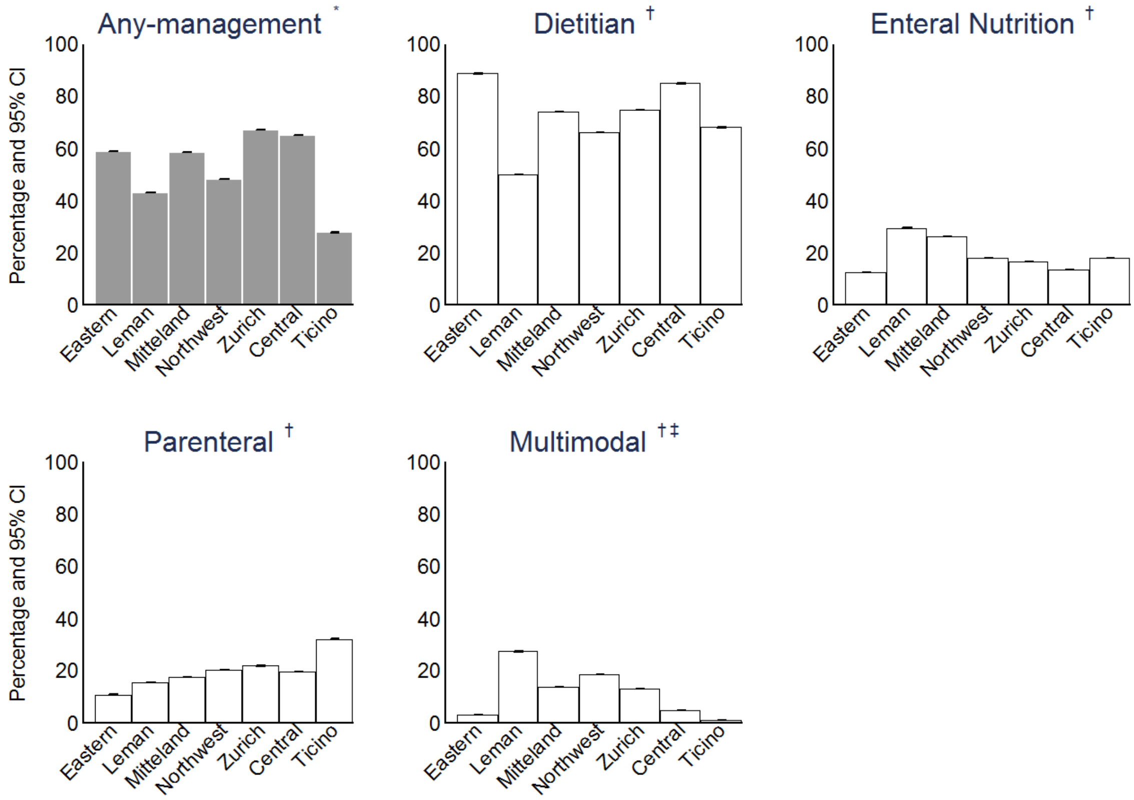
Characteristics	**Any code** (n=64 243)	**Undernutrition-related ICD-10 codes** **E43** (n=13 726)	**E44** (n=19 234)	**E46** (n=17 915)	**R63** (n=4 799)	**R64** (n=8 889)
Year						
2013	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2014	1.31 (1.28 - 1.33)	1.12 (1.08 - 1.16)	1.43 (1.38 - 1.47)	1.90 (1.83 - 1.96)	0.97 (0.91 - 1.03)	0.77 (0.73 - 0.80)
Age group, years						
20-39	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
40-64	1.81 (1.73 - 1.89)	1.68 (1.51 - 1.87)	1.88 (1.73 - 2.05)	2.00 (1.81 - 2.20)	1.36 (1.19 - 1.55)	2.02 (1.79 - 2.29)
Above 65	3.42 (3.27 - 3.58)	3.43 (3.09 - 3.80)	3.16 (2.90 - 3.44)	4.66 (4.23 - 5.13)	2.30 (2.02 - 2.61)	2.66 (2.34 - 3.01)
p-value for trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sex						
Man	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Woman	1.24 (1.22 - 1.27)	1.24 (1.20 - 1.29)	1.22 (1.19 - 1.26)	1.21 (1.18 - 1.25)	1.15 (1.08 - 1.22)	1.35 (1.29 - 1.41)
Nationality						
Swiss	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Non-Swiss	0.81 (0.78 - 0.83)	0.80 (0.76 - 0.85)	0.84 (0.80 - 0.88)	0.83 (0.79 - 0.87)	0.90 (0.83 - 0.99)	0.69 (0.65 - 0.75)
Main diagnosis						
Miscellaneous	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Malignant	1.67 (1.63 - 1.74)	2.42 (2.28 - 2.56)	1.75 (1.67 - 1.84)	1.55 (1.47 - 1.63)	1.34 (1.21 - 1.49)	2.08 (1.94 - 2.23)
Circulatory system	0.63 (0.61 - 0.65)	0.70 (0.65 - 0.75)	0.74 (0.70 - 0.79)	0.72 (0.68 - 0.76)	0.62 (0.55 - 0.70)	0.67 (0.61 - 0.73)
Respiratory system	2.07 (2.00 - 2.14)	2.70 (2.53 - 2.89)	2.17 (2.05 - 2.30)	1.61 (1.51 - 1.71)	1.15 (1.01 - 1.32)	3.85 (3.58 - 4.14)
Digestive system	1.90 (1.84 - 1.95)	2.80 (2.64 - 2.97)	2.27 (2.16 - 2.38)	1.74 (1.65 - 1.84)	1.33 (1.20 - 1.48)	1.65 (1.51 - 1.80)
Infectious	2.41 (2.32 - 2.51)	3.24 (2.99 - 3.51)	2.57 (2.40 - 2.76)	2.26 (2.10 - 2.43)	1.89 (1.63 - 2.18)	2.50 (2.24 - 2.79)
Mental & nervous system	1.19 (1.15 - 1.23)	1.24 (1.14 - 1.34)	1.11 (1.04 - 1.19)	1.27 (1.20 - 1.36)	1.74 (1.58 - 1.92)	1.48 (1.34 - 1.62)
Intensive care unit						
No	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Yes	1.96 (1.91 - 2.01)	2.56 (2.44 - 2.69)	2.14 (2.05 - 2.24)	1.66 (1.58 - 1.74)	1.23 (1.10 - 1.38)	1.28 (1.19 - 1.37)

Charlson index						
0-1	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2+	3.49 (3.41 - 3.56)	3.39 (3.23 - 3.56)	3.61 (3.47 - 3.76)	2.99 (2.87 - 3.11)	2.04 (1.88 - 2.20)	4.46 (4.20 - 4.74)
Region						
Eastern	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Léman	2.24 (2.16 - 2.31)	2.51 (2.34 - 2.70)	1.74 (1.63 - 1.86)	2.59 (2.45 - 2.75)	1.69 (1.50 - 1.90)	1.45 (1.34 - 1.58)
Mittelland	2.31 (2.23 - 2.38)	2.52 (2.34 - 2.71)	2.72 (2.56 - 2.89)	2.26 (2.13 - 2.39)	1.86 (1.67 - 2.08)	1.24 (1.14 - 1.34)
Northwest	1.19 (1.15 - 1.23)	1.34 (1.24 - 1.45)	1.32 (1.24 - 1.42)	0.92 (0.86 - 0.99)	1.22 (1.08 - 1.38)	1.27 (1.17 - 1.38)
Zürich	1.69 (1.63 - 1.75)	1.94 (1.80 - 2.09)	2.73 (2.56 - 2.90)	0.90 (0.84 - 0.96)	1.24 (1.10 - 1.41)	1.24 (1.14 - 1.35)
Central	1.18 (1.13 - 1.24)	1.20 (1.09 - 1.33)	1.86 (1.72 - 2.01)	0.64 (0.57 - 0.70)	1.09 (0.93 - 1.28)	1.08 (0.97 - 1.21)
Ticino	0.74 (0.70 - 0.79)	0.40 (0.33 - 0.47)	0.18 (0.15 - 0.22)	1.07 (0.98 - 1.17)	2.18 (1.90 - 2.51)	0.52 (0.45 - 0.61)

Codes: E43, unspecified severe protein-energy malnutrition; E44, protein-energy malnutrition of moderate and mild degree; E46, unspecified protein-energy malnutrition; R63, includes R63.0 (anorexia), R63.3 (eating difficulties and mismanagement), R63.4 (abnormal weight loss), and R63.6 (insufficient intake of food and water due to self-neglect); R64, cachexia.

Data are odd ratio (95% confidence Intervals). Multivariable analysis performed using logistic regression adjusting for all variables in the table. Results are weighted based on sex and age categories distribution of the Swiss population for years 2013 and 2014.

Figure 2 Prevalence of reported nutritional management among hospitalizations with any International Classification of Diseases 10th revision codes of undernutrition, by administrative region, Swiss hospital discharge database, 2013-2014.



* Overall prevalence of reported undernutrition using hospitalizations with any nutrition-related ICD-10 codes (n=64 243) as denominator.

† Proportion of different types of nutritional management using hospitalizations with reported nutritional management (n=35 024) as denominator.

‡ Multimodal nutritional therapy is coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file.

Overall percentage of different types of nutritional management is higher than 100% because several patients received multiple managements (i.e. dietitian + enteral nutrition).

Table 3 Multivariable analysis of the factors associated with nutritional management among hospitalizations with any International Classification of Diseases 10th revision codes of undernutrition, Swiss hospital discharge database, 2013-2014 (n=64 243).

		Different types of nutritional management			
	Any management (n= 35 024)	**Dietitian consultation** (n= 24 937)	**Enteral nutrition** (n= 7 170)	**Parenteral nutrition** (n= 5 870)	**Multimodal intervention**[1] (n= 5 399)
Year					
2013	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2014	1.43 (1.39 - 1.49)	1.55 (1.50 - 1.61)	0.98 (0.93 - 1.04)	1.04 (0.97 - 1.11)	1.19 (1.12 - 1.26)
Age group - *years*					
20-39	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
40-64	1.04 (0.94 - 1.15)	1.01 (0.91 - 1.12)	0.86 (0.75 - 0.98)	0.75 (0.64 - 0.87)	1.20 (1.00 - 1.45)
Above 65	0.99 (0.90 - 1.08)	1.02 (0.93 - 1.13)	0.59 (0.52 - 0.68)	0.49 (0.42 - 0.56)	1.43 (1.19 - 1.72)
p-value for trend	0.77	0.65	<0.001	<0.001	<0.001
Sex					
Man	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Woman	0.97 (0.94 - 1.01)	1.02 (0.99 - 1.06)	0.73 (0.69 - 0.78)	1.10 (1.03 - 1.17)	1.01 (0.95 - 1.07)
Nationality					
Swiss	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Non-Swiss	0.92 (0.87 - 0.97)	0.90 (0.85 - 0.95)	1.06 (0.97 - 1.15)	1.03 (0.94 - 1.14)	0.91 (0.83 - 1.00)
Main diagnosis					
Miscellaneous	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Malignant	1.55 (1.47 - 1.64)	1.26 (1.19 - 1.33)	1.65 (1.51 - 1.80)	3.65 (3.29 - 4.06)	0.93 (0.85 - 1.03)
Circulatory system	0.98 (0.92 - 1.04)	0.95 (0.89 - 1.01)	1.38 (1.25 - 1.53)	0.68 (0.58 - 0.79)	1.02 (0.92 - 1.13)
Respiratory system	0.97 (0.92 - 1.04)	1.03 (0.97 - 1.10)	1.11 (1.00 - 1.23)	0.50 (0.42 - 0.59)	0.89 (0.80 - 0.99)
Digestive system	1.80 (1.69 - 1.91)	1.40 (1.32 - 1.49)	1.42 (1.29 - 1.57)	4.34 (3.94 - 4.79)	1.16 (1.05 - 1.29)
Infectious	1.40 (1.29 - 1.51)	1.12 (1.04 - 1.21)	1.78 (1.59 - 1.98)	1.61 (1.40 - 1.85)	1.20 (1.06 - 1.36)
Mental & nervous system	0.82 (0.76 - 0.88)	0.81 (0.75 - 0.88)	1.31 (1.15 - 1.48)	0.40 (0.31 - 0.51)	1.05 (0.93 - 1.18)
Intensive care unit					
No	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Yes	2.99 (2.83 - 3.16)	1.43 (1.36 - 1.50)	5.17 (4.87 - 5.49)	5.79 (5.42 - 6.18)	1.01 (0.93 - 1.10)
Charlson index					
0-1	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2+	1.24 (1.20 - 1.30)	1.2 (1.15 - 1.25)	1.29 (1.2 - 1.38)	1.11 (1.02 - 1.21)	1.00 (0.93 - 1.07)
Region					
Eastern	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Léman	0.54 (0.50 - 0.57)	0.26 (0.24 - 0.27)	1.85 (1.64 - 2.10)	1.21 (1.04 - 1.40)	7.35 (6.04 - 8.94)
Mittelland	0.97 (0.91 - 1.04)	0.70 (0.66 - 0.75)	2.14 (1.90 - 2.42)	1.74 (1.51 - 1.99)	4.76 (3.91 - 5.80)

Northwest	0.61 (0.57 - 0.66)	0.41 (0.38 - 0.44)	1.11 (0.97 - 1.27)	1.62 (1.40 - 1.88)	5.31 (4.34 - 6.50)
Zürich	1.26 (1.17 - 1.36)	0.88 (0.82 - 0.94)	1.16 (1.02 - 1.32)	1.92 (1.67 - 2.21)	5.37 (4.39 - 6.56)
Central	1.09 (0.99 - 1.20)	1.04 (0.95 - 1.14)	0.84 (0.71 - 1.01)	1.59 (1.34 - 1.89)	1.71 (1.30 - 2.25)
Ticino	0.28 (0.25 - 0.32)	0.23 (0.20 - 0.26)	0.74 (0.57 - 0.95)	2.12 (1.68 - 2.67)	0.17 (0.07 - 0.44)

Abbreviations: CI, Confidence Interval; OR, Odd ratio.

