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Thierry Chevalier

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UNIVERSITÉ GRENOBLE ALPES
UFR DE MÉDECINE DE GRENOBLE

Année : 2018

**MALNUTRITION AND ITS IMPACT ON LENGTH OF STAY AND COST OF
HOSPITALIZATION, A 10 YEARS OBSERVATIONAL STUDY ON
46,350 INPATIENTS**

THÈSE
PRÉSENTÉE POUR L'OBTENTION DU TITRE DE DOCTEUR EN MÉDECINE
DIPLOME D'ÉTAT

CHEVALIER Thierry

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Professeur GAVAZZI Gaëtan

Membres :

Professeur PISON Christophe

Professeur BOSSON Jean-Luc

Professeur FONTAINE Eric (directeur de thèse)

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Thèse réalisée au Département de Nutrition du CHU de Grenoble

CHEVALIER Thierry

DÉNUTRITION ET SON IMPACT SUR LA DURÉE DU SÉJOUR ET LE COÛT DE L'HOSPITALISATION, UNE ÉTUDE OBSERVATIONNELLE DE 10 ANS SUR 46 350 PATIENTS DU CHU DE GRENOBLE

RÉSUMÉ :

La dénutrition est fréquente en milieu hospitalier (20 à 50% des patients) et son impact est majeur sur la trajectoire des patients. L'hôpital de Grenoble s'est doté, en 2007, d'une unité mobile dédiée à l'évaluation de l'état nutritionnel des patients. L'objectif principal est d'étudier la relation entre l'état nutritionnel et la durée du séjour puis entre l'état nutritionnel et le coût de l'hospitalisation.

Chaque jour, l'unité mobile évalue, avec un équipement calibré, le poids et la taille de tous les patients d'une sélection prédéfinie de services du CHU de Grenoble. Tous les services sont concernés, excepté les soins intensifs, l'orthopédie, la pédiatrie et la maternité. Les critères d'inclusion sont l'âge supérieur à 18 ans et la durée du séjour supérieure à un jour. L'état nutritionnel est évalué par l'indice de masse corporelle mesuré, ou par une variation de poids mesuré significative. L'analyse a été menée en tenant compte de l'âge, du sexe et du diagnostic en tant que facteurs de confusion potentiels.

48,776 patients ont été sélectionnés et 2,426 exclus (critères d'inclusion) entre 2007 et 2017. La prévalence de la dénutrition était de 25,7%, IC [25,3%, 26,1%]. L'augmentation de la durée du séjour était de 4,2 jours (IC à 95%: [3,8, 4,5]) et le surcoût d'hospitalisation médian était de 1 336 € (IQR: 1280 €) pour les patients souffrant de dénutrition comparés aux patients non dénutris. Ces augmentations sont significatives indépendamment de l'âge, du sexe et des pathologies sous-jacentes. Sur la base de ces résultats, la gestion rigoureuse de la nutrition des patients semble être un puissant levier pour améliorer la qualité des soins tout en réduisant les coûts.

MOTS CLÉS : Dénutrition, Durée de séjour, Coûts d'hospitalisation

FILIÈRE : Médecine Générale

MALNUTRITION AND ITS IMPACT ON LENGTH OF STAY AND COST OF HOSPITALIZATION, A 10 YEARS OBSERVATIONAL STUDY ON 46,350 INPATIENTS

ABSTRACT:

Malnutrition is prevalent in the hospital (20-50% of inpatients) with major impact on patients outcome. Grenoble hospital endowed ten years ago with a dedicated mobile unit for nutritional status evaluation. Main objective is to investigate the relation between nutritional status and length of stay and between nutritional status and cost of hospitalization.

Every day, the mobile unit monitor, with calibrated devices, the weight and size of all patients in a pre-defined selection of Grenoble hospital units. All units are concerned, except intensive care, orthopedics, pediatrics and maternity. Inclusion criteria are age above 18 years and length of stay over a day. The nutritional status of patient was assessed either by measured body-mass index or by weight variation analysis. Analysis were driven taking into account age, sex and diagnosis as potential confounders.

48,776 patients were selected and 2,426 were excluded due to inclusion criteria. Prevalence of malnutrition was 25.7 %, CI [25,3%, 26,1%]. Increase of length of stay was 4.2 days (95% CI: [3.8, 4.5]) and median hospitalization over-cost was 1,336 € (IQR: 1280 €) for malnourished patient compared to well-nourished. All this variation are strongly significant even after adjusting on sex, age and patient's pathologies.

Based on this results, a keen nutrition management of any malnourished patient appears to be a powerful key point to increase care quality while reducing costs.

MOTS CLÉS : Malnutrition, Hospital length of stay, Prevalence, Hospitalization costs, Hospitalization outcomes

FILIÈRE : Primary Care

Malnutrition and its impact on length of stay and cost of hospitalization, a 10 years observational study on 46,350 inpatients

Thierry Chevalier^a, S. Bailly^b, Josiane Arnaud^c, Jérôme Fauconnier^d, Eric Fontaine^b

^aGP Department, Grenoble University Hospital, Grenoble

^bNutrition Department, Grenoble University Hospital, Grenoble

^cBiologic Department, Grenoble University Hospital, Grenoble

^dData Department, Grenoble University Hospital, Grenoble

Keywords: Malnutrition, Hospital length of stay, Prevalence, Hospitalization costs, Hospitalization outcomes

Corresponding author: Nutrition Department, Grenoble University Hospital, Avenue Maquis du Grésivaudan, 38700 La Tronche, Grenoble. E-mail address: Efontaine@chu-grenoble.fr

Abstract

Context: Malnutrition is prevalent in the hospital setting with 20-50% of patients identified as malnourished. In many studies, malnourished patients have been shown to have a longer length of hospital stay, about 1.4–1.6 times longer, and higher hospitalization cost than well-nourished patients. Grenoble hospital endowed ten years ago with a dedicated mobile unit for nutritional status evaluation providing considerable high quality nutritional data over the last ten years.

