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DISSERTATION

Titel der Dissertation

Nutrition in Hospital and Outcome - Results on some Special Issues in the European Multicenter "nutritionDay" Study

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1 Introduction

In the last decades a change from nutritional intake as a basic need for survival to optimal nutritional intake has occurred. It is demanded that nutrition supports health, well–being and disease prevention. It is self-evident that especially in disease state the possibilities of optimal nutrition should be utilized. However, this is rarely implemented in general hospital wards. The costs spent for a meal provided by the hospital are low. The quality of the provided food needs improvement in terms of composition and density of nutrients and taste and is rarely adapted to the needs of the patient. Also the quantity eaten by the patient is not recorded as body temperature, blood pressure etc., which is recorded daily.

Despite rare use of optimal nutrition in general hospital wards, science in the field of clinical nutrition is increasing. In Austria, the Austrian society for clinical nutrition (Arbeitsgemeinschaft klinische Ernährung, AKE) exists with the corresponding society for Europe, the European Society for Clinical Nutrition and Metabolism (ESPEN). Several screening and assessment tools have been developed for assessing patient at risk for or with established malnutrition (Kondrup et al. (2003a)). Attention is given for nutrition history and weight loss. However, rare studies assess the actual nutritional intake in hospitalized patients.

The nutritionDay study was designed to give a snapshot of nutritional care on typical days in general hospital wards in Europe. Special attention was given to the assessment of the quantity eaten relative to the served meal on the day of the survey. The nutritionDay study should raise awareness of under– and malnutrition in hospitals in Europe. In this doctoral thesis, the quantity of food intake in fractions of served meals, the factors for decreased intake and how additional energy sources (snacks, supplements and artificial nutrition) are used are analyzed. Additionally, the assessment of nutritional risk as well

as gender and regional-related aspects are presented. The effect of the quantity of food intake in general hospital wards on the clinical outcome is investigated.

The structure of the thesis is not in chronologically order of the statistical analyses, but based with regard to contents: **First**, the study design and patient characteristics are described (chapter 2 and chapter 3). **Second**, **nutrition in hospital** is examined **(chapter 4)**. Main objectives are the provided meals by the hospital, their acceptance and reasons for eating less, the contribution of additional energy sources (snacks, supplements, artificial nutrition), regional and gender aspects and the assessment of nutritional risk. **Third**, the impact of **hospital nutrition on outcome** was investigated **(chapter 5)**. **Last**, a **scoring system for nutrition in hospital on the risk for death in hospital** is presented **(chapter 6)**.

The first nutritionDay survey took place in 2006 and was then annually repeated. Chronologically, chapter 5 was analyzed first as the main objective of the nutritionDay study. Second, chapter 4 was analyzed and at last chapter 6. **The thesis refers to the data sets in different phases of the nutritionDay project**:

For the part of the thesis **nutrition in hospital (chapter 4)**, mainly **data of the surveys 2006–2008** were used. Parts of this chapter (section 4.3) were used in the second publication of the nutritionDay in hospital (Schindler et al. (2010)) and for other parts (section 4.1, section 4.2, section 4.6) manuscripts exists.

In the nutritonDay project, the main focus was on the association between **nutrition in hospital and outcome (chapter 5)**. Therefore, the part of the impact of hospital nutrition on outcome was investigated chronologically first. This reflects the chronology of the nutritionDay project in analyzing different questions at different times during the study. For the part of the thesis nutrition in hospital and outcome (chapter 5), **data of the survey 2006** were used. Chapter 5 refers to the first publication of nutritionDay in hospital (Hiesmayr et al. (2009)). In section 5.4, analysis applied to the data of the surveys 2006–2008 are presented.

The part of the thesis about **scoring sytem for nutrition in hospital and outcome** was addressed at last (section 6). For the score, **data of the surveys 2006–2010** have been used. A manuscript about the scoring system is in preparation.

All analyses were done with the help of the statistical software SAS 9.1 and R 2.8.1.

2 Study design

2.1 The NutritionDay study

The one-day audit nutritionDay in Europe is a multinational cross-sectional study with a follow-up period of 30 days. The study was coordinated in close collaboration with ESPEN, AKE and the Medical University, Vienna. Participation was open to any clinical unit that registrated on the nutritionDay website (www.nutritionday.org) and requested an anonymous center (for the hospital) and unit code (for the ward within the hospital). Enrolment was mainly promoted through national clinical nutrition societies represented in the council of ESPEN. The coordinating centre in Vienna gained ethical approval for multi-centre data collection, local approval was additionally necessary in some hospitals according to the different national standards and local interpretations for observational research and audits. All hospitals were instructed to inform patients with the standardised patient information sheet about their right to refuse participation. The responsibility to obtain local approval was within the individual hospitals. Data entry was performed via a dedicated multilingual website (www.nutritionday.org). So far, the nutritionDay took part five times, always on a Thursday in January. The dates of the nutritionDay surveys were 19.01.2006, 25.01.2007, 31.01.2008, 29.01.2009 and 21.01.2010. A repeated participation over the years was possible but not obligatory.

The study has been designed so that data collection can be undertaken by local caregivers with no other external support and using just four carefully designed questionnaires. In the map, figure 2.1, the participating countries are presented. Nearly all recruited patients came from these European countries and Israel. However, in later nutritionDay surveys also countries from other continents participated.

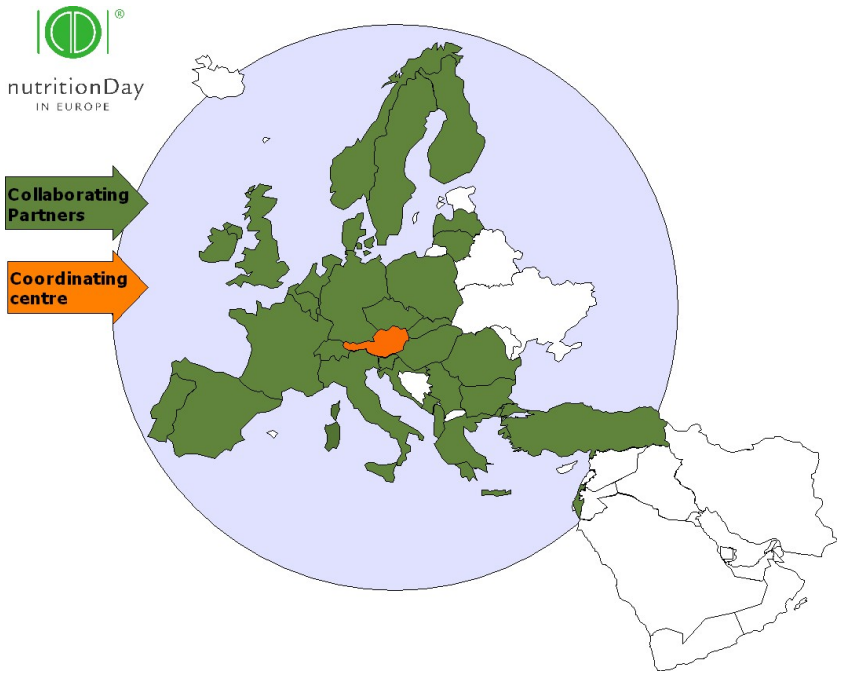


Figure 2.1: Participating countries

The overall aim of the study was to gather information on the level of nutritional care across European hospitals. Is was objected to gain a snapshot of nutritional care viewed from caregivers as well as from patients in daily routine on a typical day in hospitals through Europe. The study has been designed to assess nutritional and clinical risk factors of patients in hospital as well as their outcome within the next month. In detail, the objectives of this study were the evaluation of the amount of the provided food eaten at nutritionDay and the factors influencing decreased food intake on one typical day in European hospitals in patients eating by themselves; to evaluate, whether snacks and nutrition supplements used in daily practice in the nutritionDay cohort have the ability to add substantially on food intake and coverage of energy requirements of those patients who ate less at mealtimes on nutritionDay; to identify which patients are considered to be at nutritional risk and whether this assessment is translated into specific actions. Of special interest was the effect of food intake on all cause 30-day mortality in a large number of hospitalised patients in addition to nutritional and clinical risk factors.

2.2 Questionnaires

The first (figure 2.2) and second questionnaire (figure 2.3) had to be completed with the help of the head nurse or physician. The first questionnaire addressed the structure of the ward in which the patient resided and included information about the type of speciality of the ward, number of beds, staff on the morning shift and screening routine. The second questionnaire considered the caregiver's view of the patient, including data on patient's age, height, weight, affected organs, comorbidites, type of nutritional intake. In addition, unintended weight loss, previous and actual food intake and physical function were assessed through the questionnaires figure 2.4 and figure 2.5 to be filled out by the patients. The questionnaire allowed patients to self-report their actual food intake, including how much they ate for each meal during the NutritionDay, why they did not eat their full meal and their nutrition history before hospitalisation. Food intake at each meal was recorded by patients using simple categories (all, about a half, about a quarter, nothing) similar to those used by Olin et al. A symbolic plate was used to visualize a meal in addition to the written categories and the instruction stated on the sheet: "Please tick a circle for each meal to indicate how much you ate today". Nutritional history was recorded on questionnaire figure 2.4 with the use of selected categories that were already proposed in questionnaires to screen patients for nutrition risk and malnutrition from three scientific societies, the British Association for Parenteral and Enteral Nutrition (BAPEN), ESPEN and AKE. If needed, patients received help to fill out the third questionnaire (figure 2.4 and figure 2.5) by students, student nurses, relatives, etc. Pilot data acquisition showed that personnel specialised in nutrition was not needed to fill out the questionnaires.