[1] Multimodal nutritional therapy is coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file.

Data are odd ratio (95% confidence Intervals). Multivariable analysis performed using logistic regression adjusting for all variables in the table. Results are weighted based on sex and age categories distribution of the Swiss population for years 2013 and 2014.

Frequency of undernutrition codes allowing reimbursement

Frequencies of undernutrition codes allowing reimbursement of nutrition-related costs by administrative regions are shown in **Table 4**. Over two thirds of E43 and E44 codes were considered "reimbursable", the lowest proportions being found in Ticino and the highest in Central Switzerland or Zürich. When all undernutrition-related codes were considered, only one third was considered "reimbursable", the lowest proportions being again found in Ticino and the highest in Zürich. More details regarding the associations between undernutrition-related ICD-10 codes and CHOP codes for all of Switzerland are provided in **Supplementary Table 6**.

Discussion

This is one of the largest, nationally-representative studies regarding prevalence of reported undernutrition among hospitalized patients. It is also one of the few assessing management and cost reimbursement of reported undernutrition at the national level. Our results show that prevalence of reported undernutrition, undernutrition coding, nutritional management and even valuation of undernutrition differ considerably across Swiss administrative regions.

Prevalence and determinants of reported undernutrition

Prevalence of reported undernutrition was 3.6%, a finding in agreement with the only previous study that used undernutrition-related ICD-9 codes and that reported a prevalence rate of 3.2% among United States hospital discharges for 2010 (6). However, this value is considerably lower than those reported in other studies using different screening tools: between 14% and 32% at national level in Europe (4, 5, 7) and between 13% and 20% in different hospitals in Switzerland (1, 13). This disparity between reported and objectively assessed prevalence of undernutrition is in line with generally accepted issues regarding undernutrition underestimation, under-recognition and under-reporting in hospital settings (16). Indeed, a study conducted in England showed that the prevalence of undernutrition using government statistics was less than 1% of the prevalence obtained in national surveys using the Malnutrition Universal Screening Tool (17). Interestingly, the prevalence of reported undernutrition was similar in Léman, Mittelland and Zürich regions, possibly due to the presence of highly urbanized cantons like Geneva, Bern, and Zürich, which could lead to a better recognition and detection of health problems by health care professionals (18).

Table 4 Frequency of undernutrition codes allowing reimbursement of nutritionally related costs, by administrative region, Swiss hospital discharge database, 2013-2014.

	Switzerland (n=64 243)	**Eastern** (n=5 751)	**Léman** (n=15 231)	**Mittelland** (n=17 320)	**Northwest** (n=9 233)	**Zürich** (n=11 377)	**Central** (n=3 612)	**Ticino** (n=1 719)
E43								
All (N total)	13 695	1 103	3 340	3 752	1 946	2 639	751	164
Reimbursable *(%)* [1]	65.45	75.81	48.85	70.91	64.39	72.62	78.21	48.05
E44								
All (N total)	19 210	1 511	3 231	5 384	2 686	4 795	1 498	105
Reimbursable *(%)* [1]	77.37	77.78	65.83	83.45	69.16	81.25	82.01	54.32
All reimbursable *(%)* [2]	36.86	34.12	24.69	41.26	33.53	50.73	48.81	8.32

Codes: E43, unspecified severe protein-energy malnutrition; E44, protein-energy malnutrition of moderate and mild degree.

Results are expressed as number of patients (%), [1] based on corresponding codes, [2] based on all undernutrition-related codes (n=66 243). Results are weighted based on sex and age categories distribution of the Swiss population for years 2013 and 2014.

Hospital discharge data can serve several purposes. First, they allow monitoring of the health status of the population and allow planning of health infrastructures to adequately respond to future needs. Second, via the DRG system, they allow reimbursement of hospital costs by the Swiss health system. This duality of purposes can lead to contradictory behaviors, as hospitals might be tempted to favor more "economically interesting" codes, thus biasing the distribution of the diseases. In this study, considerable regional variations were found regarding the use of undernutrition-related ICD-10 codes, even though in January 2014 the Swiss Society of Clinical Nutrition issued recommendations for undernutrition coding (12). Whether those differences are related to reimbursement issues or to regional disparities in coding procedures remains to be assessed. Overall, our results indicate that in Switzerland, undernutrition is seldom reported in hospital discharge data, and appears to be insufficiently managed. Further, coding procedures vary considerably between regions. Hence, a national or common cantonal policy to ensure proper undernutrition detection and management is imperative and should be embedded in routine hospital practice.

Patients aged ≥65 years or discharged with a diagnosis of infectious diseases had the highest likelihood of being reported as undernourished. This result is in agreement with the nationally representative studies from the United States (6) and Brazil (19). Overall, our results suggest that, despite underestimating overall prevalence of undernutrition, hospital discharge data can be used to assess the clinical and individual determinants of undernutrition (20-23).

Prevalence and determinants of undernutrition management

International guidelines recommend that nutritional support be initiated immediately among undernourished patients (24, 25). Still, only half of hospitalizations with reported undernutrition also included a code related to undernutrition management. This finding is in line with a previous study in one Swiss hospital, where less than half of patients nutritionally 'at-risk' received nutritional support (13). In addition, considerable differences were found between regions. The reasons for such regional heterogeneity in undernutrition reporting could partly be due to the different cantonal health care policies or even to differing hospital guidelines (1, 26). Moreover, previous studies showed that recommendations regarding undernutrition screening and support are often neglected or not implemented (13, 17, 25, 27).

Dietitian consultation was the most commonly reported nutritional management, a finding in agreement with a previous Swiss study (1). Dietitian consultation is a first line treatment in malnourished patients, and should be included in any management of malnourished patients.

Frequency of undernutrition codes allowing reimbursement

Undernutrition among hospitalized patients incurs extra hospitalization costs (8, 9, 17), mainly due to increased LOS (4). In this study, only one third of all undernutrition-related ICD-10 codes and slightly over two-thirds of the E43 and E44 codes were associated with the proper CHOP codes to be considered “reimbursable”. These findings suggest that undernutrition status is undervalued in hospital discharge data, as only a small percentage of all codes will be eligible for reimbursement. Whether this undervaluation is due to inadequate documentation of nutritional management or inadequate coding of undernutrition status remains to be assessed. Further, it should be noted that not all “reimbursable” ICD-10 – CHOP codes associations actually increase reimbursements, as they have to be considered with the other comorbidities for the calculation of the DRG (28). Again, considerable differences were found between administrative regions, suggesting that coding procedures are differently applied. Noteworthy, the very low proportion of “reimbursable” codes in Ticino might significantly impact hospital reimbursements compared to other regions. It would be of interest to quantify this financial impact and to evaluate the effect of changes in coding procedures in this region. These findings are in agreement with previous literature mentioning that better reporting and coding for undernutrition can have a positive effect on hospital revenues and reimbursement (29). Proper reimbursement could only be achieved through an interdisciplinary program including early identification, proper treatment and documentation of undernutrition (10, 27, 30).

Strengths and limitations

The strength of this study includes its large and representative sample from 98% of Swiss hospitals and the inclusion of all undernutrition-related ICD-10 codes in the analysis. Nevertheless, several limitations must be acknowledged. Firstly, prevalence was based on ICD-10 codes, and not on objective assessment of undernutrition, hence, prevalence rates were underestimated but in line with similar studies. Secondly, it was not possible to assess if underreporting rates were comparable between regions, which could have explained the differences regarding prevalence of undernutrition reporting. As there are no other studies assessing regional differences in undernutrition reporting within a country, it would be imperative that our results be replicated and that underreporting rates be established for each

Swiss region by comparing objectively assessed and reported undernutrition. Finally, in the absence of an international health policy regarding undernutrition recognition, management and documentation, our results obtained for Switzerland might not be extrapolated to other countries. Still, and as reported above, our results were in agreement with the previous studies from other countries.

Conclusion

In Switzerland, there is considerable regional variation of reporting of undernutrition prevalence, management, and cost reimbursement. Undernutrition appears to be insufficiently managed and valued.

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Supplementary Materials

Supplementary Table 1 International classification of diseases, 10th revision codes used to categorize the main diagnosis at discharge.

Codes	Main diagnosis
C00-D09	Malignant
I00-I99	Circulatory system
J00-J99	Respiratory system
K00-K93	Digestive system
A00-B00	Infectious
F00-F99; G00-G99	Mental & behavioral disorder/ Nervous system
All others	Miscellaneous

Supplementary Table 2 Comparison between included and excluded participants.

Characteristics	Included (n=1 784 855)	Excluded (n=619 690)	p-value
Age group, years			<0.001
20-39	13.0	45.2	
40-64	35.5	29.5	
Above 65	51.5	25.3	
Sex			<0.001
Man	48.8	35.1	
Woman	51.2	64.9	
Nationality			<0.001
Swiss	82.8	73.7	
Non-Swiss	17.2	26.3	
Main diagnosis			<0.001
Malignant	8.9	3.2	
Circulatory system	13.0	10.7	
Respiratory system	5.9	1.9	
Digestive system	10.1	5.3	
Infectious	3.0	1.0	
Mental & nervous system	11.3	6.1	
Miscellaneous	47.8	71.8	
Intensive care unit			<0.001
No	92.5	97.1	
Yes	7.5	2.9	
Charlson Index			<0.001
0-1	73.1	92.0	
2+	26.9	8.0	
Region			<0.001
Eastern	15.3	11.9	
Léman	16.7	21.4	
Mittelland	19.0	19.9	
Northwest	19.2	15.6	
Zürich	17.2	19.7	
Central	7.5	6.9	
Ticino	5.1	4.6	

Results are expressed as column percentage. Between-group comparisons performed using chi-square test.

Supplementary Table 3 Demographic and clinical characteristics of the study population by administrative region, Swiss hospital discharge database, 2013-2014, non-weighted data

Characteristics	**Eastern** (n=272 977)	**Léman** (n=298 815)	**Mittelland** (n=339 629)	**Northwest** (n=342 134)	**Zürich** (n=306 359)	**Central** (n=133 121)	**Ticino** (n=91 820)	**p-value**
Age group, *years*								<0.001
20-39	38 647 (14.2)	35 635 (11.9)	42 532 (12.5)	43 412 (12.7)	43 677 (14.2)	19 427 (14.6)	8 427 (9.2)	
40-64	103 285 (37.8)	99 120 (33.2)	118 834 (35.0)	121 116 (35.4)	111 729 (36.5)	49 444 (37.1)	29 325 (31.9)	
Above 65	131 045 (48.0)	164 060 (54.9)	178 263 (52.5)	177 606 (51.9)	150 953 (49.3)	64 250 (48.3)	54 068 (58.9)	
Sex								<0.001
Man	134 884 (49.4)	143 308 (48.0)	165 042 (48.6)	166 265 (48.6)	149 825 (48.9)	66 684 (50.1)	44 432 (48.4)	
Woman	138 093 (50.6)	155 507 (52.0)	174 587 (51.4)	175 869 (51.4)	156 534 (51.1)	66 437 (49.9)	47 388 (51.6)	
Nationality								<0.001
Swiss	228 268 (83.6)	225 155 (75.3)	306 883 (90.4)	283 107 (82.7)	250 689 (81.8)	115 111 (86.5)	67 815 (73.9)	
Non-Swiss	44 709 (16.4)	73 660 (24.7)	32 746 (9.6)	59 027 (17.3)	55 670 (18.2)	18 010 (13.5)	24 005 (26.1)	
Main diagnosis								<0.001
Malignant	20 994 (7.7)	28 787 (9.6)	28 755 (8.5)	30 591 (8.9)	30 038 (9.8)	10 619 (8.0)	8 997 (9.8)	
Circulatory system	35 688 (13.1)	38 519 (12.9)	46 239 (13.6)	45 171 (13.2)	38 874 (12.7)	15 179 (11.4)	12 516 (13.6)	
Respiratory system	15 365 (5.6)	20 285 (6.8)	19 354 (5.7)	20 638 (6.0)	15 388 (5.0)	7 753 (5.8)	6 782 (7.4)	
Digestive system	28 651 (10.5)	26 554 (8.9)	34 281 (10.1)	33 199 (9.7)	32 992 (10.8)	14 926 (11.2)	8 886 (9.7)	
Infectious	7 113 (2.6)	7 824 (2.6)	11 658 (3.4)	10 841 (3.2)	9 267 (3.0)	4 454 (3.4)	2 843 (3.1)	
Mental & nervous system	32 896 (12.1)	35 850 (12.0)	37 940 (11.2)	38 401 (11.2)	33 042 (10.8)	14 274 (10.7)	9 980 (10.9)	
Miscellaneous	132 270 (48.5)	140 996 (47.2)	161 402 (47.5)	163 293 (47.7)	146 758 (47.9)	65 916 (49.5)	41 816 (45.5)	
Intensive care unit								<0.001
No	257 045 (94.2)	272 796 (91.3)	317 692 (93.5)	318 812 (93.2)	279 386 (91.2)	120 429 (90.5)	84 537 (92.1)	
Yes	15 932 (5.8)	26 019 (8.7)	21 937 (6.5)	23 322 (6.8)	26 973 (8.8)	12 692 (9.5)	7 283 (7.9)	
Charlson Index								<0.001
0-1	210 434 (77.1)	216 048 (72.3)	243 102 (71.6)	251 086 (73.4)	220 531 (72)	99 443 (74.7)	63 796 (69.5)	
2+	62 543 (22.9)	82 767 (27.7)	96 527 (28.4)	91 048 (26.6)	85 828 (28)	33 678 (25.3)	28 024 (30.5)	

Results are expressed as number of patients (column %). Between-group comparisons performed using chi-square test.