Objectives: Main objective is to investigate the relation between nutritional status and length of stay and between nutritional status and cost of hospitalization based on the evaluations of nutritional status driven by the nutritional mobile unit between 2007 and 2017.

Method: The dedicated nutritional unit measured each day current weight and height of a bunch of patient with calibrated equipment. Based on a day per day predefined schedule of units to be visited, all the patients of the selected units were screened. Any units were concerned except intensive care, orthopedics, pediatric and maternity units. Inclusion criteria were age above 18 years and length of stay over one day. The nutritional status of patient was assessed either by measured body-mass index or by weight variation analysis. Length of stay and hospitalization cost were extract from the digital hospital chart system. Analysis were driven taking into account age, sex and diagnosis as potential confounders.

Results: 48,776 patients were selected and 2,426 were excluded due to inclusion criteria. Prevalence of malnutrition was 25.7 %, CI [25,3%, 26,1%]. Increase of length of stay was 4.2 days (95% CI: [3.8, 4.5]) and median hospitalization over-cost was 1,336 € (IQR: 1280 €) for malnourished patient compared to well-nourished.

Conclusion: In Grenoble hospital, malnutrition is evident in a quarter of patients. This leads for these patients to substantial increase in length of stay and hospitalization cost when compared to the well-nourished regardless of diagnosis considerations. Based on this results, patient nutrition management appears to be a powerful key to increase care quality while reducing costs.

Abstract (Français)

Contexte: La dénutrition est fréquente en milieu hospitalier avec 20 à 50% des patients identifiés comme malnutris. Dans de nombreuses études, il a été démontré que les patients souffrant de dénutrition ont une durée d'hospitalisation plus longue, environ 1.4 à 1.6 fois plus longue, et un coût d'hospitalisation plus élevé que les patients non dénutris. L'hôpital de Grenoble s'est doté, il y a dix ans, d'une unité mobile dédiée à l'évaluation de l'état nutritionnel fournissant régulièrement des données nutritionnelles de grande qualité.

Objectifs: L'objectif principal est d'étudier la relation entre l'état nutritionnel et la durée du séjour ainsi que entre l'état nutritionnel et le coût de l'hospitalisation en fonction des évaluations de l'état nutritionnel menées entre 2007 et 2017 par l'unité mobile nutritionnelle.

Méthode: L'unité nutritionnelle mobile a mesuré chaque jour le poids et la taille d'un groupe de patients avec un équipement calibré. Sur la base d'un programme prédéfini des services à visiter chaque jour, l'unité mobile évaluait tous les patients des services sélectionnés. Tous les services étaient concernés, à l'exception des services de soins intensifs, d'orthopédie, de pédiatrie et de maternité. Les critères d'inclusion étaient l'âge supérieur à 18 ans et la durée du séjour supérieure à un jour. L'état nutritionnel du patient a été évalué soit par indice de masse corporelle mesuré, soit par analyse de la variation de poids. La durée du séjour et le coût de l'hospitalisation ont été extraits du système informatique de l'hôpital. L'analyse a été menée en tenant compte de l'âge, du sexe et du diagnostic en tant que facteurs de confusion potentiels.

Résultats: 48 776 patients ont été sélectionnés et 2 426 ont été exclus en raison des critères d'inclusion. La prévalence de la dénutrition était de 25,7%, IC [25,3%, 26,1%]. L'augmentation de la durée du séjour était de 4,2 jours (IC à 95%: [3,8, 4,5]) et le

surcoût d'hospitalisation médian était de 1 336 € (IQR: 1280 €) pour les patients souffrant de dénutrition comparés aux patients non dénutris.

Conclusion: À l'hôpital de Grenoble, la dénutrition est évidente chez un quart des patients. Cela conduit pour ces patients à une augmentation significative de la durée du séjour et du coût de l'hospitalisation par rapport aux patients non dénutris, et ceci, indépendamment de la pathologie. Sur la base de ces résultats, la gestion de la nutrition des patients semble être un puissant levier pour améliorer la qualité des soins tout en réduisant les coûts.

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Introduction

Malnutrition is prevalent in the hospital setting with 20-50% of patients identified as malnourished during stay or at admission (1, 2). Hospital malnutrition has been adversely related to morbidity, mortality, length of hospital stay (LOS) and costs (3, 4). The metabolic and functional body derangements, which lead to increase the previous described events, are based on the fact that nutrition status plays a fundamental role in almost every organ and system behavior of the human body. The gut of malnourished patients can reveal impaired immune function, digestion and absorption (7, 8). Muscle dysfunction, especially of thoracic muscles, interferes with ventilation function which could explain the high incidence of lung infections in the malnourished (9-11). Wound healing is also adversely affected by malnutrition (12). Despite this high prevalence of malnutrition and its adverse effects, medical awareness of the patients' nutritional status seems to be lacking (1, 13). In many studies, malnourished patients have been shown to have a longer length of hospital stay than well-nourished patients, about 1.4–1.6 times longer (5, 6).