In a small validation study, the validity and accuracy of the food intake in sheet 3b (2.5) was investigated by comparing it to a weighing method. The study was designed and conducted by Johanna Tripamer (Tripamer (2009)) and was analysed and interpreted by Elisabeth Pernicka. Patients (n=100) in different wards of the Vienna General Hospital (AKH) were asked to estimate their food consumption at lunch, filling out sheet 3b (figure 2.5). Data were compared by weighing the meal before and after lunch and calculating the percentage of the amount of food consumed. The weighing method and the answers of the sheet 3b were compared with Kendall tau rank correlation coefficient and by calculating the mean and 95% CI of the food eaten according to the weighting procedure

nutritionDay IN EUROPEAN HOSPITALS

SHEET 1

Date _ _ / _ _ / _ _ _ _

Centre Code ☐☐☐

Unit Code ☐☐☐☐

Actual number of beds that are staffed	☐☐ beds
Maximum number of beds in the unit	☐☐ beds
Main patient group admitted (please use code below):	☐☐

1	internal medicine/general	10	general surgery
2	internal medicine/gastroenterology & hepatology	11	cardiothoracic surgery
3	internal medicine/ oncology (incl. radiotherapy)	12	orthopedic surgery
4	internal medicine/ cardiology	13	trauma
5	internal medicine/ infectious diseases	14	neurosurgery
6	internal medicine/ geriatrics	15	gynaecology
7	neurology	16	long-term-care
8	psychiatry	17	others (please describe)_____
9	Ear Nose Throat (ENT)	18	internal medicine/ nephrology
		19	pediatrics

People working on your unit (excluding cleaning staff only):

morning shift

	number (morning shift only)	full time equivalent
Physicians	☐☐	☐☐
Consultants	☐☐	☐☐
Registrars	☐☐	☐☐
Nurses	☐☐	☐☐
Student Nurses	☐☐	☐☐
Nursing aides	☐☐	☐☐
Dietitians	☐☐	☐☐
Student Dietitians	☐☐	☐☐
Dietetic assistants	☐☐	☐☐
Physiotherapists	☐☐	☐☐
Others (please describe)		

Is there a person on your unit dedicated to nutritional care?	◯ YES	◯ NO
Is there a clinical nutrition team in your hospital?	◯ YES	◯ NO
Do you routinely use written procedures for nutritional care?	◯ YES	◯ NO
If YES, which one ...		
national guidelines	◯ YES	◯ NO
local standards	◯ YES	◯ NO
individual patient nutritional care plans	◯ YES	◯ NO
Do you screen your patients on admission for risk of malnutrition?	◯ YES	◯ NO
Which screening tool do you use?		
Nutritional Risk Screening (NRS) 2002	◯ YES	◯ NO
Malnutrition Universal Screening Tool (MUST)	◯ YES	◯ NO
national tool	◯ YES	◯ NO
local tool	◯ YES	◯ NO

If the patient is at risk of malnutrition or actually malnourished - what do you do? (Tick more than one if necessary)	**risk**	**malnourished**
develop an individual nutrition care plan	◯	◯
call a dietician	◯	◯
call the nutrition support team	◯	◯
call a gastroenterologist	◯	◯
other	◯	◯

When do you weigh your patients? (Tick more than one if necessary)

◯ on admission ◯ every week ◯ occasionally ◯ when requested ◯ never

COMMENTS:

Figure 2.2: Questionnaire sheet 1 to be filled out by the staff, version 2008

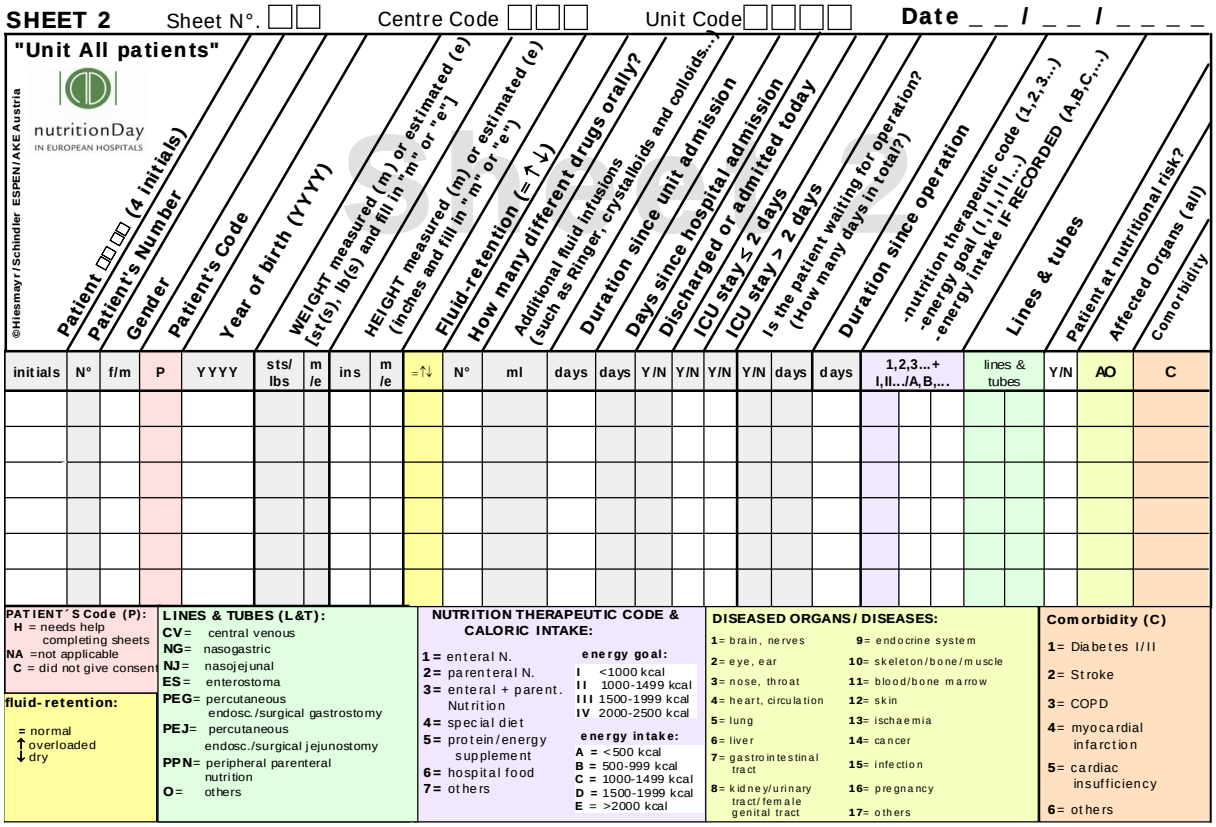
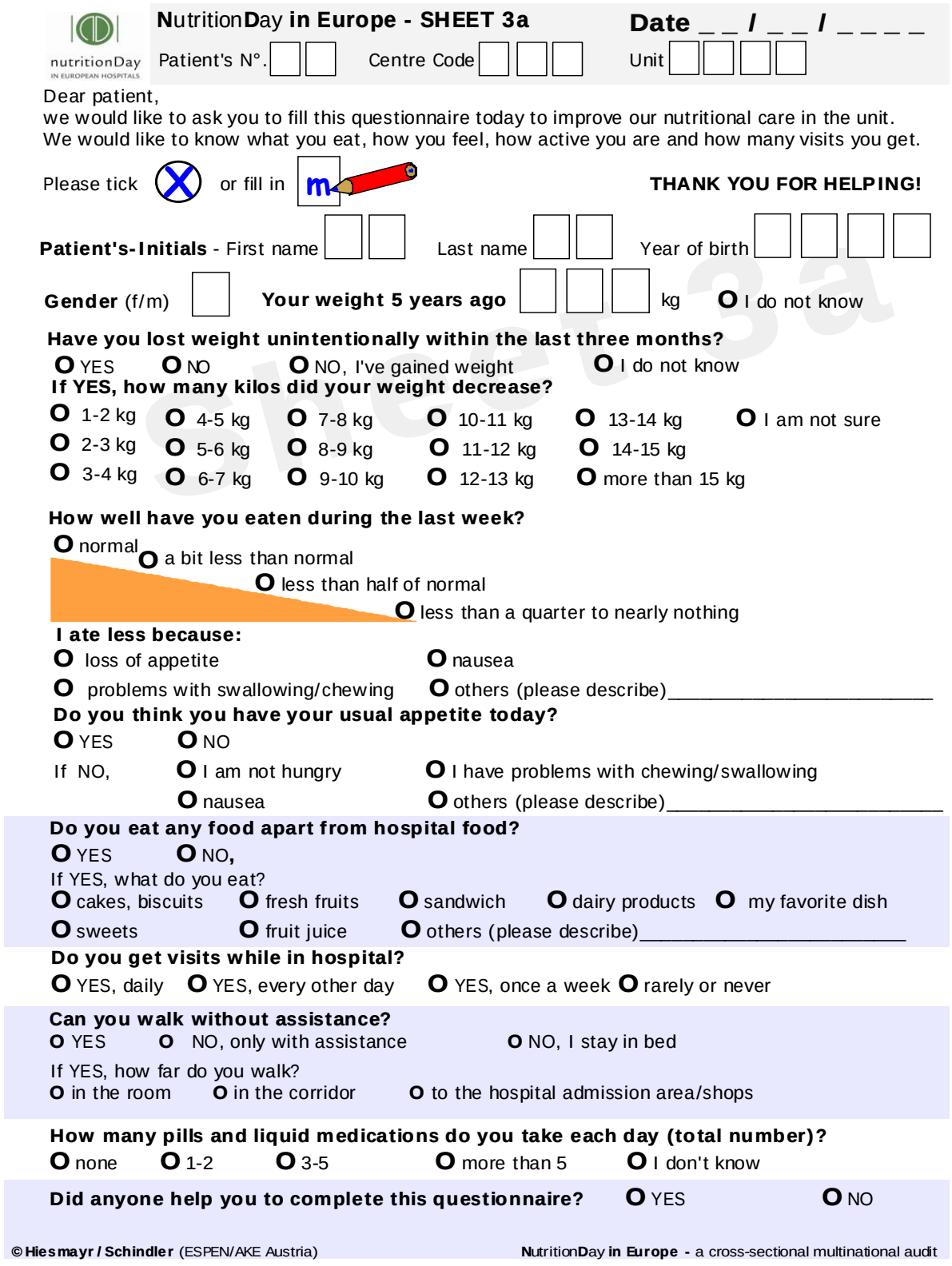