Supplementary Table 4 Multivariable analysis of the factors associated with undernutrition and by different undernutrition codes from the International classification of diseases 10th revision, Swiss hospital discharge database, 2013-2014, non-weighted data.

Characteristics	Any code (n=64 243)	Undernutrition-related ICD-10 codes				
		E43 (n=13 726)	E44 (n=19 234)	E46 (n=17 915)	R63 (n=4 799)	R64 (n=8 889)
Year						
2013	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2014	1.32 (1.29 - 1.34)	1.13 (1.09 - 1.16)	1.43 (1.38 - 1.47)	1.91 (1.85 - 1.97)	0.95 (0.90 - 1.01)	0.77 (0.74 - 0.80)
Age group, years						
20-39	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
40-64	1.89 (1.80 - 1.98)	1.76 (1.58 - 1.95)	1.99 (1.83 - 2.17)	2.08 (1.89 - 2.30)	1.39 (1.22 - 1.58)	2.15 (1.90 - 2.44)
65+	3.62 (3.46 - 3.79)	3.63 (3.28 - 4.02)	3.41 (3.14 - 3.70)	4.91 (4.47 - 5.40)	2.38 (2.10 - 2.07)	2.89 (2.55 - 3.26)
p-value for trend	0.001	0.001	0.001	0.001	0.001	0.001
Sex						
Man	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Woman	1.27 (1.25 - 1.29)	1.27 (1.23 - 1.32)	1.25 (1.21 - 1.29)	1.25 (1.22 - 1.29)	1.17 (1.11 - 1.24)	1.36 (1.30 - 1.42)
Nationality						
Swiss	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Non-Swiss	0.82 (0.80 - 0.84)	0.82 (0.78 - 0.87)	0.86 (0.82 - 0.90)	0.84 (0.80 - 0.88)	0.93 (0.85 - 1.01)	0.71 (0.66 - 0.76)
Main diagnosis						
Miscellaneous	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Malignant	1.65 (1.60 - 1.69)	2.41 (2.28 - 2.54)	1.66 (1.58 - 1.73)	1.48 (1.41 - 1.55)	1.31 (1.19 - 1.44)	2.10 (1.96 - 2.24)
Circulatory system	0.65 (0.63 - 0.67)	0.72 (0.67 - 0.77)	0.76 (0.72 - 0.80)	0.72 (0.69 - 0.76)	0.63 (0.57 - 0.70)	0.68 (0.62 - 0.74)
Respiratory system	1.99 (1.93 - 2.05)	2.62 (2.47 - 2.79)	2.04 (1.93 - 2.15)	1.54 (1.46 - 1.63)	1.12 (0.99 - 1.26)	3.65 (3.41 - 3.91)
Digestive system	1.77 (1.72 - 1.82)	2.60 (2.46 - 2.76)	2.05 (1.96 - 2.15)	1.60 (1.52 - 1.68)	1.31 (1.19 - 1.45)	1.54(1.42 - 1.68)
Infectious	2.21 (2.13 - 2.30)	3.00 (2.79 - 3.23)	2.36 (2.22 - 2.52)	2.02 (1.89 - 2.17)	1.69 (1.47 - 1.93)	2.24 (2.02 - 2.48)
Mental & nervous system	1.21 (1.17 - 1.25)	1.25 (1.16 - 1.36)	1.16 (1.09 - 1.23)	1.27 (1.19 - 1.34)	1.75 (1.60 - 1.92)	1.46 (1.34 - 1.60)
Intensive care unit						
No	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Yes	1.82 (1.78 - 1.86)	2.36 (2.25 - 2.46)	2.02 (1.94 - 2.10)	1.51 (1.44 - 1.58)	1.11 (1.01 - 1.23)	1.22 (1.14 - 1.30)

Charlson Index						
0-1	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2+	3.10 (3.04 - 3.16)	3.04 (2.92 - 3.18)	3.18 (3.06 - 3.29)	2.71 (2.62 - 2.81)	1.92 (1.79 - 2.06)	3.82 (3.62 - 4.03)
Region						
Eastern	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Léman	2.24 (2.17 - 2.31)	2.41 (2.25 - 2.58)	1.73 (1.62 - 1.84)	2.59 (2.45 - 2.74)	1.74 (1.56 - 1.95)	1.51 (1.40 - 1.63)
Mittelland	2.26 (2.19 - 2.33)	2.44 (2.28 - 2.61)	2.59 (2.44 - 2.74)	2.21 (2.09 - 2.34)	1.89 (1.70 - 2.10)	1.29 (1.19 - 1.39)
Northwest	1.17 (1.13 - 1.21)	1.27 (1.18 - 1.37)	1.29 (1.21 - 1.38)	0.93 (0.87 - 0.99)	1.22 (1.09 - 1.37)	1.28 (1.18 - 1.38)
Zürich	1.63 (1.58 - 1.68)	1.88 (1.75 - 2.02)	2.56 (2.42 - 2.72)	0.87 (0.82 - 0.93)	1.29 (1.15 - 1.45)	1.21 (1.11 - 1.31)
Central	1.19 (1.14 - 1.24)	1.24 (1.13 - 1.36)	1.86 (1.73 - 2.00)	0.63 (0.57 - 0.69)	1.10 (0.94 - 1.28)	1.09 (0.99 - 1.21)
Ticino	0.72 (0.69 - 0.77)	0.35 (0.30 - 0.42)	0.16 (0.13 - 0.20)	1.06 (0.96 - 1.15)	2.23 (1.95 - 2.56)	0.55 (0.47 - 0.64)

Codes: E43, unspecified severe protein-energy malnutrition; E44, protein-energy malnutrition of moderate and mild degree; E46, unspecified protein-energy malnutrition; R63, includes R63.3 (eating difficulties and mismanagement) R63.4 (abnormal weight loss), and R63.6 (insufficient intake of food and water due to self-neglect); R64, cachexia. Data are odd ratio (95% confidence Intervals). Multivariable analysis performed using logistic regression adjusting for all variables in the table. Results are weighted based on sex and age categories distribution of the Swiss population for years 2013 and 2014.

Supplementary Table 5 Multivariable analysis of the factors associated with nutritional management among hospitalizations with any International Classification of Diseases 10th revision codes of undernutrition, Swiss hospital discharge database, 2013-2014 (n=64 243).

		Different types of nutritional management			
Characteristics	**Any management** (n= 35 024)	**Dietitian consultation** (n= 24 937)	**Enteral nutrition** (n= 7 170)	**Parenteral nutrition** (n= 5 870)	**Multimodal intervention**[1] (n= 5 399)
Year					
2013	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2014	1.42 (1.38 - 1.46)	1.53 (1.47 - 1.58)	0.96 (0.91 - 1.02)	1.02 (0.96 - 1.09)	1.20 (1.14 - 1.28)
Age group - years					
20-39	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
40-64	1.04 (0.95 - 1.15)	1.01 (0.91 - 1.11)	0.85 (0.74 - 0.97)	0.74 (0.64 - 0.85)	1.19 (0.99 - 1.44)
Above 65	0.99 (0.90 - 1.09)	1.02 (0.93 - 1.13)	0.60 (0.52 - 0.68)	0.49 (0.42 - 0.56)	1.42 (1.18 - 1.71)
p-value for trend	0.90	0.65	<0.001	<0.001	<0.001
Sex					
Man	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Woman	0.96 (0.93 - 1.00)	1.01 (0.98 - 1.05)	0.70 (0.67 - 0.74)	1.06 (1.00 - 1.13)	1.00 (0.94 - 1.06)
Nationality					
Swiss	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Non-Swiss	0.90 (0.86 - 0.95)	0.88 (0.83 - 0.93)	1.06 (0.98 - 1.15)	1.00 (0.92 - 1.09)	0.92 (0.84 - 1.01)
Main diagnosis					
Miscellaneous	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Malignant	1.54 (1.47 - 1.62)	1.26 (1.19 - 1.32)	1.77 (1.63 - 1.92)	3.80 (3.46 - 4.18)	0.94 (0.86 - 1.03)
Circulatory system	0.99 (0.93 - 1.05)	0.94 (0.88 - 1.00)	1.43 (1.29 - 1.57)	0.69 (0.59 - 0.79)	1.05 (0.95 - 1.16)
Respiratory system	1.00 (0.94 - 1.06)	1.03 (0.97 - 1.09)	1.16 (1.05 - 1.28)	0.50 (0.42 - 0.59)	0.94 (0.85 - 1.04)
Digestive system	1.77 (1.67 - 1.88)	1.38 (1.30 - 1.46)	1.49 (1.36 - 1.63)	4.59 (4.19 - 5.04)	1.14 (1.04 - 1.26)
Infectious	1.41 (1.31 - 1.52)	1.12 (1.04 - 1.20)	1.85 (1.66 - 2.05)	1.64 (1.44 - 1.86)	1.26 (1.12 - 1.43)
Mental & nervous system	0.85 (0.79 - 0.91)	0.82 (0.76 - 0.88)	1.39 (1.23 - 1.57)	0.40 (0.31 - 0.50)	1.08 (0.96 - 1.21)
Intensive care unit					
No	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Yes	3.01 (2.85 - 3.17)	1.43 (1.36 - 1.5)	5.25 (4.97 - 5.56)	6.46 (6.07 - 6.88)	1.00 (0.92 - 1.08)
Charlson index					
0-1	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
2+	1.21 (1.16 - 1.26)	1.18 (1.13 - 1.23)	1.28 (1.20 - 1.36)	1.08 (1.00 - 1.70)	0.99 (0.93 - 1.06)
Region					
Eastern	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Léman	0.54 (0.50 - 0.57)	0.26 (0.24 - 0.28)	1.86 (1.66 - 2.10)	1.25 (1.09 - 1.44)	6.77 (5.60 - 8.19)

Mittelland	0.95 (0.89 - 1.01)	0.70 (0.66 - 0.75)	2.12 (1.89 - 2.38)	1.74 (1.52 - 1.98)	4.22 (3.48 - 5.11)
Northwest	0.62 (0.58 - 0.67)	0.41 (0.39 - 0.44)	1.11 (0.97 - 1.26)	1.72 (1.49 - 1.98)	5.00 (4.11 - 6.09)
Zürich	1.31 (1.22 - 1.40)	0.91 (0.85 - 0.97)	1.18 (1.04 - 1.33)	1.93 (1.69 - 2.20)	4.99 (4.11 - 6.06)
Central	1.14 (1.05 - 1.25)	1.10 (1.01 - 1.20)	0.85 (0.72 - 1.00)	1.70 (1.42 - 1.96)	1.61 (1.24 - 2.09)
Ticino	0.27 (0.24 - 0.31)	0.23 (0.19 - 0.26)	0.73 (0.57 - 0.94)	2.10 (1.69 - 2.61)	0.14 (0.06 - 0.34)

Abbreviations: CI, Confidence Interval; OR, Odd ratio.

[1] Multimodal nutritional therapy is coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file. Data are odd ratio (95% confidence Intervals). Multivariable analysis performed using logistic regression adjusting for all variables in the table.