These studies were usually performed in population with a low sample size (2-4). Moreover, in almost all studies solely declarative data are collected and used to determine the nutritional status of patient (5, 14), and it is well known that declarative data are highly subject to memory bias. However, a key point in analysis of impact of nutritional status on LOS is the method used to determine nutritional status. Study main objective is to investigate the relation between nutritional status and LOS and also relation between nutritional status and cost of hospitalization based on rigorous measured evaluation of nutritional status on a 10 years period.

Methods

Study participants and study design

The Grenoble University Hospital is a 2,142 beds hospital with a comprehensive range of medical and surgical specialties. As of May 2007, a dedicated mobile unit has been tasked with measuring each day the current weight and height of the patients of a selected unit with calibrated equipment, and if possible with collecting their weight one and six months before the current hospitalization. Based on a day per day predefined schedule of units to be visited, screening was carried out regularly in all units of the hospital with the exception of intensive care and orthopedics units (due to technical difficulties), of pediatric units (the criteria of malnutrition being different in children) and of maternity units (due to physiological modifications that prevent using weight for nutrition status assessment). Those acquisitions were carried out from May 2007 to May 2017. All patients measured by the dedicated mobile unit were screened for our study. The inclusion criteria were: age above 18 years old and LOS>1day; 1day admission were excluded. Maternity patient were also excluded for same reason. Approximately, 700 patients per month were thereby recorded.

Nutritional assessment

The nutritional status of patient was assessed either by measured body-mass index (BMI) or by weight variation analysis. Patients were divided into three groups: severe malnourished, moderate malnourished and well-nourished. The common threshold (15) were used for groups definition: severe malnourished if BMI<16 for age<70 and BMI<18 for age≥70 (or weight variation>15% of total weight over 6 months), moderate malnourished if BMI<18,5 for age<70 and BMI<21 for age≥70 (or weight

variation > 10% of total weight over 6 months), well nourished is none of the previous criteria.

In some cases, for specific analysis, the nutrition status has been divided into only two categories: malnourished or well-nourished. In this case, moderate malnourished and severe malnourished were grouped into a single malnourished group. The well-nourished group remains unchanged.

Hospitalization outcomes (LOS and cost of hospitalization)

For all patients with weight acquisition between September 2007 and September 2017, the digital hospital chart system was queried to get LOS, Diagnosis Related Group (DRG) and cost of hospitalization. Diagnosis Related Groups is based on ATIH system, the French Agency of Technologies for Hospitalization Information system, that is the reference used by all French hospitals for this purpose. Cost of hospitalization are computed using all the data available in the digital hospital chart system such as diagnosis, prescriptions and investigations realized for a patient all along his stay at the hospital.

Statistical analyses

Qualitative variables were expressed by using effective and percent and quantitative variables by using median and interquartile range.

A natural logarithmic transformation was performed to normalize the distribution of LOS [$\ln(\text{LOS})$]. The Chi square test, was used for two-level categorical variable comparisons. ANOVA was used for multi-level categorical variable comparisons. A linear mixed analysis was performed to assess the association between $\ln(\text{LOS})$, and nutritional status (2-levels or 3-levels categorical variable depending on the context).

Age and sex were added as fixed effects as possible confounders. DRG's were included as random effect.

Statistical analysis were performed by using the python scientific statistical libraries: pandas v0.20.2 and statsmodels v0.8.0. A pvalue threshold of 0.05 was considered for significativity.

Results

A total of 48,776 patients were included on the period 2007-2017. 2,426 were excluded due to age or a one-day LOS. Finally, the study population was constituted by 46,350 patients.

Table 1 shows the characteristics of included patients. The median age was 67 years old with quartile Q1 of 53 years old and Q3 of 78 years old. The sex ratio was 57.2 % of male patients. The median weight was 69 kg with an interquartile of 22 kg. The median size was 167 cm with interquartile of 14 cm.

TABLE 1
Characteristics of study participants

	Value	Min/Max
Number of included patients	46,350	
Age (years)		18 / 113
Mean +/- SD	64.6 +/- 18.2	
Median (IQR)	67 (25)	
≥70 (%)	44%	
Sex (%)		
Male	57.2 %	
Female	42.8 %	
Weight (kg)		21 / 250
Median (IQR)	69 (22)	
Size (cm)		94 / 210
Median (IQR)	167 (14)	
BMI (kg/m ²)		10,6 / 78
Median (IQR)	24.5 (6.5)	

SD, standard deviation; IQR, inter-quartile range; BMI, body mass index

Table 2 provides the prevalence of malnutrition (moderate or severe), the LOS and Cost of hospitalization. The ratio of severe malnutrition is 8.4% and go up to 25.7% for malnutrition including moderate or severe. The median LOS was 10 days and the median cost of hospitalization was 4,758 €.