Figure 2.3: Questionnaire sheet 2 to be filled out by the staff, version 2008



NutritionDay in Europe - SHEET 3a Date _ _ / _ _ / _ _ _ _

Patient's N°. Centre Code Unit

Dear patient,
we would like to ask you to fill this questionnaire today to improve our nutritional care in the unit.
We would like to know what you eat, how you feel, how active you are and how many visits you get.

Please tick or fill in **THANK YOU FOR HELPING!**

Patient's-Initials - First name Last name Year of birth

Gender (f/m) **Your weight 5 years ago** kg O I do not know

Have you lost weight unintentionally within the last three months?
O YES O NO O NO, I've gained weight O I do not know

If YES, how many kilos did your weight decrease?
O 1-2 kg O 4-5 kg O 7-8 kg O 10-11 kg O 13-14 kg O I am not sure
O 2-3 kg O 5-6 kg O 8-9 kg O 11-12 kg O 14-15 kg
O 3-4 kg O 6-7 kg O 9-10 kg O 12-13 kg O more than 15 kg

How well have you eaten during the last week?
O normal
O a bit less than normal
O less than half of normal
O less than a quarter to nearly nothing

I ate less because:
O loss of appetite O nausea
O problems with swallowing/chewing O others (please describe)_____

Do you think you have your usual appetite today?
O YES O NO
If NO, O I am not hungry O I have problems with chewing/swallowing
O nausea O others (please describe)_____

Do you eat any food apart from hospital food?
O YES O NO,
If YES, what do you eat?
O cakes, biscuits O fresh fruits O sandwich O dairy products O my favorite dish
O sweets O fruit juice O others (please describe)_____

Do you get visits while in hospital?
O YES, daily O YES, every other day O YES, once a week O rarely or never

Can you walk without assistance?
O YES O NO, only with assistance O NO, I stay in bed
If YES, how far do you walk?
O in the room O in the corridor O to the hospital admission area/shops

How many pills and liquid medications do you take each day (total number)?
O none O 1-2 O 3-5 O more than 5 O I don't know

Did anyone help you to complete this questionnaire? O YES O NO

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Figure 2.4: Questionnaire sheet 3a to be filled out by the patients, version 2008

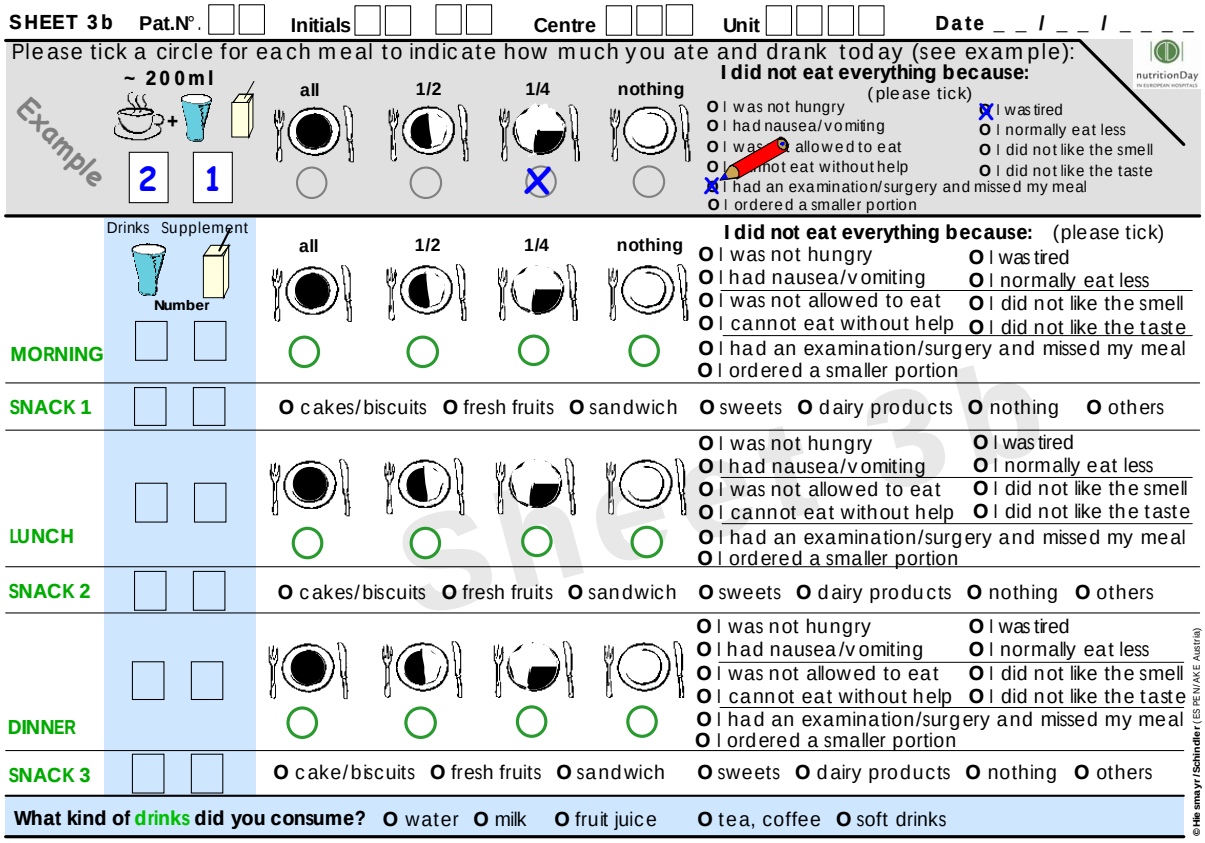

Figure 2.5: Questionnaire sheet 3b to be filled out by the patients, version 2008

stratified for the answers given by the patients (figure 2.6). Patients' self–assessment in the sheet 3b strongly correlated with the actual eaten meal portions assessed by weighing (r=0,616; p<0,0001). The findings of this trial underline the validity of the sheet 3b used to document eaten portion sizes of patients and support to assess the quantity eaten from a hospital meal in the categories "all", "half", "quarter" and "nothing", because the category "three quarter" was linked with high variation (figure 2.6).

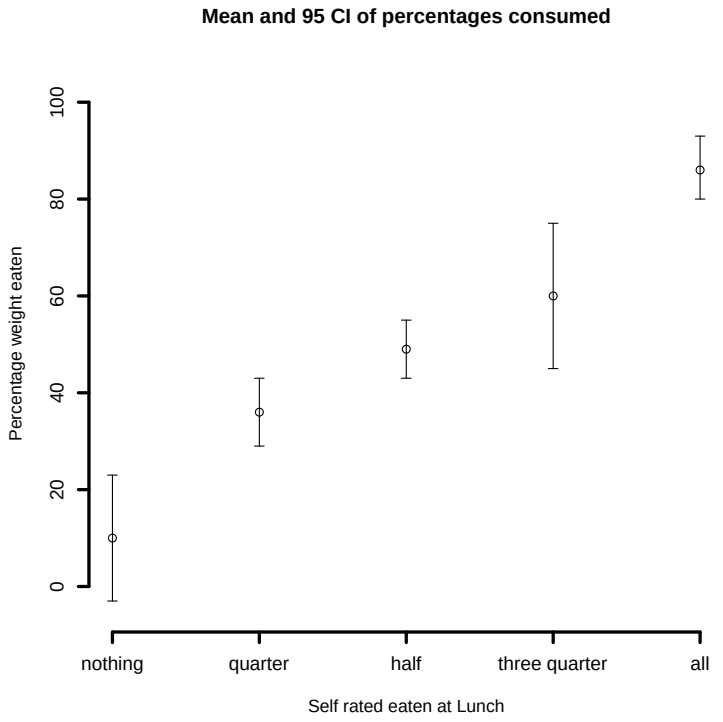

Figure 2.6: Validation of the sheet 3b, found in figure 2.5

Outcome data were recorded by the local responsible coordinator 30 days after NutritionDay. Data entry was performed via a dedicated multilingual website. The outcome evaluation took place at day 30 after nutritionDay with information about date and type of outcome. Possible outcomes of the patients were "discharge home", "death", "still in hospital", "transferred to another hospital", "transferred to long-term care", "rehabilitation", "readmitted", "others" (figure 2.7).