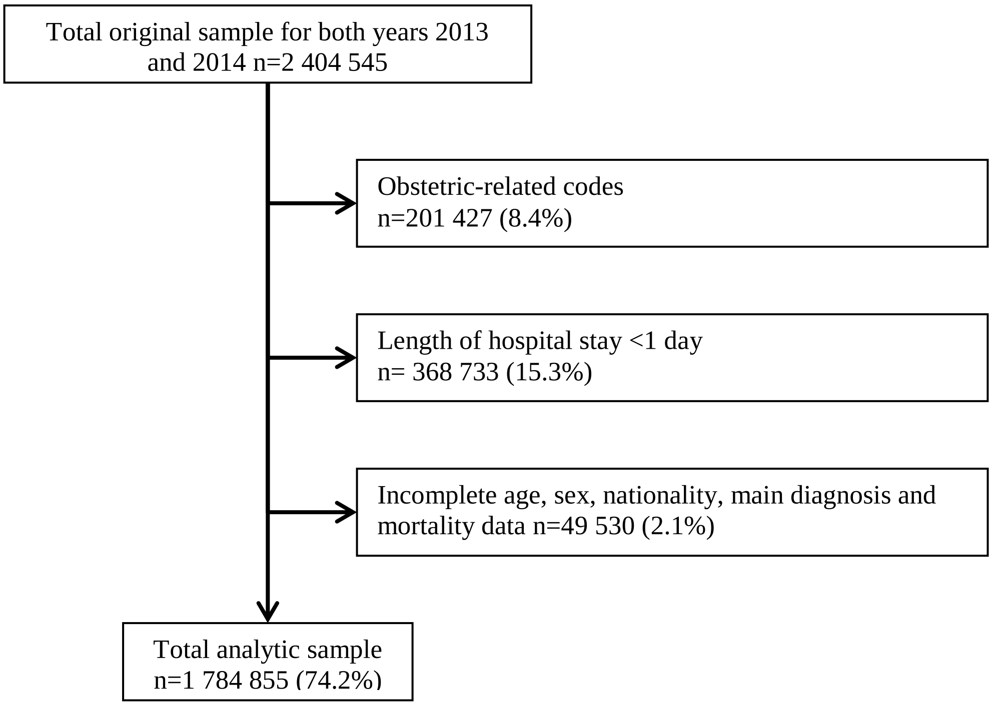
Supplementary table 6 Association of International Classification of Diseases 10th revision undernutrition-related codes and Swiss classification of surgical interventions for nutritional management allowing reimbursement of nutritional management by the Swiss health system.

	CHOP code			
ICD-10 code	**96.6 or 99.15**	**89.0A.32 or 89.0A.4***	**None**	**Total**
E43	1 223 (8.9)	9 060 (66.2)	3 412 (24.9)	13 695
E44	1 038 (5.4)	13 683 (71.2)	4 489 (23.4)	19 210
E46	1 594 (8.9)	4 744 (26.5)	11 554 (64.6)	17 892
Other undernutrition-related codes [1]	1 065 (7.9)	2 527 (18.8)	9 854 (73.2)	13 446
Total	4 920 (7.7)	30 014 (46.7)	29 309 (45.6)	64 243

Abbreviations: CHOP, Swiss classification of surgical interventions; ICD-10, International Classification of Diseases 10th revision; **Codes:** E43, unspecified severe protein-energy malnutrition; E44, protein-energy malnutrition of moderate and mild degree; E46, unspecified protein-energy malnutrition; 96.6, enteral infusion of concentrated nutrients; 99.15, parenteral infusion of concentrated nutrient solutions; 89.0A.32, nutritional advice and therapy; 89.0A.4*, multimodal nutritional therapy (*=any number). Multimodal nutritional therapy is coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file.

[1] E12, malnutrition-related diabetes mellitus; E40, kwashiorkor; E41, nutritional marasmus; E42, marasmic kwashiorkor; R63, includes R63.0 (anorexia), R63.3 (eating difficulties and mismanagement), R63.4 (abnormal weight loss), and R63.6 (insufficient intake of food and water due to self-neglect); R64, cachexia. Results are expressed as number of patients (row %). Only the associations indicated in grey are susceptible to reimbursement in Switzerland.

Supplementary Figure 1 Participant selection procedure



Chapter 8

Sixteen years trends in reported undernutrition in Switzerland

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Original article

Sixteen years trends in reported undernutrition

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SUMMARY

Background & aims: How undernutrition is reported in hospital discharge data is not understood. To assess trends in reported undernutrition and its management among hospitalized patients in Switzerland, and the association between reported undernutrition and in-hospital mortality, acquired infection, intensive care unit stay (ICU), and length of hospital stay (LOS).

Methods: Data from the Swiss hospital discharge databases from 1998 to 2014 (n = 13,297,188 hospitalizations, 52.2% women, 48.4% aged 65+, and 85% Swiss national). Reported undernutrition was defined by the presence of any undernutrition-related International Classification of Diseases 10th revision code. Nutritional management was defined by the presence of any nutritional intervention code.

Results: Prevalence of reported undernutrition increased from 0.32% in 1998 to 3.97% in 2014 in Switzerland, and similar but varying trends were found for each of the seven Swiss administrative regions: ranging from 0.18% to 2.13% in Ticino and from 0.23% to 5.63% in Mittelland. Undernutrition management of hospitalizations with reported undernutrition increased from 0.6% in 1998 to 57.8% in 2014, with wide variations according to administrative region: from 0% to 32.9% in Ticino and from 0% to 68.9% in Central Switzerland. After multivariable adjustment, reported undernutrition was positively associated with in-hospital mortality: odds-ratio and (95% confidence interval): 2.30 (2.26–2.34); acquired infection: 3.57 (3.46–3.70); ICU stay: 1.65 (1.63–1.68) and longer LOS: 19.6 ± 0.2 vs. 13.0 ± 0.1 days.

Conclusion: Undernutrition is increasingly reported in Switzerland; still, over 40% of undernourished hospitalizations don't benefit from nutritional support. Reported undernutrition is associated with increased in-hospital mortality, acquired infection, ICU stay, and LOS.

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1. Introduction

Undernutrition is a frequent condition among hospitalized patients [1], leading to increased morbidity, mortality, length of hospital stay, risk of nosocomial infection, and health costs [2–5]. Hospital discharge data is commonly used for disease surveillance and prevention, public health reporting, health services evaluation, and health care costs [6,7]. Hence, adequate reporting of patient's nutritional status in hospital discharge data could provide valuable information regarding the prevalence, health and economic impact of this condition, and for hospitals, increase reimbursement from third party payers [8]. Still, we have previously shown that nutritional status of hospitalized patients is frequently underreported [9].

Switzerland is a small European country with the second highest and ever increasing per capita health expenditures in the world [10,11]. Hence, information regarding trends in undernutrition is necessary for adequate planning of the resources to manage this condition. To our knowledge, only one study on trends in hospital undernutrition has been conducted in Switzerland, limited to two years (1999 and 2008) and conducted in a single hospital [12]. The results showed no difference in prevalence between the two study periods (69% *vs.* 70%). Thus, the objectives of this study were to assess a) trends in reported undernutrition; b) trends in undernutrition management among hospitalized patients, and c) the association of reported undernutrition with unfavourable hospital outcomes (e.g. in-hospital mortality and

Abbreviations: CHOP, Swiss classification of surgical interventions; DRG, diagnosis-related groups; ICD-10, International Classification of Diseases 10th revision; ICU, intensive care unit; LOS, length of stay; OR, odds ratio.

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acquired infection) in Switzerland and in each of the seven administrative Swiss regions. We used Swiss hospital discharge databases from 1998 to 2014 to fulfil these aims.

2. Methods

2.1. Databases and available data

Data from the Swiss hospital discharge databases between 1998 and 2014 were used. The database was provided by the Swiss federal office of statistics (http://www.bfs.admin.ch); it covers 98% of public and private hospitals within Switzerland and includes all stays for each hospital. The main cause for hospitalization and the comorbidities are coded using the International Classification of Diseases 10th revision (ICD-10) of the World Health Organization. Hospital procedures are coded using the Swiss classification of surgical interventions (CHOP) (16), which also includes non-surgical interventions such as nutritional management.

Eligibility criteria were as follows: adult patients (aged ≥20 years); length of hospital stay >1 day; not having any ICD-10 codes related to pregnancy, childbirth and puerperium (i.e. ICD-10 codes beginning with letter "O") as main diagnosis, and having complete demographic data and information on main diagnosis and mortality. As it was not possible to identify patients, the results relate to the number of discharges and not to the number of patients. Due to Swiss data protection legislation, ages were provided in categories; hence, it was not possible to include hospitalizations for patients aged 18 or 19.

2.2. Prevalence and management of undernutrition

Presence of undernutrition was assessed by searching all ICD-10 codes related to nutritional status: E12 (undernutrition-related diabetes mellitus), E40 (kwashiorkor), E41 (nutritional marasmus), E42 (marasmic kwashiorkor), E43 (unspecified severe protein-energy undernutrition), E44 (protein-energy undernutrition of moderate and mild degree), E46 (unspecified protein-energy undernutrition), R63 (R63.0: Anorexia, R63.3: feeding difficulties and mismanagement; R63.4: abnormal weight loss and R63.6: Insufficient intake of food and water due to self-neglect), and R64 (cachexia).

As only some ICD-10 codes qualify for reimbursement of hospital expenses, we further grouped them as follows: E43, E44.0, E44.1, E46 and any other code.

Presence of nutritional management was assessed by searching all CHOP codes related to enteral nutrition (96.6 and 96.35), parenteral nutrition (99.15), nutritional advice and therapy (89.0A.30, 89.0A.31 or 89.0A.32, depending on year) and multimodal nutritional therapy (89.0A.4*, where * = any number). Multimodal nutritional therapy can be coded when management is performed by a specialized team including a specialist doctor, a nurse and a dietician, and includes nutritional evaluation, several meetings to adapt nutritional management, and adequate nutritional documentation in the medical file (16).

2.3. Unfavourable hospital outcomes

Overall length of hospital stay (LOS) was indicated in days and length of stay in an intensive care unit (ICU) in hours. When the length of stay in the ICU was zero, it was considered as no stay in ICU. Vital status at discharge was indicated as dead or alive. Acquired hospital infection was defined as the presence of at least one ICD-10 code out of a specific list (Supplemental Table 1).

2.4. Other covariates

Age was categorized into 4 groups (20–34, 35–49, 50–64, and above 65) and nationality as Swiss/non-Swiss. Main diagnoses for hospitalizations were categorized into seven groups based on the ICD-10 codes (Supplemental Table 2). The Charlson index was computed from all ICD-10 codes according to an algorithm defined for Switzerland [13].

2.5. Statistical analysis

Statistical analyses were performed using Stata version 14.2 for Windows (Stata corp, College Station, TX, USA). Descriptive analyses were presented as percentage and comparisons were performed using chi-square. Trends were performed for all of Switzerland and stratified by the seven Swiss administrative regions (Leman, Mittelland, Northwest, Zurich, Northeast, Central and South) (Supplemental Fig. 1). Trends were assessed using logistic regression adjusting for sex, age group, nationality, main diagnostic category, and ICU stay. For Switzerland, a further adjustment on administrative region was performed. Linear and quadratic trends were assessed using the **contrast** post-estimation command. The results were expressed as Odds-ratio (OR) and corresponding 95% confidence intervals.

For the associations between undernutrition reporting and in-hospital acquired infection, death or ICU stay, sensitivity analyses were conducted using the E-value [14]. Briefly, the E-value is defined as the minimum strength of association, on the risk ratio scale, that an unmeasured confounder would need to have with both the treatment and the outcome to fully explain away a specific treatment-outcome association, conditional on the measured covariates. A large E-value implies that considerable unmeasured confounding would be needed to explain away an effect estimate [14]. As the prevalence of the outcomes of interest was <15%, the relative risk formula was applied. Due to the large sample sizes, statistical significance was considered for a two-sided test at $p < 0.001$.

3. Results

3.1. Characteristics of the hospitalizations

Of the initial 19,574,840 hospitalizations, 6,277,652 (22.1%) were excluded; the reasons for exclusion are presented in Supplemental Fig. 2. The excluded hospitalizations had a higher frequency of women and young hospitalizations, and a lower frequency of Swiss nationals, hospitalizations with ICU stay, and in-hospital mortality (Supplemental Table 3). The characteristics of the included hospitalizations according to calendar year are summarized in Table 1.

3.2. Trends in reported undernutrition

The number and the percentage of hospitalizations with reported undernutrition, for Switzerland and each Swiss administrative region are summarized in Fig. 1 and Supplemental Table 4, respectively. Those findings were further confirmed by multivariable analysis, which showed a significant increase in the likelihood of reporting undernutrition for Switzerland and all administrative regions (Fig. 2). Significant linear trends were found for Switzerland and all regions, and significant quadratic trends were also found for Switzerland, Léman, Mittelland, Northwest and Eastern regions.

The distribution of the different undernutrition-related ICD-10 codes, for Switzerland and each Swiss administrative region are presented in Supplemental Fig. 3. An increasing use of E43, E44 and E46 codes at the expense of the other codes was observed.

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Table 1
Characteristics of the participants, Swiss hospital discharge data, 1998–2014.