TABLE 2
LOS, Cost and nutritional status of study participants

	Value	Min/Max
Number of included patients	46,350	
LOS (days)		2 / 532
Mean +/- SD	14.4 +/- 16.2	
Median (IQR)	10 (14)	
Cost of hospitalization (€)		
Mean +/- SD	7,474 +/- 8,958	
Median (IQR)	4,758 (5,268)	
Malnutrition		
Moderate or severe	25.7 %	
Severe	8.4 %	

LOS, length of stay; SD, standard deviation; IQR, inter-quartile range

Table 3 shows the number of patients, age, sex, LOS and cost of hospitalization divided by the nutrition status screening result, well-nourished or malnourished (including moderate and severe malnourished). There is no significant difference of the gender ratio according to nutrition status. Patients with a screening nutrition status of malnourished (moderate or severe) were older ($p < 0.001$), and had a longer LOS [median 13 days, IQR: 16 days] than patients with screening result well-nourished [median 9 days, IQR: 12 days ($p < 0.001$)]. Patients with a screening nutrition status of malnourished (moderate or severe) had also a higher cost of hospitalization [median

5,806 €, IRQ: 5,787 €] than patients with screening result well-nourished [median 4,470 €, IQR:5,094 € ($p < 0.001$)].

TABLE 3
LOS and Cost vs nutritional status (well-nourished, malnourished)

	Well-nourished N=34,430	Malnourished N=11,920	Pvalue
Age (years)			$p < 0.001$
Mean +/- SD	64.1 +/- 17.9	65.9 +/- 19.1	
Median (IQR)	66 (25)	69 (27)	
Sex (%)			$p = 0.17$
Male	57.3	56.6	
Female	42.7	43.4	
LOS (days)			$p < 0.001$
Mean +/- SD	13.1 +/- 15.4	18.1 +/- 17.9	
Median (IQR)	9 (12)	13 (16)	
Cost of hospitalization (€)			$p < 0.001$
Mean +/- SD	7,051 +/- 8,720	8,696 +/- 9,507	
Median (IQR)	4,470 (5,094)	5,806 (5,787)	

N, Number of patients; LOS, length of stay; SD, standard deviation; IQR, inter-quartile range

Table 4 shows the result of the same analysis that one presented in Table 3 using a mixed linear model with taking into account age, sex as confounders and DRG's as random effect. LOS and cost of hospitalization are analyzed with multilinear regression. Results indicated that nutrition status is significantly associated to an increase of the LOS [+4.2 days (95% CI: 3.8, 4.5), $p < 0.001$] and also indicated that nutrition status is significant determinant of cost of hospitalization [+1,251 (95% CI: 1,145, 1,357), $p < 0.001$] when taking into account all the aforementioned confounders.

TABLE 4

Mixed linear regression for ln(LOS) and Cost with adjustment on confounders

	Coefficient	95% Confidence interval	Pvalue
LOS ~			
Malnourished	4.2	[3.8 – 4.5]	p < 0.001
Sex	-0.02	[-0.3 – 0.27]	P=0.91
Age	0.11	[0.1 – 0.12]	p < 0.001
Cost ~			
Malnourished	1,251	[1,145 – 1,357]	p < 0.001
Sex	-290	[-426 – -154]	p < 0.001
Age	24	[20.1 – 27.6]	p < 0.001

LOS, length of stay

Table 5 shows the number of patients, age, sex, LOS and cost of hospitalization divided by the nutrition status screening result, well-nourished, moderate malnourished and severe malnourished. There is no significant difference of the gender ratio whether patients were well-nourished, moderate or severe malnourished. Patients with a screening nutrition status of moderate or severe malnourished were older ($p < 0.001$), had a longer LOS [median 12 days with IQR: 14 days (moderate malnourished) and 15 days with IQR: 19 days (severe malnourished)] than patients with screening result well-nourished [median 9 days with IQR: 12 days ($p < 0.001$)]. Patients with a screening nutrition status of moderate or severe malnourished had also a higher cost of hospitalization [median=5,343 € with IQR=5,790€ (moderate malnourished) and median=6,414 € with IQR=5,890€ (severe malnourished)] than patients with screening result well-nourished [median=4,470 € with IQR=5,094€ ($p < 0.001$)].

TABLE 5

LOS and Cost vs nutritional status (well-nourished, moderate or severe malnourished)

	Well-nourished	Malnourished (moderate)	Malnourished (severe)	Pvalue
	N=34,430	N=8,014	N=3,906	
Age (years)				p < 0.001
Mean +/- SD	64.1 ± 17.9	65.7 +/- 19.4	66.1 +/- 18.6	
Median (IQR)	66 (25)	70 (27)	69 (26)	
Sex (%)				p = 0.26
Male	57.3	56.3	57.2	
Female	42.7	43.7	42.8	
LOS (days)				p < 0.001
Mean +/- SD	13.1 +/- 15.4	16.7 +/- 16.4	21.1 +/- 20.5	
Median (IQR)	9 (12)	12 (14)	15 (19)	
Cost of hospitalization (€)				p < 0.001
Mean +/- SD	7,051 +/- 8,720	8,120 +/- 8,607	9,877 +/- 11,035	
Median (IQR)	4,470 (5,094)	5,343 (5,790)	6,414 (5,890)	

N, Number of patients; LOS, length of stay; SD, standard deviation; IQR, interquartile range