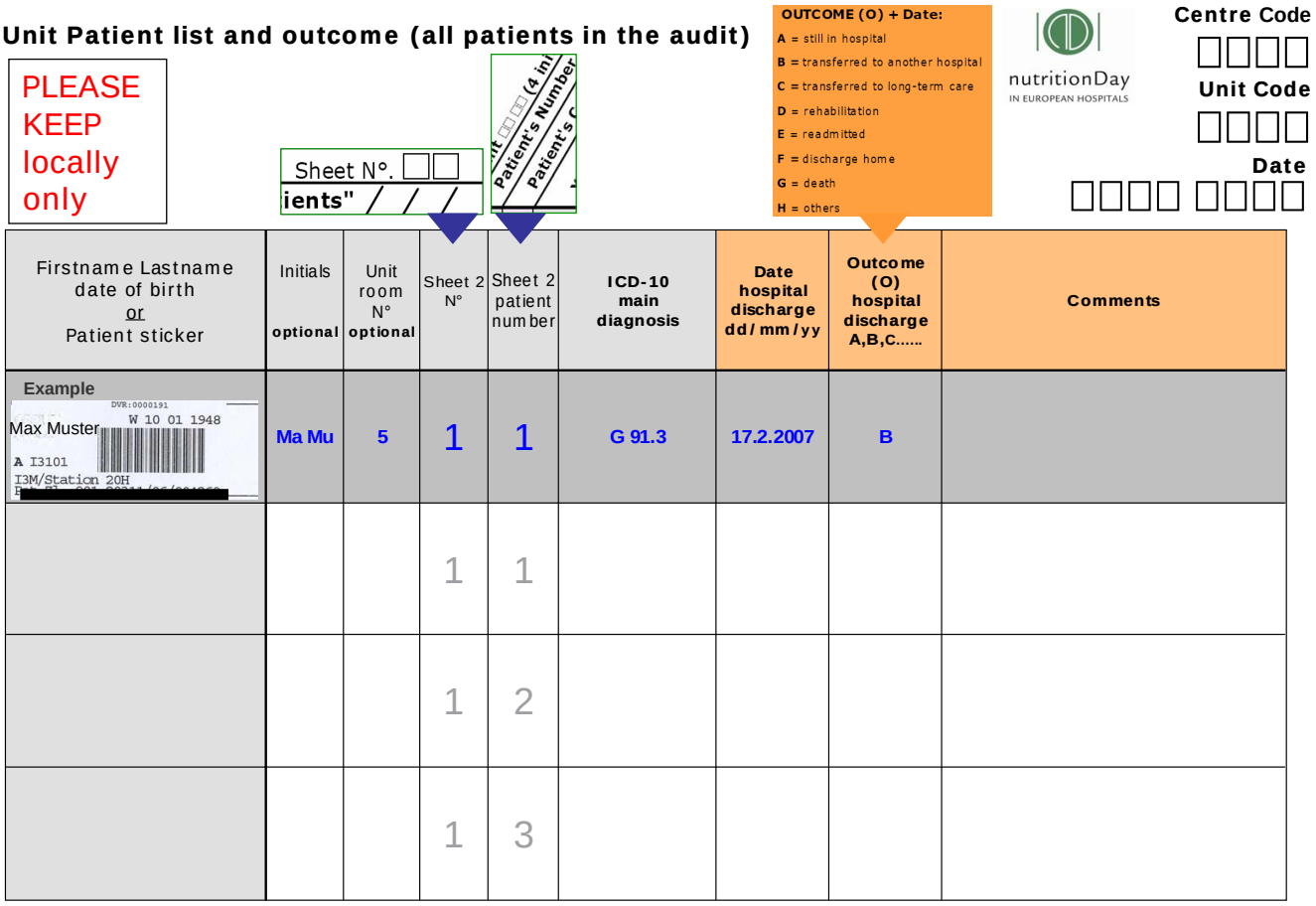

Figure 2.7: Sheet for outcome evaluation to be filled out by the staff, version 2008

There have been some changes in the questionnaires of the surveys in the years 2006, 2007 and 2008. Especially, the questionnaires of the year 2006 were modified. The questionnaires of the years 2007 and 2008 were similar. The following changes had occurred between the questionnaires of the year 2006 and 2007/2008: In sheet 1 (figure 2.2), the questions "Do you screen your patients on admission for risk of malnutrition?" and "Which screening tool do you use?" were added in the surveys 2007 and 2008. In sheet 2 (figure 2.3), the question about "energy goal" and "Patient at nutritional risk?" were added in the surveys 2007 and 2008. The question "Do you eat any food apart from hospital food?" was introduced in the surveys 2007 and 2008 (figure 2.4). In the sheet 3b (figure 2.5), the possible categories of types of snacks were modified in the year 2007/2008.

2.3 Study design characteristics

From each patient, the number of days already in hospital (table 3.4) at the NutritionDay was assessed as well as the type and date of outcome. Therefore, the sum of the days lying already in hospital on the day of the survey together with the days staying in hospital from day of the survey to the outcome day can be calculated as the total length of stay in hospital of the patient. The follow up period was restricted to 30 days beginning with the nutritionDay. If the outcome of the patient occurred later than the follow-up date, the outcome of the patient is so-called "right-censored". For the censored patients, only the truncated length of hospital stay is known. The length of stay of the right-censored patients is the sum of the days lying already in hospital on the day of the survey plus 30 for the follow-up period. The patients with reported outcome in the follow-up period could experience different types of outcomes (see figure 2.7). These different outcomes are competing to each other, because the competing events removed the subject from being at risk for a specific outcome. Therefore the setting is called competing risk setting.

Every patient that was in hospital on the date of the nutritionDay had a chance to be included in the study. By nature of the cross-sectional study design, patients with longer lenght of stay (LOS) had higher probability to take part on nutritionDay. This type of sampling causes length bias as patients with longer LOS are more easily included in the study. E.g. a patient whose total hospitalization time is 2 days is more likely to be sampled than a patient whose hospitalization time is 1 day as he has twice the chance to

be included.

In figure 2.8, the lexis diagram of the study design of observational studies is displayed. Each 45 ° line represents one patient. In the cross-sectional nutritionDay study, only patients who are present in the hospital on the date of the survey can participate. Therefore, only patients who cross the doted line at day 0 (nutritionDay) are possible participants. In figure 2.9, only the participants are displayed. The information that is gained on the nutritionDay survey is marked in blue. The days the patients are already in hospital on the nutritionDay study is assessed for every patient. The days the patient is in hospital after the nutritionDay study is also assessed. However, if the patients experience the outcome after the follow-up period, the patient is censored. The occurrence of censoring is shown in figure 2.9 on the right side.

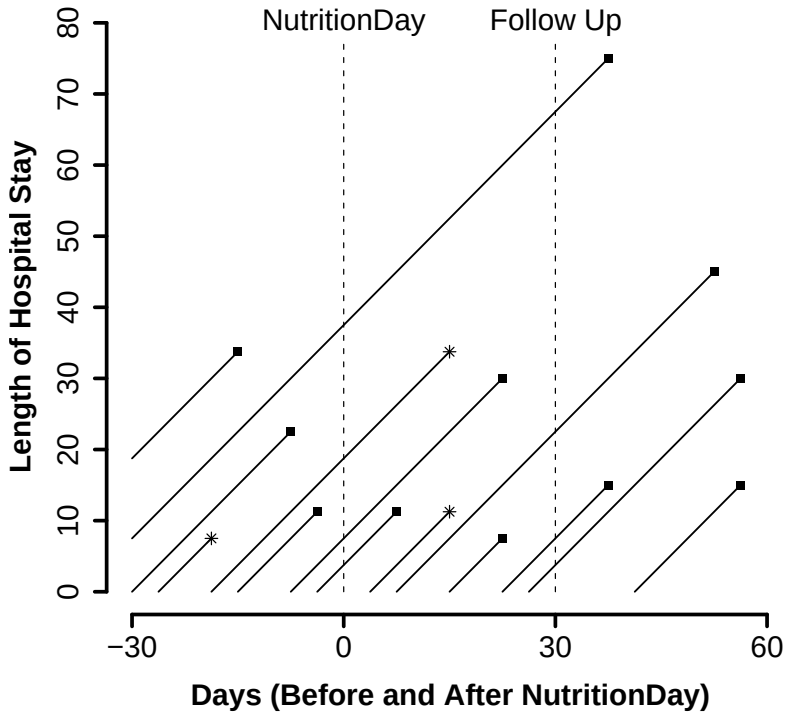

Figure 2.8: **Patients in hospital:** Each 45 ° line represents one patient. On the x-axis the time before and after NutritionDay is given and on the y-axis the LOS is given. Some of patients were discharged from hospital before NutritionDay and therefore, cannot participate at the NutritionDay study. Only patients, who are in hospital on the NutritionDay (who cross the dotted line at day 0) can participate. The second dotted line (at day 30) shows the date of the follow-up. If the outcome of the patients occurs within the 30 days between NutritionDay and follow-up day, the complete length of stay of the patient is known. For these patients, the date and type of outcome is reported. The different symbols at the discharge of the patients show the different types of outcomes.