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006
N	450,690	572,827	654,104	704,187	749,694	789,291	803,300	813,221	818,655
Women	52.5	52.7	53.2	52.6	52.6	52.3	52.1	52.0	51.9
Age groups									
20–34	14.3	13.0	11.8	10.9	10.6	11.1	10.8	10.2	9.8
35–49	18.8	18.5	17.7	17.8	17.8	18.4	18.6	18.1	17.7
50–64	24.0	24.0	24.4	24.6	24.5	24.5	24.6	24.7	24.8
Above 65	42.9	44.5	46.1	46.7	47.1	46.1	46.0	47.0	47.7
Swiss national	87.9	89.0	90.1	89.0	89.2	85.7	84.3	84.2	83.9
ICU	5.3	4.1	4.8	4.9	4.9	4.9	5.0	4.7	4.2

Year	2007	2008	2009	2010	2011	2012	2013	2014
N	831,474	845,343	841,808	851,052	870,655	880,269	900,984	919,634
Women	52.1	52.0	51.9	51.6	51.7	51.5	51.4	51.2
Age groups								
20–34	9.5	9.4	9.4	9.2	9.2	9.4	9.3	9.3
35–49	17.1	17.0	16.8	16.6	16.1	15.8	15.6	15.2
50–64	24.4	24.4	24.2	24.2	23.8	23.9	23.9	23.7
Above 65	49.0	49.3	49.5	50.0	51.0	50.9	51.3	51.8
Swiss national	84.0	83.8	83.7	83.5	83.5	83.1	83.0	82.6
ICU	5.7	5.9	6.2	6.4	6.1	7.2	7.8	7.1

ICU, intensive care unit. Results are expressed as percentage of the column total. Analyses performed using chi-square; all comparisons have $p < 0.001$.

Conversely, the percentage of the E43, E44 and E46 codes differed between regions; in 2014, E44.1 code represented 7.9% of all codes in Léman and 22.2% in Central Switzerland, while E46 code represented 17.8% of all codes in Central Switzerland and 48.5% in Ticino (Supplemental Fig. 3).

3.3. Trends in reported undernutrition management

The number and the percentage of hospitalizations with reported undernutrition that also included a code for nutritional management for Switzerland and each Swiss administrative region are summarized in Fig. 2 and Supplemental Table 5, respectively. The values increased considerably after 2010, although in 2014 at least one third of all hospitalizations with reported undernutrition still had no nutritional management documented. Those findings were further confirmed by multivariable analysis restricted to the period 2009–2014, which showed a significant increase in the likelihood of managing undernutrition for Switzerland and all administrative regions (Fig. 3).

3.4. Associations with unfavourable hospital outcomes

After multivariable adjustment for sex, age group, nationality, main diagnostic category, year, and administrative region, reported undernutrition was significantly and positively associated with in-hospital mortality, acquired infection, ICU stay, and with a longer LOS, and similar findings were obtained when the analyses were stratified by administrative region (Table 2). Sensitivity analysis showed relatively high E-values for the associations between reported undernutrition and in-hospital death or acquired infection, while the E-values for ICU were lower (Supplemental Table 6).

4. Discussion

Our results indicate that undernutrition status is increasingly being reported in Swiss hospital discharge data. Still, in 2014, 40% of undernourished hospitalizations had no indication of nutritional management. The differences in trends between the seven Swiss administrative regions cannot be explained by differences in patient's characteristics and are likely due to differing or absence of local guidelines regarding undernutrition screening, reporting, and management.

4.1. Trends in reported undernutrition

There is little information regarding trends in undernutrition prevalence among hospitalized patients worldwide [15]. Although valuable initiatives such as the nutrition day [16] or the Fight Against Malnutrition [17] provide important information on nutritional status of hospitalized patients in a wide range of countries and hospital settings, no trends in undernutrition have been derived. A study conducted in Geneva comparing two years (1999 and 2008) showed comparable prevalence of undernutrition (60% and 70%) [12], while a study conducted between 2004 and 2007 in the Netherlands reported a decrease of the condition [15]. Our results showed a steady increase in the number of hospitalizations and in the prevalence of reported undernutrition in the Swiss hospital discharge data, suggesting that diagnosis of undernutrition has improved likely due to medical staff becoming increasingly aware of its importance. Still, in 2014, the prevalence of reported undernutrition was less than 10%, compared to measured rates of over 20% [1] or even 60% [18] in hospital studies. Hence, undernutrition status appears to be considerably underreported in Swiss hospital discharge data, which is in line with our previous findings [9]. Still, this reported prevalence was higher than the 3.2% rate reported in 2010 in the USA [19], suggesting that the underreporting rate might be even larger in other countries.

An increasing use of E43, E44, and E46 codes at the expense of the undernutrition-related ICD-10 codes was observed. Our results also show that coding of certain conditions is dependent on their reimbursement; for instance, as only the E43, E44 and E46 codes qualify as reimbursable by the Swiss Diagnosis-related groups (DRG), they progressively replaced the other undernutrition-related codes in the hospital statistics. Interestingly, the E43 code was the most frequent in Central Switzerland compared to the E46 code in Ticino. A possible reason for such differences might be different coding recommendations according to administrative regions, but this issue remains to be assessed. These coding recommendations might have significant economic impact in the future; for instance, starting in January 2017, the E46 code will no longer be considered for reimbursement by the Swiss DRG system. Hence, unless the coding procedure changes considerably in Ticino, a significant part of all undernutrition-related codes will no longer be considered for reimbursement, with possible economic consequences. Overall, our results stress the need to strengthen common

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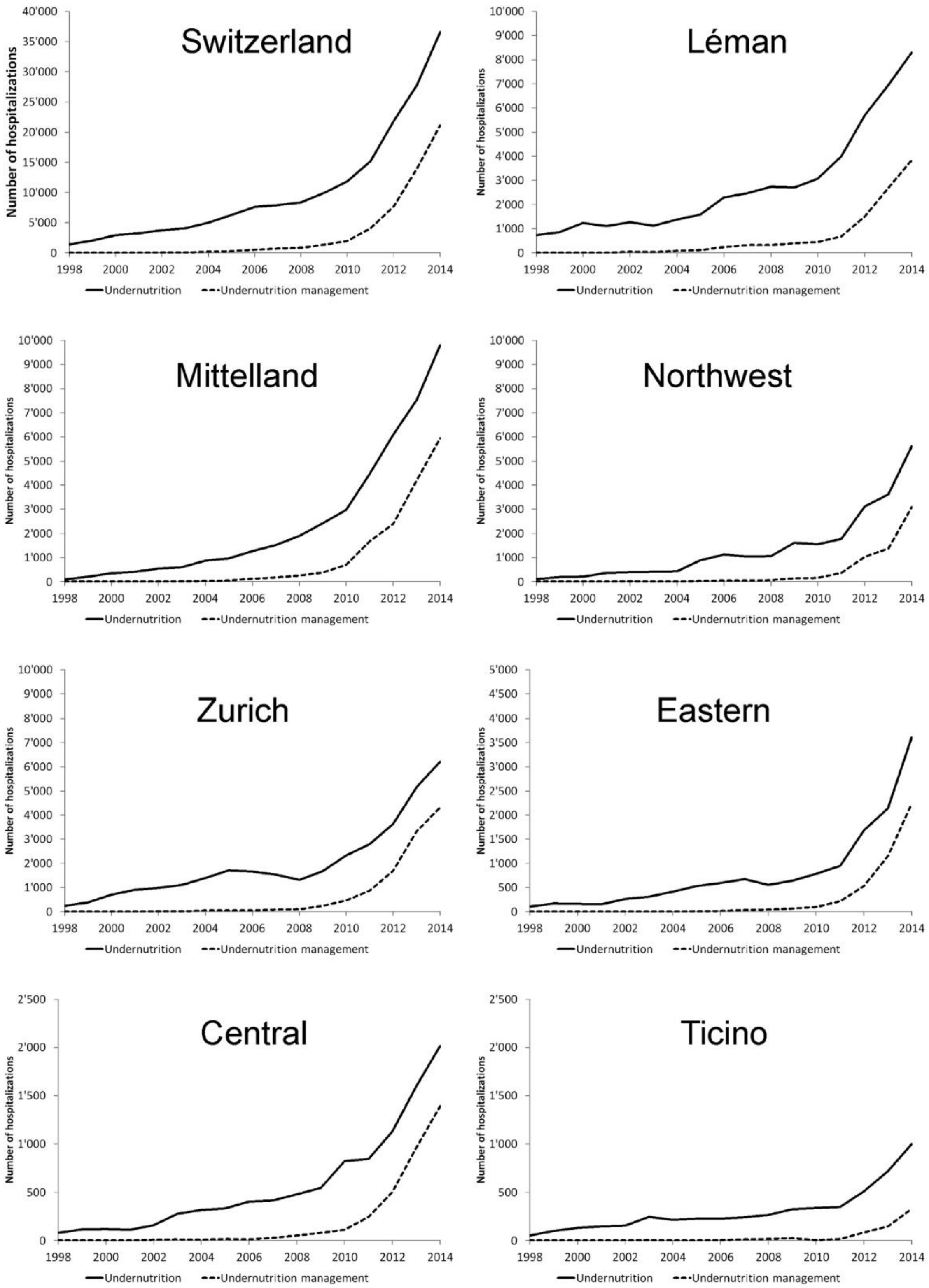

Fig. 1. Number of hospitalizations with reported undernutrition (full lines) and undernutrition management (dotted lines), for Switzerland and the seven Swiss administrative regions, Swiss hospital discharge data, 1998–2014.

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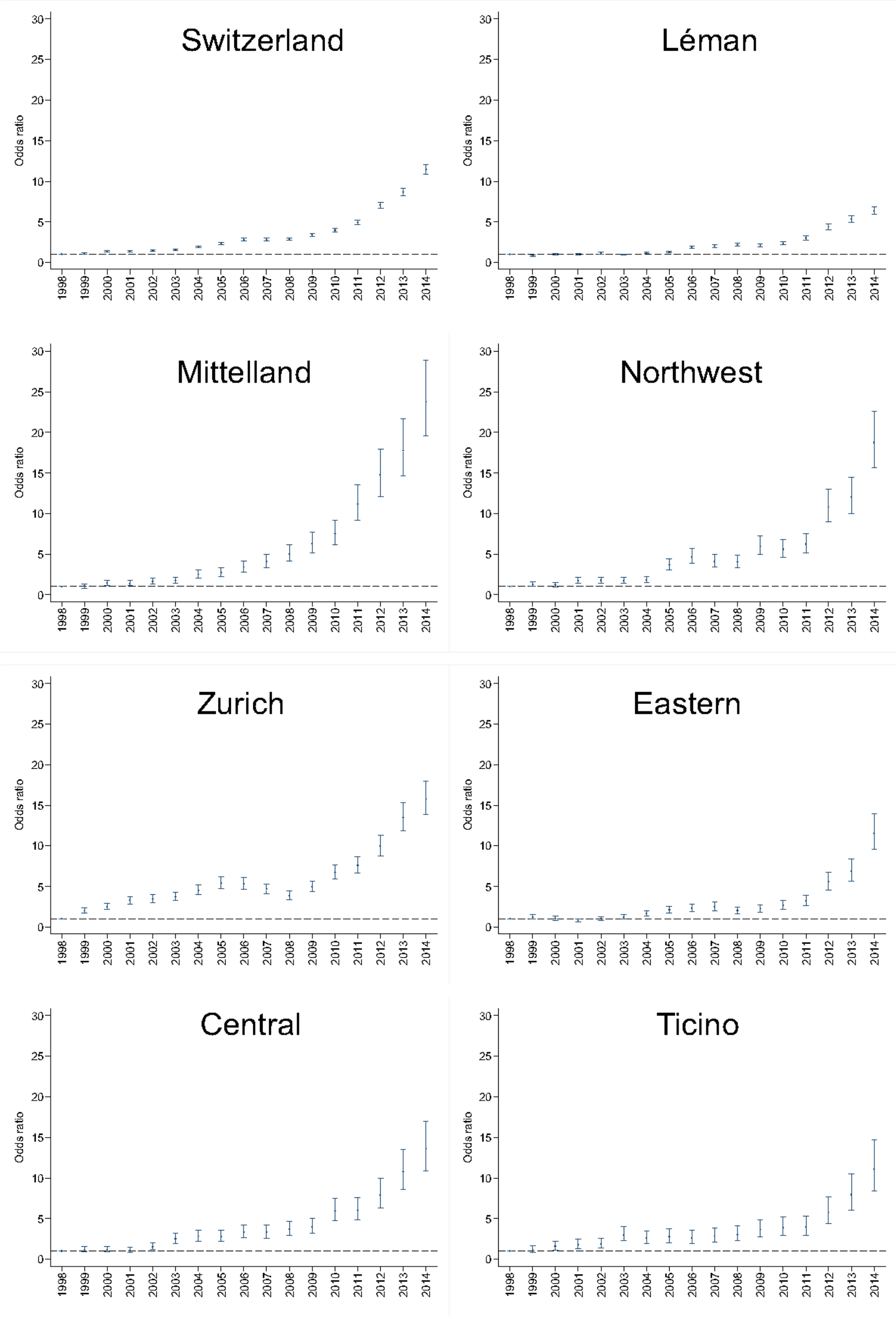

Fig. 2. Trends in hospitalizations with reported undernutrition, for Switzerland and the seven Swiss administrative regions, Swiss hospital discharge data, 1998–2014. Results are expressed as multivariate adjusted odds ratio and 95% confidence interval. Significant linear trends were found for Switzerland and all regions, and significant quadratic trends were also found for Switzerland, Léman, Mittelland, Northwest and Eastern regions.