Table 6 shows the result of the same analysis that one presented in Table 5 using a mixed linear model with taking into account age, sex as confounders and DRG's as random effect. LOS and cost of hospitalization are analyzes with multivarible linear regression. Results indicated that nutrition status is a significant determinant of LOS [The regression coefficients of LOS for moderate malnourished and severe malnourished were respectively 2.8 days (95% CI: 2.5, 3.2) p < 0.001 and 6.8 days (95% CI: 6.4, 7.4) p < 0.001]. Results indicated that nutrition status is also a significant determinant of cost of hospitalization [The regression coefficients of COST for moderate malnourished and severe malnourished were respectively 1,022€ (95% CI:

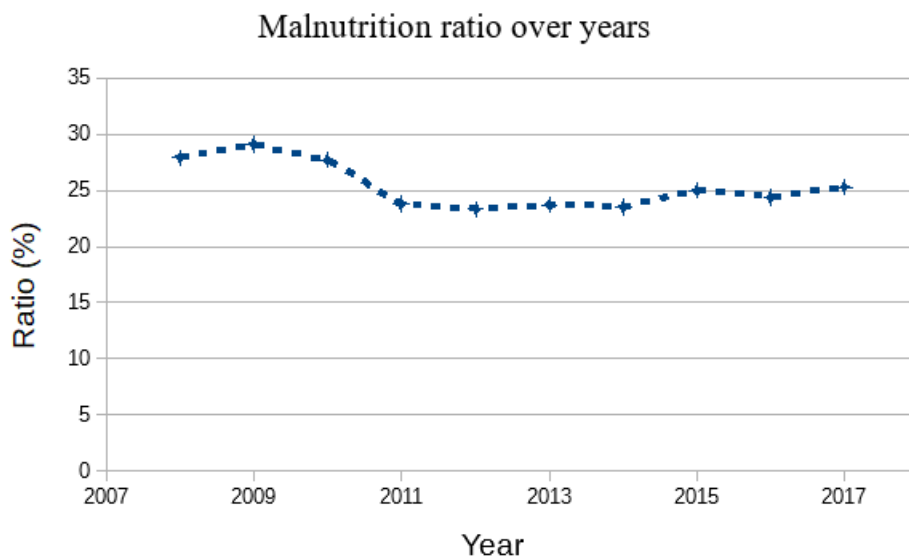
846, 1,199) $p < 0.001$ and 2,689€ (95% CI: 2,448, 2,930) $p < 0.001$] when taking into account all the aforementioned confounders.

TABLE 6
Mixed linear regression for ln(LOS) and Cost with adjustment on confounders

	Coefficient	95% Confidence interval	Pvalue
ln(LOS) ~			
Malnourished (moderate)	2.8	[2.5 – 3.2]	$p < 0.001$
Malnourished (severe)	6.8	[6.4 – 7.4]	$p < 0.001$
Sex	-0.002	[-0.29 – 0.29]	$P=0.99$
Age	0.11	[0.1 – 0.12]	$p < 0.001$
Cost ~			
Malnourished (moderate)	1,022	[846 – 1,199]	$p < 0.001$
Malnourished (severe)	2,689	[2,448 – 2,930]	$p < 0.001$
Sex	-288	[-424 – -153]	$p < 0.001$
Age	23.9	[20.2 – 27.7]	$p < 0.001$

LOS, length of stay

Figure 1 shows the evolution of malnutrition prevalence all along the study. There is clearly no evolution of the prevalence value with time.



Discussion

This study is one of the largest studies providing analyses of impact of malnutrition on LOS and hospitalization costs based on a mobile unit dedicated to the monitoring of the weight and size of each included patient. Weight and size of each inpatient were acquired, using high quality anthropometric devices, by dedicated team to this task with specific qualifications and instructions all along this 10 last years. This monitoring of weight and size acquisitions give a reliable and objective assessment of nutritional status. Most of the time, studies tackling this problem are based on declared weight and size data and are submit to high level of variability due to memory bias.

The number of screened patients as reached 46,350 hospital patients in 2018 and still increase over time. All the data were collected in the same very systematic way all along the 10 years of the study. In that respect, the strict acquisition protocol give access to reliable information of nutritional status in a very large hospitalized population. The screening method based on a day per day predefined schedule of hospital units to be screened over the last 10 years enable a very good representativeness of Grenoble hospital inpatients population. The systematic work of the dedicated mobile unit, give a reliable nutrition status evaluation due to reliable weight and size measurements, thus correlation with LOS and costs could be done in a reliable way.

The second key point of this study is the control of the confounding effect of diagnosis on malnutrition outcomes. Although previous studies have shown a prospective association between malnutrition and clinical outcomes, the confounding effect of diagnosis have hardly been taken into account (4, 6). In this study, besides classical confounding control on age and sex, DRG's were also taken into account as potential confounding effect. For that purpose no DRG's were excluded and all DRG's concerned in the study population were used.

The prevalence screening results all over the 10 years of the study reveal a malnourished ratio of 25.7%, CI [25,3%, 26,1%]. This ratio is in line with this related in other equivalent studies (2, 3, 16), but appears to be higher to some other large studies which have a ratio around 15% (5, 17). The main reason of those differences pointed by all authors is the method used for nutrition state evaluation. Unfortunately, no consensus is defined for BMI thresholds and many different nutritional score are used depending on data available to investigators. As high quality acquisitions of weight and size were available we naturally based our evaluation on BMI criteria. The thresholds were those used for the reimbursement of oral nutrition complement in France. Whatever the criteria for nutrition status are, the prevalence of malnutrition is always higher than any other known chronic pathology.