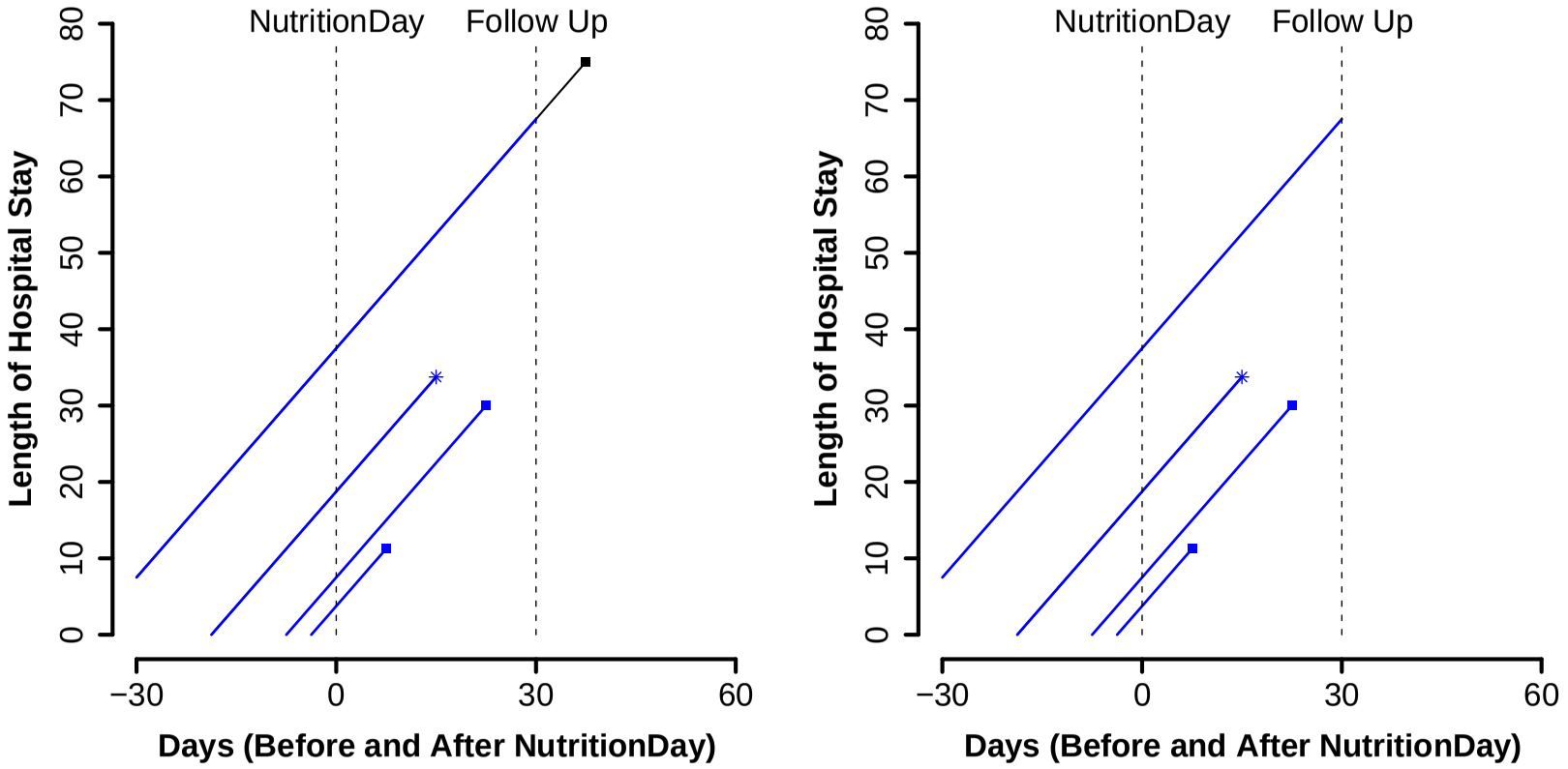

Figure 2.9: **NutritionDay Participants:** Each 45 ° line represents one participant. On the x-axis the time before and after NutritionDay is given and on the y-axis the LOS is given. Only patients, who are in hospital on NutritionDay (who cross the dotted line at day 0) can participate. From the participants, the time spent in hospital before NutritionDay is known. The type and date of outcome is known, if the outcome occurs within 30 days of follow-up. All information which is received at the NutritionDay study is marked in blue. The different symbols at discharge from hospitals show the different types of outcomes. Outcomes that occurred after the follow-up period are not assessed. The right-censoring is displayed in the right figure as for one patient only the truncated length of stay can be reported.

3 Patient characteristics

3.1 Patients demographics

All inpatients older or equal than 18 years from all kinds of hospital wards could participate. In the surveys of the years 2006, 2007 and 2008 35077 patients, who have given informed consent and have received the nutritionDay sheets, were available for analysis. Patients who have not received the sheets to be filled out by the patients (figure 2.4 and 2.5) have been excluded from the analysis. In total, subjects from 27 countries and 451 centers participated. The patients came from 1529 hospital wards. From these wards, 16% participated in two surveys and 11% took part on all three years of the nutritionDay study. Wards from 16 different specialties participated. These wards were summarized in 5 groups of wards and the patient mix coming from these 5 wards is given in table 3.2. Patients from internal medicine and general surgery units represented the majority of participants. As the actual number of beds that were staffed in the wards was assessed in figure 2.2, the patient recruitment within each ward could be calculated. Median patient recruitment within each ward was 91% of occupied beds.

Demographic data of the patients are presented for each year of survey in table 3.1. The mean age and mean BMI of the participants was stable in the four years of surveys. The patients were on average 62-63 years old (depending on the year of the survey) and had a BMI of 25. In total, 50% of the patients were male and female.

Data of the nutritionDay survey 2009 were available for analysis in summer 2009 and were only used for the analysis in section 4.6 and in section 6.4. Additionally, the data of the nutritionDay survey 2010 have only be used as a validation sample in the section 6.5.

Table 3.1: Patients demographics

nutritionDay survey	2006		2007		2008	
	mean ± std	N	mean ± std	N	mean ± std	N
age	62.3 ± 17.6	14070	63.1 ± 17.9	9204	62.6 ± 16.9	11803
BMI	25.6 ± 5.5	13487	25.7 ± 5.6	8821	25.6 ± 5.7	10942
weight in kg	72.1 ± 16.8	13614	72.3 ± 17.4	8960	71.3 ± 18.3	11391
weight 5 years ago in kg	75.1 ± 16.7	11440	76.1 ± 19.0	7111	74.7 ± 18.0	10319
	proportion	N	proportion	N	proportion	N
gender	48%	14070	53%	9204	48%	11803

Table 3.2: Patient case mix

nutritionDay survey	2006 N=14070 proportion	2007 N=9204 proportion	2008 N=11803 proportion
type of ward			
internal	42%	40%	36%
surgery	33%	31%	30%
geriatrics	6%	11%	9%
neurology	5%	4%	4%
others	14%	14%	21%

3.2 Patients' disease characteristics

The characteristics of patients are given in table 3.3. Affected organs according to the ICD-top category had to be indicated by the staff. Patients could have multiple affected organs and therefore, the percentages in table 3.3 do not add to 100%. Additionally, comorbidities of the patients had to be filled out. Again, multiple comorbidities could be present. However, contrary to affected organs, the absence of any comorbidity was also possible. Indeed, 40% of the patients had no comorbidity according to the staff. Again, the proportions of affected organs or comorbidities were stable across the years of survey.

The time the patient was already in hospital was variable due to the cross-sectional design of the study. Therefore, the survey on nutrition and disease related factors were performed on different days of the patients' hospital stay. The mean time patients were already in hospital on the day of the survey was again similar across the years of surveys (table 3.4). To avoid that patients could take part several times on the nutritionDay surveys, patients who have been in hospital since more than 365 days on the days of the survey have been excluded. However, no such participants have been found. It can not be excluded that a patient who is admitted to a hospital several times has participated in several nutritionDay surveys.

Table 3.3: Patients characteristics

nutritionDay survey	2006 N=14070 proportion	2007 N=9204 proportion	2008 N=11803 proportion
affected organs			
Brain, nerves	14%	14%	13%
Eye, ear	3%	2%	2%
Nose, throat	4%	4%	3%
Heart, circulation	23%	23%	21%
Lung	14%	12%	11%
Liver	7%	7%	7%
Gastrointestinal tract	21%	25%	22%
Kidney, urinary tract	9%	14%	9%
Endocrine system	6%	7%	7%
Skeleton, bone, muscle	16%	17%	18%
Blood, bone marrow	5%	4%	3%
Skin	3%	3%	3%
Ischaemia	2%	2%	1%
Cancer	15%	16%	17%
Infection	6%	6%	5%
Others	8%	6%	9%
comorbidities			
Diabetes I/II	16%	16%	17%
Stroke	5%	5%	4%
COPD	6%	6%	5%
Myocardial infarction	4%	4%	3%
Cardiac insufficiency	10%	12%	10%
Others	32%	37%	37%

Table 3.4: Length of hospital stay on day of survey

nutritionDay survey	2006	2007	2008
N with information on days since admission	12727	8128	7952
days since admission on day of survey median (lower quartile; upper quartile)	6 (3;14)	6 (3;14)	7 (3;15)

4 Nutrition in hospital

4.1 The contribution of meals and snacks to nutrition in hospitals

The results of this section 4.1 refer to the manuscript, to be submitted:

> Schindler, Pernicka, Bauer, Hiesmayr : The contribution of meals and snacks to nutrition in hospitals and their impact on outcome - findings from the 2006, 2007, 2008 cross-sectional nutritionDay survey.

Malnutrition is defined as over- as well as under-nutrition along with inflammatory activity on the body (Meijers et al. (2010)). Research about malnutrition in hospital focuses on undernutrition per se (negative nutrient balance) or under–nutrition associated malnutrition. It is a state of deficiency of energy, macronutrients and micronutrients, including vitamins and trace elements. Malnutrition is often related to age and/or disease, affects 20-60% of hospitalized patients (Bistrian et al. (1974), Norman et al. (2008)) and leads to increased length of hospital stay and measurable adverse effects on body function, quality of life and clinical outcome.