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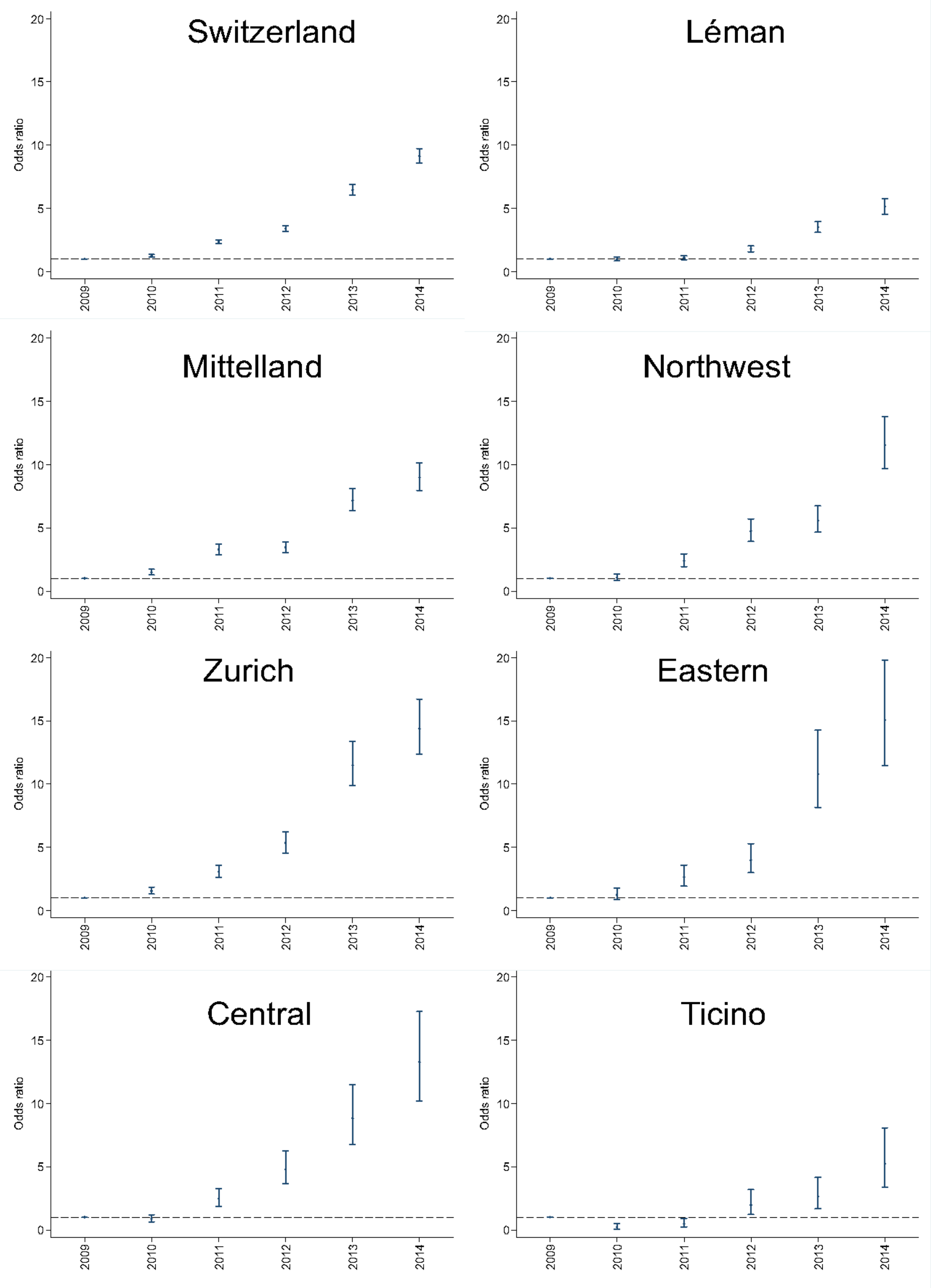

Fig. 3. Trends in hospitalizations with reported undernutrition and undernutrition management, for Switzerland and the seven Swiss administrative regions, Swiss hospital discharge data, 2009–2014. Results are expressed as multivariate adjusted odds ratio and 95% confidence interval. Due to the small number of cases before 2009, only the period 2009–2014 is shown. Significant linear trends were found for Switzerland and all regions, and significant quadratic trends were also found for Switzerland and Ticino.

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Table 2
Association of reported undernutrition with unfavourable hospital outcomes, for Switzerland and each Swiss administrative region, Swiss hospital discharge data, 1998–2014.

	In-hospital death	Intensive care unit	Acquired infection	Length of stay	
				Not reported	Reported
Overall Switzerland	2.30 (2.26–2.34)	1.65 (1.63–1.68)	3.57 (3.46–3.70)	13.0 ± 0.1	19.6 ± 0.2
Swiss Administrative regions					
Léman	2.35 (2.27–2.44)	1.28 (1.24–1.32)	3.32 (3.09–3.56)	13.2 ± 0.1	25.0 ± 0.2
Mittelland	2.21 (2.12–2.29)	2.35 (2.28–2.42)	4.16 (3.91–4.42)	13.1 ± 0.1	17.9 ± 0.6
Northwest	2.17 (2.06–2.28)	1.37 (1.31–1.44)	3.37 (3.06–3.70)	13.1 ± 0.1	18.6 ± 0.5
Zurich	2.44 (2.34–2.54)	1.91 (1.84–1.97)	3.86 (3.58–4.15)	12.3 ± 0.1	16.7 ± 0.5
Eastern	2.15 (2.01–2.31)	1.32 (1.24–1.42)	3.35 (2.97–3.78)	14.2 ± 0.1	18.5 ± 1.3
Central	2.36 (2.18–2.55)	1.83 (1.73–1.94)	3.32 (2.87–3.85)	12.3 ± 0.1	15.1 ± 1.2[1]
Ticino	3.22 (2.91–3.57)	1.04 (0.93–1.16)[2]	2.64 (2.05–3.39)	12.3 ± 0.1	16.7 ± 0.3

Results are expressed as multivariable-adjusted odds ratio and (95% confidence interval) for reported undernutrition relative to no reporting, or as multivariate-adjusted average ± standard error. For in-hospital death, intensive care unit and acquired infection, analyses were performed using logistic regression adjusting for sex, age groups, nationality, main diagnostic category, Charlson index and year. For length of stay, analyses were performed on log-transformed data adjusting for sex, age groups, nationality, main diagnostic category, intensive care unit, in-hospital death and year. For Switzerland, a further adjustment on administrative region was performed. All results are $p < 0.001$, except [1] ($p < 0.05$) and [2] not significant.

reporting and coding of undernutrition status, as suggested by the Swiss Society of Dieticians [20,21]. Our results also indicate that focussing on specific undernutrition-related ICD-10 codes might lead to biased results, as the choice of the codes is not solely dependent on the patient's status but also on the reimbursement potential of the code.

4.2. Trends in reported undernutrition management

In 2011, two new CHOP codes regarding nutritional management (89.0A.30 for dietary advice and 89.0A.31 for nutritional therapy) were introduced in the Swiss CHOP system [20]. The codes were further grouped into a single code, nutritional advice and therapy (89.0A.32) in 2012. This introduction led to a considerable increase in the number of reported undernutrition management, as the previous codes were only related to enteral and parenteral nutrition. Notwithstanding, in 2014, only 60% of hospitalized patients with reported undernutrition had an indication of nutritional management. Nevertheless, it should be noted that this value is considerably higher than in a previous Swiss study [18] or a study conducted in six other European countries, where prevalence of clinical nutrition support ranged between 19.9% in Greece to 39.0% in Estonia [17].

Considerable differences in nutritional management were found according to the administrative regions, and those differences persisted after multivariable adjustment for possible confounders. Overall, our results suggest that undernutrition is managed differently according to administrative region, but the reasons for such differences remain to be assessed. It remains a necessity to have a common guideline regarding undernutrition management in Switzerland, so that undernourished patients can benefit from the same quality of care irrespective of the hospital they attend.

4.3. Associations with unfavourable hospital outcomes

Reported undernutrition was associated with an increased likelihood of in-hospital mortality, in-hospital acquired infection, ICU stay and LOS. Furthermore, sensitivity analysis showed relatively high E-values for the associations between reported undernutrition and in-hospital death and acquired infection, suggesting that theses associations are unlikely due to unmeasured confounders. Conversely, the E-values for ICU were lower, suggesting that the observed associations could be ruled out by an unmeasured confounder associated with both the undernutrition and the ICU with a minimal OR ranging between 1.79 and 3.99 [14]. Nevertheless, these findings confirm the previous literature [2,3,19] indicating that undernutrition is a serious condition carrying a significant burden for in-patients, the health care team and the community, as increased LOS leads to increased health care costs.

4.4. Study strengths and limitations

The strength of this study relies on its long time period and on its large sampling rate, covering almost all Swiss hospitals (98%). The results can thus reliably be considered as representative of all Swiss hospitalizations for the period between 1998 and 2014.

This study has also several limitations. Firstly, prevalence of undernutrition was based on ICD-10 codes, and not on objective assessment of undernutrition; consequently, and as indicated previously, prevalence rates are underestimated but nevertheless higher than in similar studies [19]. Secondly, it was not possible to distinguish if the observed increase in the prevalence of reported undernutrition is due to a real increase in this condition or to a higher awareness regarding this condition by the health care professionals. Still, our results indicate that undernutrition is an increasing concern among hospitalized patients and that it should be increasingly considered for future public health care policies. Thirdly, due to legal constraints and to the lack of a unique identifier, only hospitalizations could be analysed, not individual patients. Therefore, it is likely that undernourished patients with multiple hospitalizations might have artificially increased the prevalence of undernutrition. Finally, and as for undernutrition, prevalence of undernutrition management was based on CHOP codes, not on an objective evaluation of the nutritional therapies provided to the patients; whether nutritional therapies are under or over reported in Swiss hospital discharge data has not yet been assessed.

5. Conclusion

Undernutrition status is increasingly reported in Swiss hospital discharge data. Still, in 2014, over 40% of undernourished hospitalizations had no indication of nutritional management. Reported undernutrition is associated with increased in-hospital mortality, acquired infection, ICU stay, and LOS. Trends differ considerably between Swiss administrative regions and are independent of the hospitalization's characteristics.

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Conflict of interest

There is no conflict of interest to declare.

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SKS and PMV conceived the paper. SKS analyzed data and wrote the manuscript. CdM revised the manuscript for important intellectual content. PMV supervised the analysis, and had primary responsibility for final content. All authors have read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.01.021.