The current study found a significantly increase of LOS of 4.2 days (95% CI: [3.8, 4.5]), thus shifting LOS from 13.1 days (95% CI: [12.9, 13.2]) for well-nourished patients to 18.1 days (95% CI: [17.8, 18.4]) for malnourished patients, which represent a 1.4 times longer stay for malnourished patient compared to well-nourished. This difference persisted even after adjusting regression on confounders especially DRG's, highlighting that malnutrition is a major trigger of LOS whatever the underlying pathology. That means that no units should be excluded for systematic malnutrition screening regardless the pathology it's dealing with. Any patient in any unit of the hospital could gain high benefits through a correction of nutritional status, leading to global increasing of patient quality care. It is often argued that malnutrition could be due to diseases and not the reverse. This could then be difficult to conclude that malnutrition alone leads to the worst outcome of the patient in question. However, some evidence of malnutrition poor impact could be found even in good health people. It has

been shown that for hunger strikers, in good health, that reach the threshold of 38% weight loss, one third of them died (18). Even short nutrition unsuitable behavior lead to wrong disruptive reactions, so it has been shown that long overnight fast in well-nourished patients, scheduled for surgery, induce peripheral insulin resistance and negative nitrogen balance in post-operative period (19).

Besides harmful effects of malnutrition itself, increasing of LOS drive patient in situation where they are exposed to well-known complications associated with longer hospital stays.

Therefore, it is quite obvious that increasing LOS will increase hospitalization costs. However, the amount of increase in costs is relevant to analyze in regard to the important number of patients concerned by this situation. Our study found that hospitalization costs hike from 4,470€ (median value) for well-nourished patient to 5,806€ for malnourished patients. This difference still persists with high significance after adjusting regression on all confounders as age, sex and DRG's. The shift is then 1,022€ for moderate malnourished patient and reached 2,689€ for severe malnourished patients. Regarding the costs aspects in a general way, the costs' increase constitutes, on average, an over-cost of 32% for any patient that reach the hospital with a bad nutrition status. Analyzing this data in the particular case of Grenoble hospital in an institution way is much more striking. Assuming that almost 25% of patients are malnourished and that around 200,000 patients are admitted to Grenoble hospital a year (Data 2016), the savings dealing appropriately with nutrition could reach 50 millions euros a year.

These results provide the basis for a discussion on the necessity of early malnutrition screening for any inpatients, which straightaway lead to two major questions. The first is what is the method to be used to obtain best malnutrition screening. The second is to

make sure the re-nutrition treatment is effective to make it beneficial for the patient. A recent systematic review and meta-analysis on nutritional support and outcomes in malnourished inpatients concluded that nutritional support increase intake and body weight, but that there was very little effect on clinical outcomes overall except for non-elective re-admissions (20). High quality trials are probably needed to fill this gap.

A first limitation of this study is the not perfect representative of the all hospital's units. Due to specificity of some pathologies, a few units were excluded from the mobile unit schedule and were never visited. It is the case in particular for maternity where weight is not a relevant element for nutrition estimation. It was also the case for orthopedic unit where medical device are often present and that over-weight the patient. It is also true for pediatric unit where nutrition status evaluation is specific. Rigorously, the results can not apply to the population of those units.

Another limitation is the method used for collecting data, unfortunately the used protocol is intrinsically not exactly representative of the hospital population on the LOS point of view. Patients with longer LOS have a higher probability of being included than patients with very short LOS. Indeed, as the measurements of weight and size are based on a predefined schedule of units to be monitored, a patient present for a long stay has a higher probability to be selected in our population than a patient with a short LOS. However, the systematic evaluation of all patients of a unit enable to limit this bias. For the patients that were not selected, costs values were lower and LOS was shorter, leading to the assumption that these patients were less complex and that the missing data of these patients would not have resulted in underestimation but more probably in an overestimation of the percentage of patients with a positive malnutrition result. Nevertheless, the length of the study and the large number of patients enable pertinent

and significant statistical results, although it should be noticed that results of LOS and hospitalization cost increase are likely overestimated.

Another limitation is the lack of smoking status availability so that adjusting could be done on it. Unfortunately, in our study, as in almost on other comparable studies, no smoking information were available.

Conclusion

As many countries encountered high difficulties with their health system from the care availability and costs control point of view, there is nowadays a general agreement that nutrition is a high level trigger for health management efficiency. It's true for healthy people, it is even more for people suffering from chronical pathologies. In Grenoble hospital, malnutrition is evident in a quarter of admitted patient, with an astounding steady trends over the years. This leads for these patients to substantial increase in length of stay and hospitalization cost when compared to the well-nourished regardless of the diagnosis considerations. Length of stay is 1.4 times longer for malnourished patient and for whom the cost is increased by 30% corresponding for Grenoble hospital to an over-cost of 50 million euros each year. If nutritional status and disease determine the patient outcome, then the best solution is to treat the disease and to nourish the patient.

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Acknowledgments:

Acknowledgment to all the staff who worked in the mobile unit dedicated to nutrition assessment evaluation at Grenoble hospital all along the last 10 years.