Malnutrition is increasingly becoming a global political and health issue, negatively affecting social and economic performances of high and low income countries. However, it is generally perceived that overweight and obesity should represent the major concerns, since their prevalence is increasing in high income countries, potentially leading to higher disability among the population and greater healthcare costs. In low income countries, obesity is a concern as well, since the shift toward increasing body mass index of the general population is a marker of better economic conditions but may also predict the future greater impact of degenerative diseases on the national wellbeing. However, also malnutrition as it pertains to undernutrition remains a clinically relevant issue in low and

high income countries, although it has received very little attention when devising policies to enhance public health and healthcare at the national and international levels.

The causes of malnutrition are multifaceted – disease per se can increase energy and nutrient requirements and/or can be paralleled by impaired food intake due to disease associated loss of appetite (i.e., secondary anorexia) and functional impairment. Previous studies (Barton et al. (2000a), Dupertuis et al. (2003)) suggest that secondary anorexia is a relevant player in hospital malnutrition since they show that the majority of patients do not consume the whole meals provided and that food wastage in hospital is rather high.

To maintain the balance between requirements and intake also in those patients not meeting their needs by hospital food, fortified menus, snacks, liquid oral nutritional supplements, enteral and parenteral nutrition should be used. Provision of fortified menus or snacks between meals have been demonstrated to improve patients' energy and nutrient intake (Gall et al. (1998), Barton et al. (2000b), Price et al. (2006)). Similarly, liquid oral nutritional supplements (Milne et al. (2009)) and artificial nutrition have been shown to improve patients' nutritional status (Lochs et al. (2006)).

However, whether scientific evidence is translated into routine clinical practice remains largely unknown, since large and international surveys addressing the assessment of nutritional intake and clinical management of reduced nutritional intake in hospitalized patients are lacking. Therefore, the aim of this study was to evaluate the amount of food eaten and the factors influencing decreased food intake on one typical day in European hospitals. Also, we aimed at evaluating whether snacks used in daily practice in the nutritionDay cohort have the ability to add substantially on food intake and coverage of energy requirements of those patients who ate less at mealtimes on one typical day in European hospitals.

4.1.1 Statistical methods

General methodology

If the case of a dichotomous response variable Y and a set of predictor variables $X = (X_1, X_2, ..., X_m)$, a binary logistic regression model is generally preferred. The so called

logit model is given as

$$P[Y = 1 \mid X] = \frac{\exp(\beta_0 + \sum_{i=1}^{k} \beta_i X_i)}{1 + \exp(\beta_0 + \sum_{i=1}^{k} \beta_i X_i)}$$

$$\frac{P[Y = 1 \mid X]}{P[Y = 0 \mid X]} = \exp(\beta_0 + \sum_{i=1}^{k} \beta_i X_i)$$

The odds ratio in the logit model for the comparison of x_A to x_B is then

$$\frac{P(Y = 1 \mid X^{(A)})/P(Y = 0 \mid X^{(A)})}{P(Y = 1 \mid X^{(B)})/P(Y = 0 \mid X^{(B)})} = \exp(\sum_{i=1}^{k} \beta_i [X_i^{(B)} - X_i^{(A)}])$$

For every unit increase in X_i, the odds for $Y = 1$ increased by the factor $\exp(\beta_i)$ holding all the other covariables constant.

If the response variable Y has ordinal scale, ordinal regression can be used, if the assumption of proportional odds are fullfilled. The so-called proportional odds model is given as

$$\frac{P(Y \leq j \mid X)}{P(Y > j \mid X)} = \exp(\beta_0 + \sum_{i=1}^{k} \beta_i X_i)$$

and shows how likely is the response to be a category j or below j versus a response that's higher than j. The odds ratio in the proportional odds model for the comparision of x_A to x_B is then

$$\frac{P(Y \leq j \mid X^{(A)})/P(Y > j \mid X^{(A)})}{P(Y \leq j \mid X^{(B)})/P(Y > j \mid X^{(B)})} = \exp(\sum_{i=1}^{k} \beta_i [X_i^{(B)} - X_i^{(A)}])$$

For every unit increase in X_i, the odds for being in a lower response level increased by the factor $\exp(\beta_i)$ holding all the other covariables constant. The proportional odds model assumes that the effect of the independents is the same for each level (j) of the dependent (Y).

Generalized Estimating Equations (GEE) were introduced by Liang and Zeger (Liang and Zeger (1986)) as a method for handling correlated discrete data that would typically be analyzed with a Generalized Linear Model (GLM). This approach accommodates dichotomous and ordinal outcomes for which the correlation among observations that generated the data would otherwise not be considered if it were processed with logistic binary regression or ordinal regression as described previously. The primary difference is

their ability to account for the within-cluster covariance structure. The GEE model can be applied when the population averaged response as a function of the covariates should be investigated. Explanatory variables can be a mix of categorical and continuous data. The available covariance structure has to be specified. The covariance structure defines how observations within a subject or cluster are correlated with each other. Correlated data are modeled with the same link functions and linear predictor equation as found with independent data. The random component of GEEs is also described by the same variance functions, but now the covariance structure of the correlated measurements must also be modeled. The number of clusters is a key issue for the procedure to work. The interpretation of the parameters from a GEE model with binary or ordinal response is analogous to the standard logistic or ordinal regression model. For binary response, the transformed regression coefficient $\exp(\beta_i)$ is the odds for $Y = 1$ for a subject where $x_i = 1$ divided by the odds for $Y = 1$ from a subject where $x_i = 0$. However, the GEE model adjusts for the correlation between measurements from the same cluster. Measurements from different clusters are considered to be independent in order to consistently estimate the variance. The regression of the response on explanatory variables is modeled accounting for within-cluster correlation. The interpretation of the parameter does not depend on the respective cluster but rather is valid for the whole population of potential clusters in the study and actually averages the effect of $X = (X_1, X_2, ..., X_m)$ across the clusters.

All tests were two-sided. P-values < 0.05 were considered to be statistically significant. Data analysis was performed using the Statistical software of SAS Institute Inc., Version 9.1 and R 2.8.1.

For multivariate analyses, logistic and ordinal regression analysis using GEE with hospitals as repeated measures were carried out using SAS's PROC GENMOD to account for within hospital correlation. As patients in the same hospital are supplied by same source, organization and care of nutrition, hospitals were taken as clusters. Exchangeable covariance structure was applied, which means that correlation between any two patients of the i^{th} hospital is the same. Models with binary and ordinal response variables were performed. For binary response variable, the probability distribution is binomial, and the link function is logit. For ordinal response variable, distribution is multinomial, and the link function is cumlogit. In this doctoral thesis, GEE are applied several. For simplicity

models with binary response are called GEE_{binary} and models with ordinal response are called $GEE_{ordinal}$. Because of the huge amounts of the resuls, it is omitted to present standard univariate analysis and investigation of correlation among predictors. Main focus is put on the multivariate analysis.

Table 4.1 gives an overview of the analyses performed in chapter 4. In this chapter, dependent variables are marked **bold** and independent variables are marked *italic*.

Table 4.1: Overview of multivariate analyses in chapter 4

dependent variable	type of variable	section
quantity eaten at lunch	ordinal	4.1
snacks eaten at nutrition day	ordinal	4.1
reason for eating less - "not being hungry"	binary	4.1
reason for eating less - "having nausea or vomiting"	binary	4.1
reason for eating less - "did not like the taste or smell"	binary	4.1
reason for eating less - "normally eat less"	binary	4.1
Receiving supplements in hospital	binary	4.2
subjective classification of patients at nutritional risk	binary	4.3
energy intake	ordinal	4.6
energy need	ordinal	4.6
weight loss	ordinal	4.6
quantity eaten in previous week	ordinal	4.6
quantity eaten at nutritionDay	ordinal	4.6
reason for eating less - "several reasons separately analyzed"	binary	4.6

Applied statistical methods

Ordinal target variables were a) quantity eaten at lunch (all, half, quarter, nothing) and b) snacks eaten at nutrition day (no snack, 1 or 2, more than 2 snacks). The following nutrition related parameters were studied as influence factors: *"How well have you eaten during the last week?", "Have you lost weight unintentionally within the last 3 months?, intake at nutritionDay (snacks eaten before or after lunch for a) eaten at lunch, intake at lunch for b) snacks), "Do you get visits while in hospital?" and receiving supplementation (yes/no).* The following disease related parameters were used in all multivariate analysis to adjust for severity of disease: *age, BMI in categories according to WHO, sex, length of hospital stay prior to the survey, number of drugs, mobility status, ICU stay prior to the survey, affected organs according to the ICD-10 top*

group, presence of specific comorbidities, specialties of the wards, presence of dieticians, country and year of survey. For analyzing influence factors on stating specific reasons for eating less than the provided food by the hospital, the target population are the patients eating less in hospital.

The influence factors for **ticking a special reason at lunch** were analyzed with the same models for binary response, but within target population of patients consuming less. The studied reasons were **"not being hungry", "having nausea or vomiting", "did not like the taste or smell" and "normally eat less"** as the most chosen reasons.

For comparison between the quantity eaten (all, half, quarter, nothing) at different meal times (breakfast, lunch, dinner), weighted kappa coefficients and Spearman correlation coefficients were calculated.

Patients with artificial nutrition were excluded in all analysis. As the main objective was to study the amount of food eaten in hospital by the patients and the reasons for eating less food than provided, only patients with spontaneous and autonomous nutrition intake could be studied.