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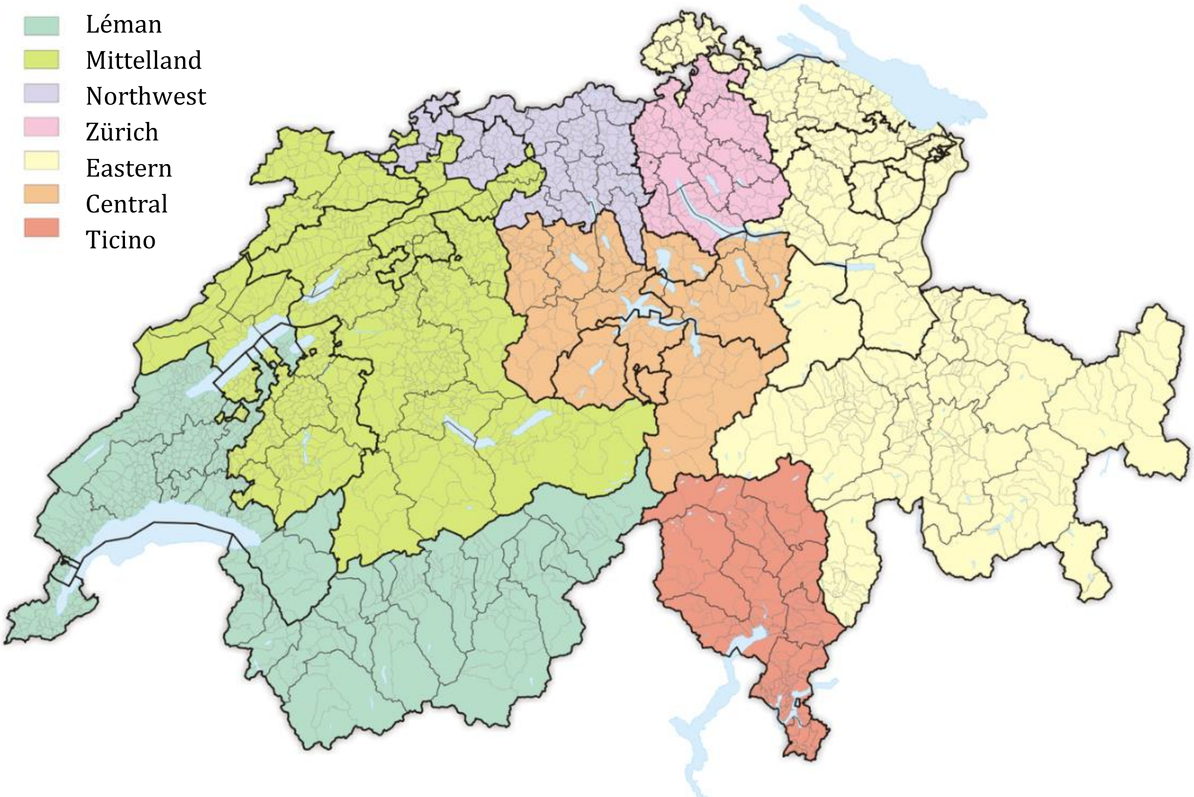
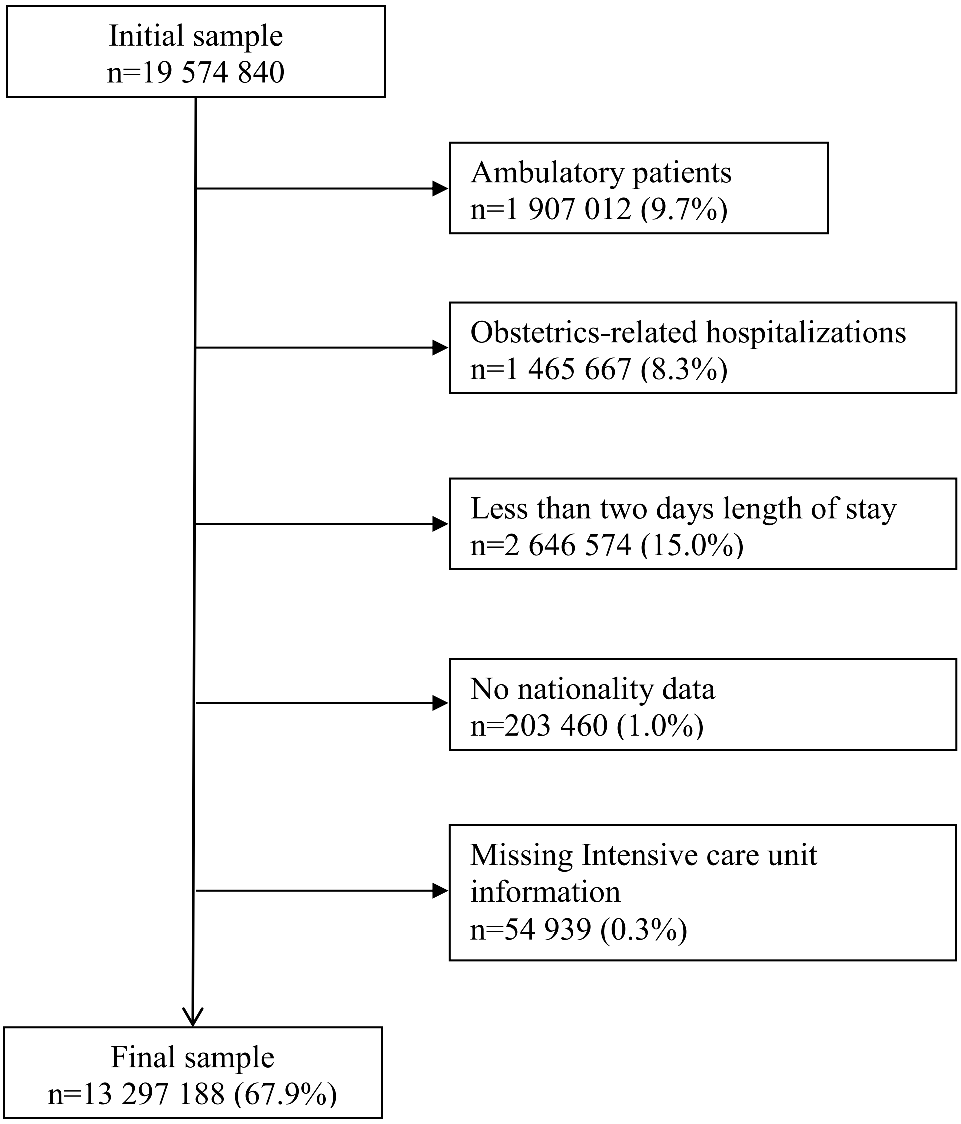
Supplemental Materials

Supplementary Figure 1 The seven administrative regions of Switzerland.

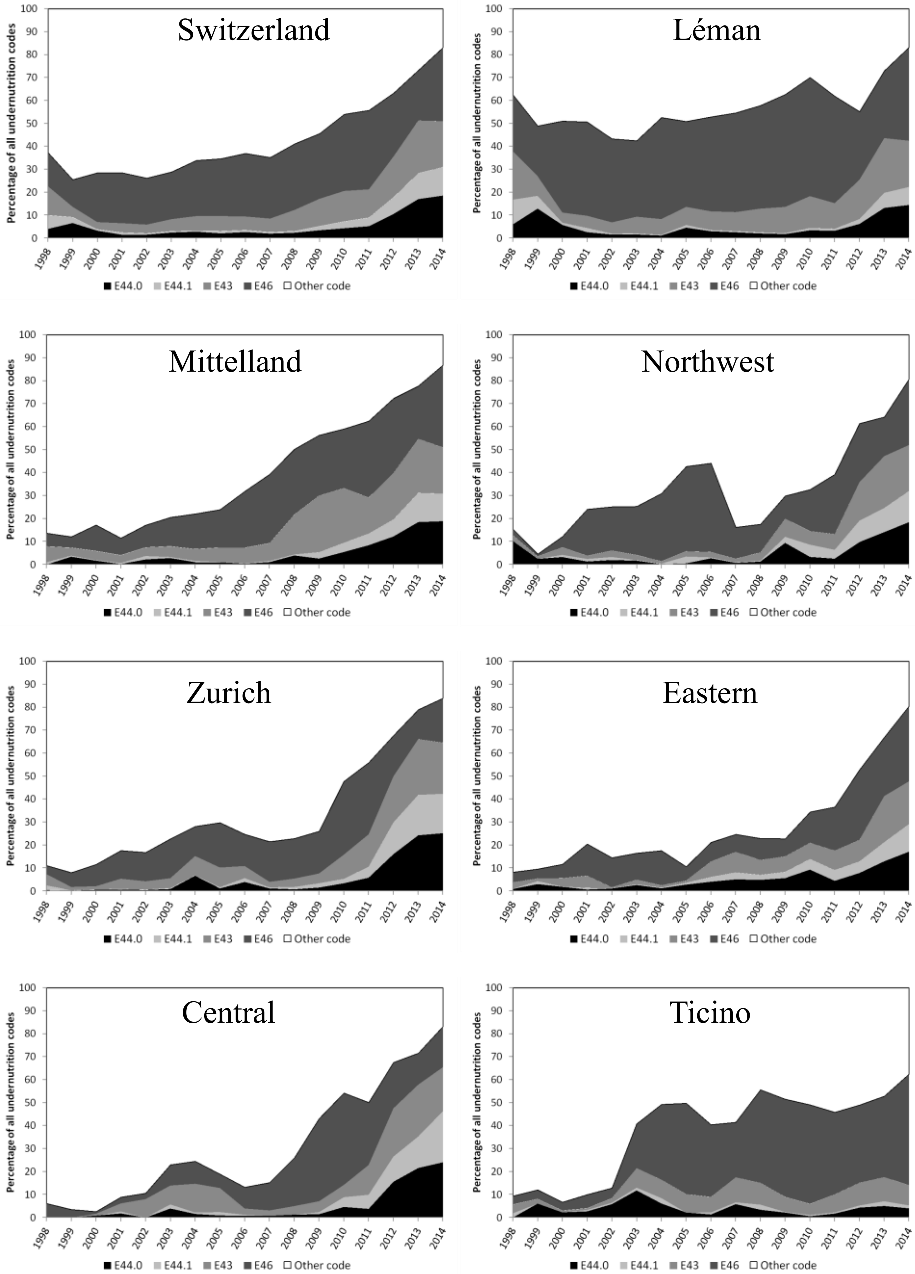


Adapted from Tschubby - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=12420300.

Supplementary Figure 2 Exclusion criteria



Supplementary Figure 3 Trends in specific undernutrition-related ICD-10 codes, for Switzerland and the seven Swiss administrative regions, Swiss hospital discharge data, 1998-2014.



Results are expressed as percentage of all undernutrition-related ICD-10 codes.

Supplemental Table 1 List of ICD-10 codes used to define hospital-acquired infection

Code	Designation
T80.2	Infections following infusion, transfusion and therapeutic injection
T82.6	Infection and inflammatory reaction due to cardiac valve prosthesis
T82.7	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts
T83.5	Infection and inflammatory reaction due to prosthetic device, implant and graft in urinary system
T83.6	Infection and inflammatory reaction due to prosthetic device, implant and graft in genital tract
T84.5	Infection and inflammatory reaction due to internal joint prosthesis
T84.6	Infection and inflammatory reaction due to internal fixation device [any site]
T84.7	Infection and inflammatory reaction due to other internal orthopedic prosthetic devices, implants and grafts
T85.7	Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
A04.7	Clostridium difficile infection

Abbreviations: ICD-10, international classification of diseases 10th revision.

Supplemental Table 2 List of ICD-10 codes used to define disease groups.

Disease group	**ICD-10 code begins with**
Malignant	C or D0
Cardiovascular	I
Pulmonary	J
Gastrointestinal	K
Infection	A or B
Neuro-psycho	F or G
Miscellaneous	All other letters

Abbreviations: ICD-10, international classification of diseases 10^{th} revision.

Supplemental Table 3 Comparison between excluded and included hospitalizations, Swiss hospital discharge data, 1998-2014.

	Included (n=13 297 188)	**Excluded** (n=6 277 652)
Women	6 914 984 (52.0)	3 963 998 (63.1)
Age groups		
20-34	1 356 505 (10.2)	1 994 261 (31.8)
35-49	2 279 574 (17.1)	1 494 417 (23.8)
50-64	3 227 354 (24.3)	1 222 385 (19.5)
Above 65	6 433 755 (48.4)	1 566 589 (25.0)
Swiss national	11 301 429 (85.0)	4 691 289 (74.7)
Intensive care unit	755 174 (5.7)	130 531 (2.1)
Deceased	319 579 (2.5)	77 961 (1.3)

Results are expressed as number of hospitalizations and (column total). Between-group comparisons performed using chi-square test; all comparisons are significant at $p<0.001$.

Supplemental Table 4 Percentage of hospitalizations with reported undernutrition, for Switzerland and each Swiss administrative region, Swiss hospital discharge data, 1998-2014.

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
N	450 690	572 827	654 104	704 187	749 694	789 291	803 300	813 221	818 655
Overall Switzerland	0.32	0.35	0.45	0.46	0.50	0.52	0.63	0.77	0.93
Administrative regions									
Léman	0.78	0.66	0.87	0.81	0.93	0.78	0.94	1.05	1.54
Mittelland	0.23	0.23	0.32	0.32	0.38	0.41	0.57	0.63	0.81
Northwest	0.15	0.20	0.19	0.28	0.29	0.28	0.29	0.59	0.74
Zurich	0.22	0.43	0.59	0.77	0.81	0.85	1.04	1.25	1.21
Eastern	0.22	0.26	0.22	0.18	0.23	0.26	0.35	0.45	0.49
Central	0.19	0.22	0.23	0.23	0.32	0.51	0.57	0.59	0.71
Ticino	0.18	0.22	0.29	0.33	0.34	0.56	0.48	0.51	0.49

Results are expressed as percentage. Trend analyses performed using logistic regression adjusting for gender, age group, nationality, main diagnostic category and intensive care unit. For Switzerland, a further adjustment on administrative region was performed. All trends are significant with $p<0.001$.

Supplemental Table 4 (continued) Percentage of hospitalizations with reported undernutrition, for Switzerland and each Swiss administrative region, Swiss hospital discharge data, 1998-2014.

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
N	831 474	845 343	841 808	851 052	870 655	880 269	900 984	919 634
Overall Switzerland	0.95	0.99	1.18	1.39	1.75	2.48	3.08	3.97
Administrative regions								
Léman	1.64	1.80	1.79	2.01	2.61	3.78	4.61	5.39
Mittelland	0.97	1.20	1.52	1.85	2.71	3.60	4.35	5.63
Northwest	0.68	0.67	1.02	0.97	1.09	1.86	2.09	3.19
Zurich	1.10	0.93	1.23	1.67	1.89	2.47	3.41	3.91
Eastern	0.54	0.44	0.50	0.61	0.73	1.25	1.56	2.56
Central	0.71	0.80	0.89	1.30	1.31	1.73	2.38	2.92
Ticino	0.54	0.58	0.71	0.74	0.76	1.11	1.52	2.13

Results are expressed as percentage. Trend analyses performed using logistic regression adjusting for gender, age group, nationality, main diagnostic category and intensive care unit. For Switzerland, a further adjustment on administrative region was performed. All trends are significant with $p<0.001$.

Supplemental Table 5 Percentage of hospitalizations with reported undernutrition that received any type of nutritional support, for Switzerland and each Swiss administrative region, Swiss hospital discharge data, 1998-2014.