Tables

TABLE 1
Characteristics of study participants

	Value	Min/Max
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Mean +/- SD	64.6 +/- 18.2	
Median (IQR)	67 (25)	
>70 (%)	44%	
Sex (%)		
Male	57.2 %	
Female	42.8 %	
Weight (kg)		21 / 250
Median (IQR)	69 (22)	
Size (cm)		94 / 210
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BMI (kg/m ²)		10,6 / 78
Median (IQR)	24.5 (6.5)	

N, number of participants; SD, standard deviation; IQR, inter-quartile

TABLE 2

LOS, Cost and nutritional status of study participants

	Value	Min/Max
N	46,350	
LOS (days)		2 / 532
Mean +/- SD	14.4 +/- 16.2	
Median (IQR)	10 (14)	
Cost of hospitalization (€)		
Mean +/- SD	7,474 +/- 8,958	
Median (IQR)	4,758 (5,268)	
Malnutrition		
Moderate or severe	25.7 %	
Severe	8.4 %	

N, number of participants; LOS, length of stay

TABLE 3

LOS and Cost vs nutritional status (well-nourished, malnourished)

	Well-nourished	Malnourished	Pvalue
N	34,430	11,920	
Age (years)			p < 0.001
Mean +/- SD	64.1 +/- 17.9	65.9 +/- 19.1	
Median (IQR)	66 (25)	69 (27)	
Sex (%)			p = 0.17
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N, number of participants; LOS, length of stay;

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Mixed linear regression for ln(LOS) and Cost with adjustment on confounders

	Coefficient	95% Confidence interval	Pvalue
LOS ~			
Malnourished	4.2	[3.8 – 4.5]	p < 0.001
Sex	-0.02	[-0.3 – 0.27]	P=0.91
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Sex	-290	[-426 – -154]	p < 0.001
Age	24	[20.1 – 27.6]	p < 0.001

N, number of participants; LOS, length of stay; DRG, Diagnosis Related Group

TABLE 5

LOS and Cost vs nutritional status (well-nourished, moderate or severe malnourished)

	Well-nourished	Malnourished (moderate)	Malnourished (severe)	Pvalue
N	34,430	8,014	3,906	
Age (years)				p < 0.001
Mean +/- SD	64.1 +/- 17.9	65.7 +/- 19.4	66.1 +/- 18.6	
Median (IQR)	66 (25)	70 (27)	69 (26)	
Sex (%)				p = 0.26
Male	57.3	56.3	57.2	
Female	42.7	43.7	42.8	
LOS (days)				p < 0.001
Mean +/- SD	13.1 +/- 15.4	16.7 +/- 16.4	21.1 +/- 20.5	
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Median (IQR)	4,470 (5,094)	5,343 (5,790)	6,414 (5,890)	

N, number of participants; LOS, length of stay

TABLE 6

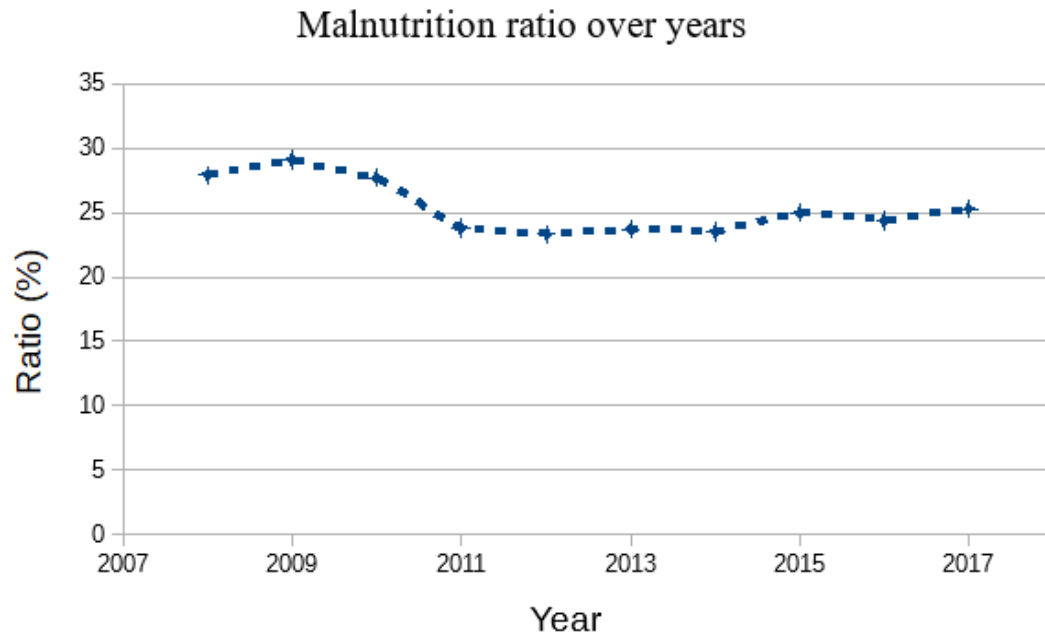
Mixed linear regression for ln(LOS) and Cost with adjustment on confounders

	Coefficient	95% Confidence interval	Pvalue
ln(LOS) ~			
Malnourished (moderate)	2.8	[2.5 – 3.2]	p < 0.001
Malnourished (severe)	6.8	[6.4 – 7.4]	p < 0.001
Sex	-0.002	[-0.29 – 0.29]	P=0.99
Age	0.11	[0.1 – 0.12]	p < 0.001
Cost ~			
Malnourished (moderate)	1,022	[846 – 1,199]	p < 0.001
Malnourished (severe)	2,689	[2,448 – 2,930]	p < 0.001
Sex	-288	[-424 – -153]	p < 0.001
Age	23.9	[20.2 – 27.7]	p < 0.001