4.1.2 Results

The nutritionDay data presented in this section consists of three one-day cross-sectional audits (2006, 2007, and 2008) of food intake by hospitalized patients. A total of 29518 patients treated in 1804 wards from 438 hospitals in 26 countries participated in the three audits of the nutritionDay study and were able to eat by themselves. The analysis was restricted to patients who can eat by themselves. Therefore, patients with artificial nutrition were excluded from this analysis. The reason behind was, that patients with total or partly artificial nutrition have low to no influence on the quantity nutrition consumed. As the main objective was to study the quantity eaten in hospital selected by the patients and the reasons for less eaten, only patients with autonomous nutrition intake could be studied.

Patient's Food intake from main meals

More than two thirds of the patients were provided with hospital food including special diets (table 4.2). However, as indicated by the patients, more than 50% of them consumed half or less of the entire provided meals (figure 4.2). A complete breakfast, compared with the other meals, was slightly more often eaten. Not surprisingly, the proportion of subjects not allowed eating due to examination or surgery was higher in the morning. Every eighth patient was not allowed to have breakfast (figure 4.2). A complete lunch and dinner was eaten by 41% of those patients who where allowed to eat. The agreement between the quantity of meal consumed at lunch and at dinner was 0.55 (95% CI for weighted kappa 0.54; 0.56) for all who were allowed to eat at both meals and where information was present (n=24202). There was a significant positive correlation between the quantity eaten at the three main meals (lunch vs. dinner, Spearmen correlation coefficient r=0.61, p<0.0001, lunch vs. morning r=0.53, p<0.0001, morning vs. dinner r=0.53, p<0.0001). There was only a small chance that the patients who ate nothing for lunch to eat at least a quarter of dinner and vice versa (figure 4.3).

On average, 19% of the served meals were not eaten (N=25629), when counting the quarters that were eaten less than the provided meal at lunch. So, every fifth meal was thrown away.

The answers to the questions about previous and actual food intake given by the patients were surprisingly stable across the years of survey. In figure 4.1, the barcharts for the answers given to the questions "Please tick a circle for each meal to indicate how much you ate and drank today" stratified for the years of survey are given. The numbers given at each year of survey indicated the number of patients asked for their food intake in the according year. In each barchart, the number of patients giving answer to the questions is indicated.

The quantity eaten at morning, lunch and dinner are surprisingly stable for the three years of survey. Overall, the proportion of patients being not allowed to eat because of medical reasons or because they missed the meal due to examinations, was highest in the morning and decreased at lunch and dinner. The proportion of patients eating the complete breakfast was higher than the proportion of patients eating the whole meal at

lunch or dinner. Especially at lunch, the proportion of patients eating half of the served portion was higher than at morning or dinner.

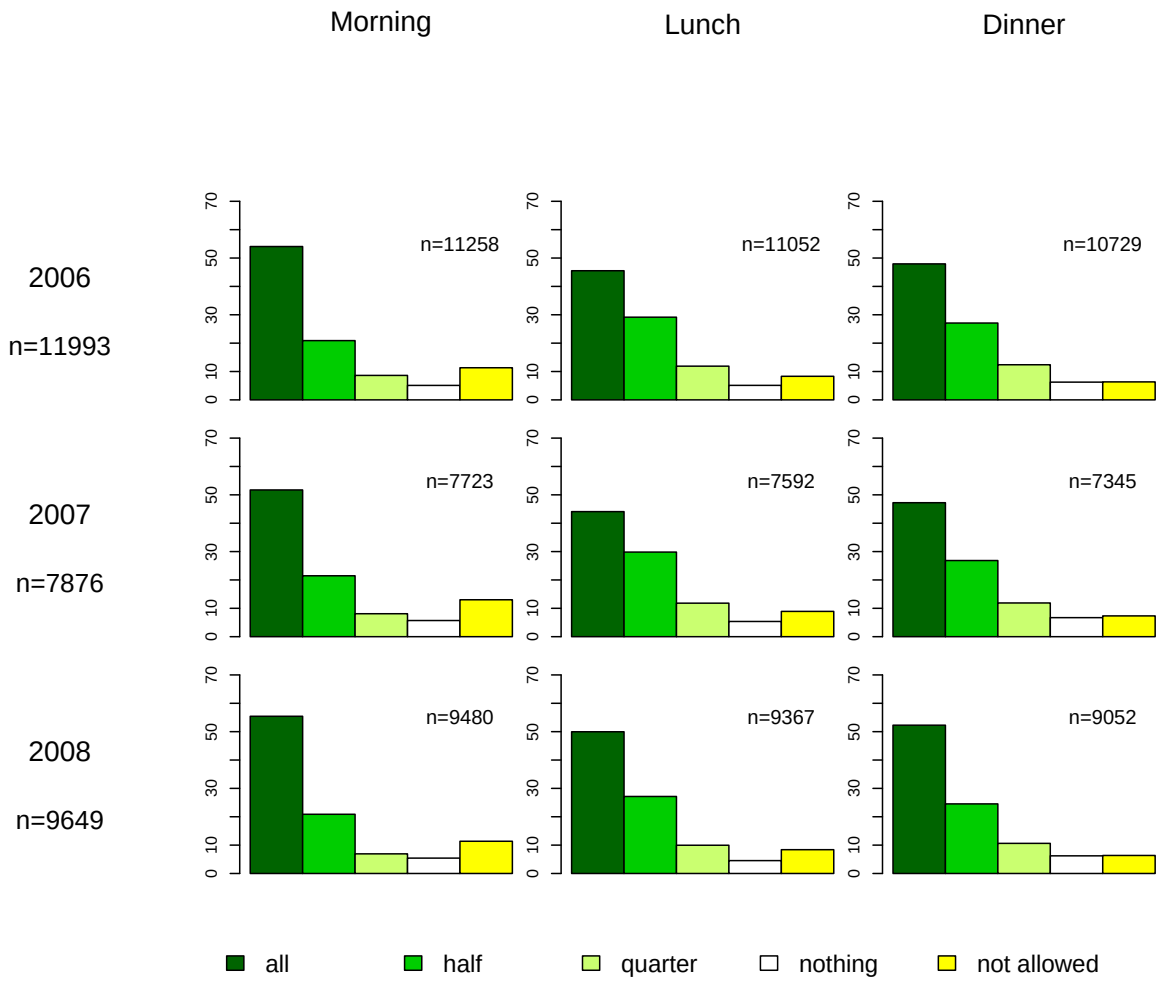

Figure 4.1: Quantity eaten at main meals stratified for year of survey, the number of patients giving an answer to the question of food intake is presented for each year and meal

Table 4.3 shows the odds ratios from the multivariate analysis of factors influencing diminished lunch intake adjusted for affected organs, comorbidities, number of drugs taken, days spent in the hospital prior to nutritionDay, any ICU stay, country and year of the survey. Women and patients with lower BMI consumed less at lunch. Subjects who had

eaten snacks before or after lunch consumed more at lunch. There was a progressive increase in the odds ratio for eating more at lunch on nutritionDay when the amount consumed in the previous week was higher. Patients who had lost weight in the previous 3 months or were not sure about their weight loss and who received protein supplementation ate less at lunch on nutritionDay (table 4.3). Patients with the affected organs liver, kidney/urinary tract, gastrointestinal tract, as well as cancer were more likely to consume only parts of the provided lunch (OR_{liver}=0.81 p<0.0001; $OR_{kidney/urinary}$=0.85 p=0.0005; $OR_{gastrointestinal}$=0.81 p<0.0001; OR_{cancer}=0.81 p<0.0001). The number of drugs taken did not influence the quantity eaten at lunch.

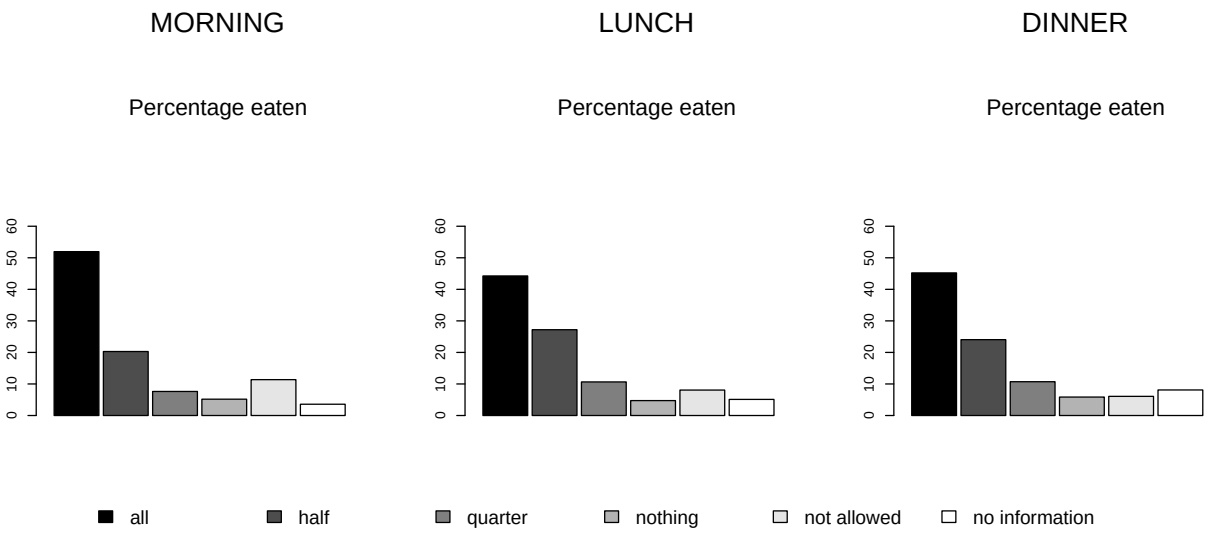

Figure 4.2: Quantity eaten at main meals, N=29518

Reasons for not eating - patient's view

About half of the patients (46.6%) consumed the entire provided meal at lunch. From the patients eating less or nothing at lunch, 8.5% of the patients were not allowed to eat or missed the meal due to an examination. The reasons for eating less of the main meals than provided for patients allowed to eat are presented in figure 4.4. Generally, patients did not eat the complete meals because they were not hungry, indicated by nearly 40% of the patients in all meal times followed by not liking the taste/smell and