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Overall Switzerland	0.6	0.9	1.2	1.0	2.4	2.6	4.0	4.6	6.7	8.9	10.4	13.6	16.8	26.9	35.4	50.1	57.8
Administrative regions																	
Léman	0.5	0.9	0.8	0.8	3.6	3.8	5.9	7.4	10.3	13.0	11.8	14.9	14.7	17.1	26.5	38.8	46.4
Mittelland	1.0	0.5	0.6	0.7	0.6	2.3	4.7	5.4	9.9	11.3	13.8	16.1	23.3	37.6	39.2	55.9	60.6
Northwest	0.9	2.0	6.1	2.7	4.0	1.5	2.8	3.5	4.7	5.7	6.3	9.6	10.3	20.5	33.2	38.2	54.9
Zurich	1.2	1.3	1.0	1.1	1.5	2.2	3.5	3.1	3.2	5.0	7.6	14.4	20.0	31.3	46.6	64.7	69.4
Eastern	0.0	0.6	1.2	0.7	0.4	0.7	1.2	2.6	3.0	4.6	7.9	9.9	12.8	23.1	31.6	54.0	61.9
Central	0.0	0.0	0.0	0.0	5.0	4.7	3.1	4.8	3.7	7.0	11.3	14.5	13.5	29.0	44.4	60.2	68.9
Ticino	0.0	0.0	0.0	0.0	0.0	1.6	0.9	0.9	2.7	5.4	6.8	7.7	2.1	4.6	16.3	20.6	32.9

Results are expressed as percentage of hospitalizations with an undernutrition-related ICD-10 code at discharge. Trend analyses performed using logistic regression adjusting for gender, age group, nationality, main diagnostic category and intensive care unit. For Switzerland, a further adjustment on administrative region was performed. All trends are significant with $p<0.001$.

Supplemental Table 6 sensitivity analysis of the association of reported undernutrition with unfavorable hospital outcomes, for Switzerland and each Swiss administrative region, Swiss hospital discharge data, 1998-2014.

	In-hospital death	**Intensive care unit**	**Acquired infection**
Overall Switzerland	4.03 (3.95 - 4.11)	2.69 (3.00 - 2.75)	6.60 (6.38 - 6.86)
Administrative regions			
Léman	4.13 (3.97 - 4.31)	1.88 (1.79 - 1.97)	6.10 (5.63 - 6.58)
Mittelland	3.85 (3.66 - 4.01)	4.13 (3.99 - 4.27)	7.79 (7.28 - 8.31)
Northwest	3.76 (3.54 - 3.99)	2.08 (1.95 - 2.24)	6.20 (5.57 - 6.86)
Zurich	4.31 (4.11 - 4.52)	3.23 (3.08 - 3.35)	7.18 (6.62 - 7.77)
Eastern	3.72 (3.43 - 4.05)	1.97 (1.79 - 2.19)	6.16 (5.39 - 7.02)
Central	4.15 (3.78 - 4.54)	3.06 (2.85 - 3.29)	6.10 (5.19 - 7.16)
Ticino	5.89 (5.27 - 6.60)	1	4.72 (3.52 - 6.24)

Results are expressed as E-value and (95% confidence interval). The odds ratio for intensive care unit in Ticino being non-significant, the E-value is by default 1.

Chapter 9

General Discussion

Summary of main results and comparison with the literature

In **chapter 2,** we reviewed the evidence that being undernourished or 'at-risk' of undernutrition was associated with longer length of hospital stay (LOS) and higher costs. Based on our review, undernutrition-related costs represented between 2.1% and 10% of the national health expenditure. Importantly, our findings also showed that screening at admission and proper nutritional support could lead to considerable cost savings (1–4). The results of the review were further confirmed by the cross-sectional studies conducted in the internal medicine ward of the Lausanne university hospital (CHUV).

In **Chapter 3**, being nutritionally 'at-risk' was associated with approximately 5500 CHF higher healthcare costs and with higher in-hospital mortality rate than being 'not at-risk', a finding in line with previous studies (5–8). Surprisingly, our results showed no significant association between being nutritionally 'at-risk' and longer LOS, contrary to the previous literature (5,7,8); possible explanations would be a relatively small sample sizes and also the large variation in LOS, leading to a low statistical power. Our results showed that screening for undernutrition improved between 2013 and 2014 in the internal medicine ward of the CHUV and three in every five screened patients were considered to be 'at-risk' of undernutrition. Although the nutritional management rate observed was comparable to the previous literature (7,9) and even higher than previously reported in Switzerland (23.2% among patients 'at-risk' of undernutrition) (6), still less than half of the nutritionally 'at-risk' patients benefited from nutritional management. Our results are in agreement with the NutritionDay study in western European countries and a study conducted in Scandinavian countries (10,11). NutritionDay showed that only 20% of 'at-risk' patient received nutrition supplements and 28% had dietetic assistance; in Scandinavia, nutritional care rate among 'at-risk' patients has been reported to be 46%, 37% and 22% in Denmark, Sweden and Norway, respectively. Worryingly, the percentage of nutritional management in our study decreased between 2013 and 2014, probably due to the issue that available staff could not comply with the increase in the number of patients nutritionally 'at-risk'. Our results indicate that an improvement in undernutrition screening without a concomitant improvement in the resources needed to manage the resulting increase in the number of patients 'at-risk' of undernutrition is an ineffective strategy both from public health and economic perspectives.

The association between undernutrition and health costs was further explored in **Chapter 4**, where we showed that patients nutritionally 'at-risk' had higher costs but also higher reimbursements than patients ‘not at-risk’. Still, the reimbursements failed to fully cover the excess costs associated with being nutritionally ‘at-risk’, leading to lower net reimbursement rates which are comparable to other studies (12,13). Probable reasons include a lower coverage rate with increasing LOS, under-reporting of undernutrition leading to inadequate DRG classifications or low valuation of undernutrition by the Swiss DRG system (12,14,15). This latter hypothesis is currently being explored by simulation studies conducted in collaboration with the medical coding group of the CHUV. Interestingly, although our results showed that patients ‘at-risk’ had higher costs related to intensive care, the absolute differences between ‘at-risk’ and ‘not at-risk’ patients were modest, never exceeding 2% of the total costs. Overall, our results suggest that being nutritionally ‘at-risk’ does not influence particularly one type of hospital costs; rather, it tends to increase all types of costs.

In **Chapters 5 and 6** we studied the validity of using undernutrition codes reporting in hospital administrative discharge databases. **Chapter 5** showed that objective measurements of undernutrition are not documented, leading to an underestimation of the prevalence of undernutrition in hospital discharge data. In **Chapter 6** we further examined the diagnostic accuracy of International classification of disease-10th revision (ICD-10) undernutrition codes by using administrative hospital discharge data. Our results showed that undernutrition-related codes have a good specificity but a low sensitivity. Positive predictive values (PPV) considerably varied depending on different diagnostic criteria used. Our results are comparable to the only study that investigated the accuracy of undernutrition-related codes in the Danish national registry (PPV of 70.9% using both screened-confirmed and clinically-confirmed *vs.* 11.0% when using only screened-confirmed undernutrition) (16). Possible reasons include inadequate documentation of undernutrition in the electronic medical record, and/or difficulties in obtaining the necessary information, and/or inappropriate use of undernutrition-related codes (17–19). Of note, lack of clear criteria for undernutrition diagnosis and differing results of the nutrition screening tools could also contribute to the low accuracy of undernutrition-related codes (20). Overall, our results suggest that the quality of hospital electronic data should be audited before it can be used to estimate the prevalence or an impact of a given condition. It should be noted that our results prompted a change in the way nutritional status was documented in the electronic medical record of the CHUV. Whether those changes improved the reliability of the undernutrition-related ICD-10 codes remains to be assessed.

Chapters 7 and 8 expanded our research topics to the whole Switzerland. To our knowledge, this is the first ever assessment of the prevalence and management of undernutrition for the whole Switzerland. The first study showed a low prevalence of reported hospital undernutrition, a finding consistent with the only nationally representative study that used undernutrition-related codes, which reported a prevalence rate of 3.2% among United States hospital discharges for 2010 (21). However, our results are considerably lower than previously objectively assessed rates ranging between 20% and 30% among hospitalized patients in Switzerland (6,22). This disparity between reported and objectively assessed prevalence of undernutrition is in line with generally accepted issues regarding undernutrition underestimation, under-recognition and underreporting in hospital settings (23). Our results also showed considerable differences in undernutrition reporting and management between Swiss administrative regions. Those differences could not be accounted for by differences in patients' characteristics, suggesting that regional guidelines (if any) were being applied. In fact, such regional disparities could rather be explained by different cantonal health care policies and hospital guidelines (22,24). The analysis of the trends also showed interesting patterns, namely a considerable increase in the use of specific undernutrition-related codes following the decision to reimburse specific associations of undernutrition-related codes and nutritional interventions. Our results indicate that reporting of undernutrition is not driven by diagnosis but rather by economic issues; hospitals using the codes that might provide higher reimbursement levels rather than the codes that correspond to the condition. Importantly, although a considerable increase was observed for undernutrition management (from 0.6% in 1998 to 57.8% in 2014 among hospitalizations with reported undernutrition), still at least one third of hospitalizations with reported undernutrition had no nutritional management documented in 2014. Our results thus confirm the previous findings at the CHUV that identification of undernutrition does not lead to nutritional management. Indeed, previous studies have shown that recommendations regarding undernutrition screening and management are often neglected or not implemented (10,25–27). Overall, it would be important that guidelines regarding screening, management and reporting of undernutrition be implemented at the Swiss level.

Strength and limitations

Undernutrition is a neglected public health issue in Switzerland, and little if no information existed regarding its prevalence, determinants, management, and its health and economic consequences. This project was one of the few to tackle simultaneously all those parameters, and we believe it brought important information that will be (as is currently being) used to improve screening, management, and reporting of undernutrition in hospitalized patients. Besides being one of the few studies that assessed the direct costs of undernutrition, this project was also the first to extensively use available electronic data from the CHUV and the first to analyze undernutrition reporting and management at the national level. This project pioneered the data extraction from the Lausanne university hospital, revealing several inconsistencies in the screening, management, and documentation of undernutrition. Those inconsistencies have been brought forward to the responsibles and measures are under way to solve them. It also raised the important issue of undernutrition-related costs reimbursement, as our recent findings suggest that undernutrition is not properly valued in the Swiss DRG system.

This project also has several limitations. First, due to administrative restrictions, it was not possible to obtain data from all departments of the Lausanne university hospital. Hence, our analyses were limited to a single department and our results might not be extrapolated to other departments or other hospitals. A further legal constraint precluded the use of individual identification, and only hospitalizations (not individual patients) could be analyzed; hence, it was possible neither to consider multiple hospitalizations nor perform a follow-up of undernourished patients. In the Swiss hospital discharge data, the use of ICD-10 codes underestimated prevalence rates relative to the use of objective measurements, which were unavailable in the database. As for undernutrition prevalence, using Swiss classification of surgical interventions (CHOP) codes for evaluating undernutrition management implementation may over or under estimates the rates compare to objective evaluation of nutritional therapies. Finally, the DRG system and level of reimbursement varies between countries, so the results obtained for Switzerland might not be applicable in other countries.

Public health relevance and proposals

Our results show that undernutrition carries a significant economic burden to Swiss hospitals and is undervalued by the Swiss DRG system. They also show a considerable variation in the way undernutrition status and its management is reported throughout Switzerland. In a country with a highly technical health system, the fact that almost two out of five patients ‘at-risk’ of undernutrition do not benefit from nutritional management cannot be accepted. Finally, our results demonstrate that solely implementing undernutrition screening without implementing the other steps (e.g. management and monitoring) of the undernutrition management process is ineffective. In order to change the current findings, we thus make the following proposals:

1. Standardize the screening and management of undernutrition among hospitals. European guidelines have been issued (1,28), but it is unclear if they were accredited by Swiss clinical nutrition society and are being implemented in Swiss hospitals. Most importantly, adopting a robust and unique set of procedures should be implemented for whole nutritional management steps from screening at admission to discharge and even further (home nutritional support), rather than focusing on one step.

2. Standardize the coding of undernutrition status and its management in hospital discharge data. This is paramount if an adequate monitoring is to be developed and if prevalence and management rates are to be compared between hospitals, cantons or regions. Guidelines have already been issued (29), and it would be important that they are implemented throughout the country.

3. Improve the documentation of nutritional status in the hospital files. This is currently being done at the CHUV, and we expect that it will improve the quality of undernutrition reporting. It would be important that such procedures be also implemented in other hospitals.

4. Re-evaluate the importance of undernutrition in the Swiss DRG system. This proposal carries considerable economic and even political consequences. Strong support and large body of evidences will be needed from multicenter studies to bring undernutrition to the Swiss DRG agenda and the chances of success are reduced.

Noteworthy, given the decisional autonomy given to hospitals, we are aware that most measures presented will be hard to implement. Hence, it would be important that some hospitals take the lead regarding the implementation and auditing of those measures. If the implementation leads to better health care and (hopefully) reduces or does not increase costs, then spreading the implementation to other hospitals would be facilitated.

The next steps

The economic analyses were an eye-opener regarding the non-health consequences of undernutrition. Such analyses should be broadened to other departments of the CHUV, other hospitals (a request to analyze the data from the Hôpital du Valais has been submitted), medical houses and community-dwelling patients. We expect to start collaboration with the health economics team of the Institute of Social and Preventive Medicine (IUMSP) to further develop this topic.

Auditing the changes that occurred due the results of this thesis will also be important. Finally, studies assessing the barriers for proper screening and management of undernutrition at both hospital and national levels should be conducted.

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