N, number of participants; LOS, length of stay; DRG, Diagnosis Related Group

Figures

FIGURE 1
Malnutrition ratio from 2008 to 2017



THÈSE SOUTENUE PAR : CHEVALIER Thierry

TITRE :

DÉNUTRITION ET SON IMPACT SUR LA DURÉE DU SÉJOUR ET LE COÛT DE L'HOSPITALISATION, UNE ÉTUDE OBSERVATIONNELLE DE 10 ANS SUR 46 350 PATIENTS DU CHU DE GRENOBLE

CONCLUSION :

La dénutrition est fréquente en milieu hospitalier (20 à 50% des patients) et son impact est majeure sur la trajectoire des patients. L'hôpital de Grenoble s'est doté, il y a dix ans, d'une unité mobile dédiée à l'évaluation de l'état nutritionnel des patients. L'objectif principal est d'étudier la relation entre l'état nutritionnel et la durée du séjour puis entre l'état nutritionnel et le coût de l'hospitalisation.

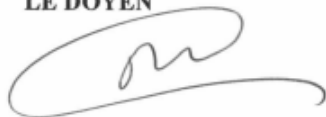
Chaque jour, l'unité mobile évalue, avec un équipement calibré, le poids et la taille de tous les patients d'une sélection prédéfinie de services du CHU de Grenoble. Tous les services sont concernés, excepté les soins intensifs, l'orthopédie, la pédiatrie et la maternité. Les critères d'inclusion sont l'âge supérieur à 18 ans et la durée du séjour supérieure à un jour. L'état nutritionnel est évalué par l'indice de masse corporelle mesuré, ou par une variation de poids mesuré significative. L'analyse a été menée en tenant compte de l'âge, du sexe et du diagnostic en tant que facteurs de confusion potentiels.

48 776 patients ont été sélectionnés et 2 426 exclus (critères d'inclusion) entre 2007 et 2017. La prévalence de la dénutrition était de 25,7%, IC [25,3%, 26,1%]. L'augmentation de la durée du séjour était de 4,2 jours (IC à 95%: [3,8, 4,5]) et le surcoût d'hospitalisation médian était de 1 336 € (IQR: 1280 €) pour les patients souffrant de dénutrition comparés aux patients non dénutris. Ces augmentations sont significatives indépendamment de l'âge, du sexe et des pathologies sous-jacentes. Sur la base de ces résultats, la gestion rigoureuse de la nutrition des patients semble être un puissant levier pour améliorer la qualité des soins tout en réduisant les coûts.

VU ET PERMIS D'IMPRIMER

Grenoble, le : 11.02.2018.

LE DOYEN



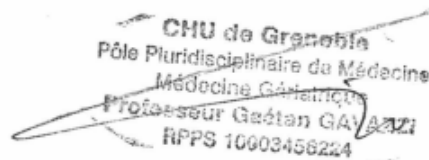
Pr. Patrice MORAND

Pour le Président
et par délégation

Le Doyen de Médecine
Pr. Patrice MORAND

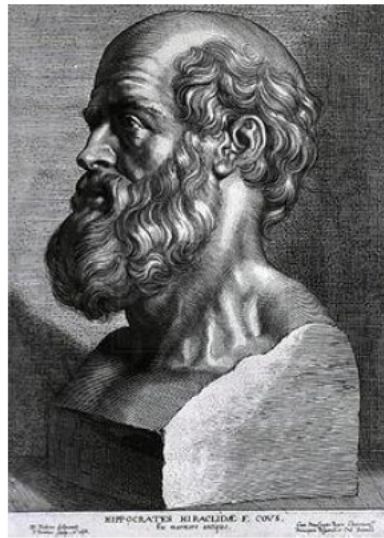
le 2/6/18

LE PRÉSIDENT DE LA THÈSE



CHU de Grenoble
Pôle Pluridisciplinaire de Médecine
Médecine Gériatrique
Professeur Gaëtan GAVAZZI
RPPS 10003456224

Pr. Gaëtan GAVAZZI



SERMENT D'HIPPOCRATE

En présence des Maîtres de cette Faculté, de mes chers condisciples et devant l'effigie d'HIPPOCRATE,

Je promets et je jure d'être fidèle aux lois de l'honneur et de la probité dans l'exercice de la Médecine.

Je donnerai mes soins gratuitement à l'indigent et n'exigerai jamais un salaire au dessus de mon travail. Je ne participerai à aucun partage clandestin d'honoraires.

Admis dans l'intimité des maisons, mes yeux n'y verront pas ce qui s'y passe ; ma langue taira les secrets qui me seront confiés et mon état ne servira pas à corrompre les mœurs, ni à favoriser le crime.

Je ne permettrai pas que des considérations de religion, de nation, de race, de parti ou de classe sociale viennent s'interposer entre mon devoir et mon patient.

Je garderai le respect absolu de la vie humaine.

Même sous la menace, je n'admettrai pas de faire usage de mes connaissances médicales contre les lois de l'humanité.

Respectueux et reconnaissant envers mes Maîtres, je rendrai à leurs enfants l'instruction que j'ai reçue de leurs pères.

Que les hommes m'accordent leur estime si je suis fidèle à mes promesses.

Que je sois couvert d'opprobre et méprisé de mes confrères si j'y manque.