Table 4.2: Practice of nutritional care, N=29518

Nutritional care	% patients
Exclusively hospital food	67.1%
Exclusively special diet	14.9%
Protein supplements	2.4%
Other type of nutrition care - not specified	4.0%
Combination of hospital food and supplements	3.3%
Combination of hospital food and other type of nutrition care - not specified	2.8%
Combination of special diet and supplements	1.0%
Other combination	0.6%
No information on type of nutritional care	3.9%

Table 4.3: Multivariate analysis showing influence factors for the quantity eaten at lunch (ordinal response); OR > 1 indicated higher intake, N=24557 analysis is adjusted for number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, mobility, visits, previous icu stay, affected organs, comorbidities, specialty, country and year of survey

Parameter		OR (95% CI)	p-value
Age	Per 10 years	1.01 (0.99; 1.03)	0.3051
Gender	For female gender	0.65 (0.59; 0.72)	<0.0001
	<18.5	0.76 (0.68; 0.85)	<0.0001
	18.5–25	1.00	reference
	25–30	1.09 (1.03; 1.15)	0.0038
BMI	30–35	1.17 (1.08; 1.28)	0.0002
	35–40	1.28 (1.12; 1.46)	0.0004
	>40	1.36 (1.14; 1.62)	0.0007
	missing information	1.00 (0.83; 1.20)	0.9982
Have you lost weight unintentionally within the last 3 months?			
	yes	0.91 (0.86; 0.97)	0.0017
	no	1.00	reference
	no, I have gained weight	1.01 (0.92; 1.11)	0.8338
	I am not sure	0.81 (0.72; 0.92)	0.0008
	missing information	0.93 (0.75; 1.14)	0.4876
How well have you eaten during the last week?			
	normal	1.00	reference
	a bit less than normal	0.47 (0.44; 0.50)	<0.0001
	less than half of normal	0.26 (0.24; 0.28)	<0.0001
	less than a quarter to nearly nothing	0.17 (0.15; 0.19)	<0.0001
	missing information	0.36 (0.29; 0.43)	<0.0001
Receiving supplements		0.84 (0.75; 0.93)	0.0010
Eating a snack	before or after Lunch	1.47 (1.38; 1.56)	<0.0001
Dietetic personal present		0.99 (0.90; 1.09)	0.8591

Table 4.4: Multivariate analysis showing influence factors for the number of snacks eaten over the nutritionDay (ordinal response); OR > 1 indicated higher intake, N=23221 analysis is adjusted for number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, mobility, visits, previous icu stay, affected organs, comorbidities, specialty, country and year of survey

Parameter		OR (95% CI)	p-value
Age	Per 10 years	0.89 (0.87; 0.91)	<0.0001
Gender	For female gender	1.06 (0.99; 1.14)	0.0713
	<18.5	1.03 (0.89; 1.19)	0.6752
	18.5–25	1.00	reference
	25–30	0.90 (0.85; 0.96)	0.0012
BMI	30–35	0.84 (0.77; 0.91)	<0.0001
	35–40	0.89 (0.78; 1.02)	0.0955
	>40	0.90 (0.76; 1.08)	0.2721
	missing information	0.88 (0.75; 1.03)	0.1166
Have you lost weight unintentionally within the last 3 months?			
	yes	1.05 (0.98; 1.12)	0.1463
	no	1.00	reference
	no, I have gained weight	1.08 (0.97; 1.19)	0.1485
	I am not sure	0.92 (0.82; 1.03)	0.1520
	missing information	1.07 (0.85; 1.34)	0.5639
How well have you eaten during the last week?			
	normal	1.00	reference
	a bit less than normal	0.99 (0.93; 1.06)	0.7508
	less than half of normal	0.83 (0.75; 0.90)	<0.0001
	less than a quarter to nearly nothing	0.58 (0.52; 0.65)	<0.0001
	missing information	0.97 (0.77; 1.21)	0.7718
How much the patient ate today at lunch			
	all	1.00	reference
	50%	0.78 (0.73; 0.84)	<0.0001
	25%	0.64 (0.58; 0.71)	<0.0001
	nothing	0.48 (0.37; 0.63)	<0.0001
	not allowed	0.17 (0.14; 0.20)	<0.0001
	no information	0.55 (0.43; 0.70)	<0.0001
Receiving supplements		1.06 (0.94; 1.19)	0.3794
Dietetic personal present		1.00 (0.88; 1.15)	0.9572

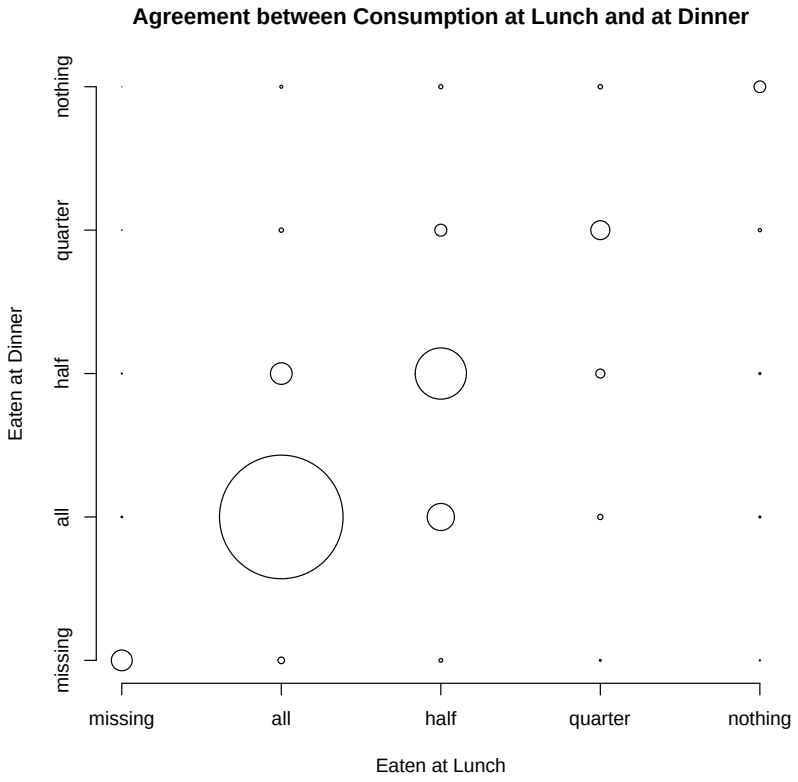

Figure 4.3: Agreement between lunch and dinner, size of the circle represents the frequency of answers in the specific combination of quantity eaten at lunch and at dinner, N=29518

nausea. The following results of the multivariate analyses are not shown in detail in tables: At lunch (n=12570 being allowed to eat and consuming less than provided) not being hungry was most often indicated by patients eating a quarter of the meal ($p<0.0001$), and was independent from BMI ($p=0.1137$) and if the patient had lost weight in the previous 3 months ($p=0.1650$). Older patients ticked this reason ($p=0.0005$), as well as that eating normally less significantly more often ($p=0.0001$). Patients with a BMI below 18 kg/m^2 indicated also more often the reason because of "eating normally less" ($p=0.0004$). "Eating normally less" was ticked more often by patients who have eaten half than patient eating less than half of the provided meal ($p<0.0001$). Having nausea or vomiting decreased during the day, and was more often ticked in the morning. Emesis and sickness restrained more patients from eating only a quarter ($p<0.0001$) or anything ($p<0.0001$) of the meal provided at lunch than eating greater parts of the provided meal. Interestingly nausea was also a reason for not eating in patients with unintended weight loss ($p=0.0081$). The dislike of taste or smell was most present at lunch, followed by dinner and morning. Older subjects complained about the taste and smell of the food less often ($p<0.0001$). The latter was also true for patients with diminished food intake in the week before nutritionDay. Those patients ate less because of the absence of hunger ($p<0.0001$) and because of nausea ($p<0.0001$). The reason for reduced lunch intake was associated with the food intake around this meal. Patients who consumed half or less of the provided hospital food at lunch but compensated the reduced food intake by higher snack intake reasoned their reduced intake on dislike of taste/smell ($p<0.0001$) or because they normally eat less ($p<0.0001$) than the provided portion. In exchange, the reasons not being hungry ($p=0.0005$), nausea and vomiting ($p=0.0001$) for reduced intake of the provided hospital meal at lunch were associated with additional low snack intake.

Food intake apart from the main meals

There are two ways of compensating for insufficient food intake in patients able to eat themselves derived from the main courses - eating more snacks between the meals (provided by the hospital, brought in by visitors or bought in the hospital shop) or adding energy and nutrients by using commercial oral nutritional supplements. From all patients giving information about their snack intake (N=23221), 46% of the patients consumed

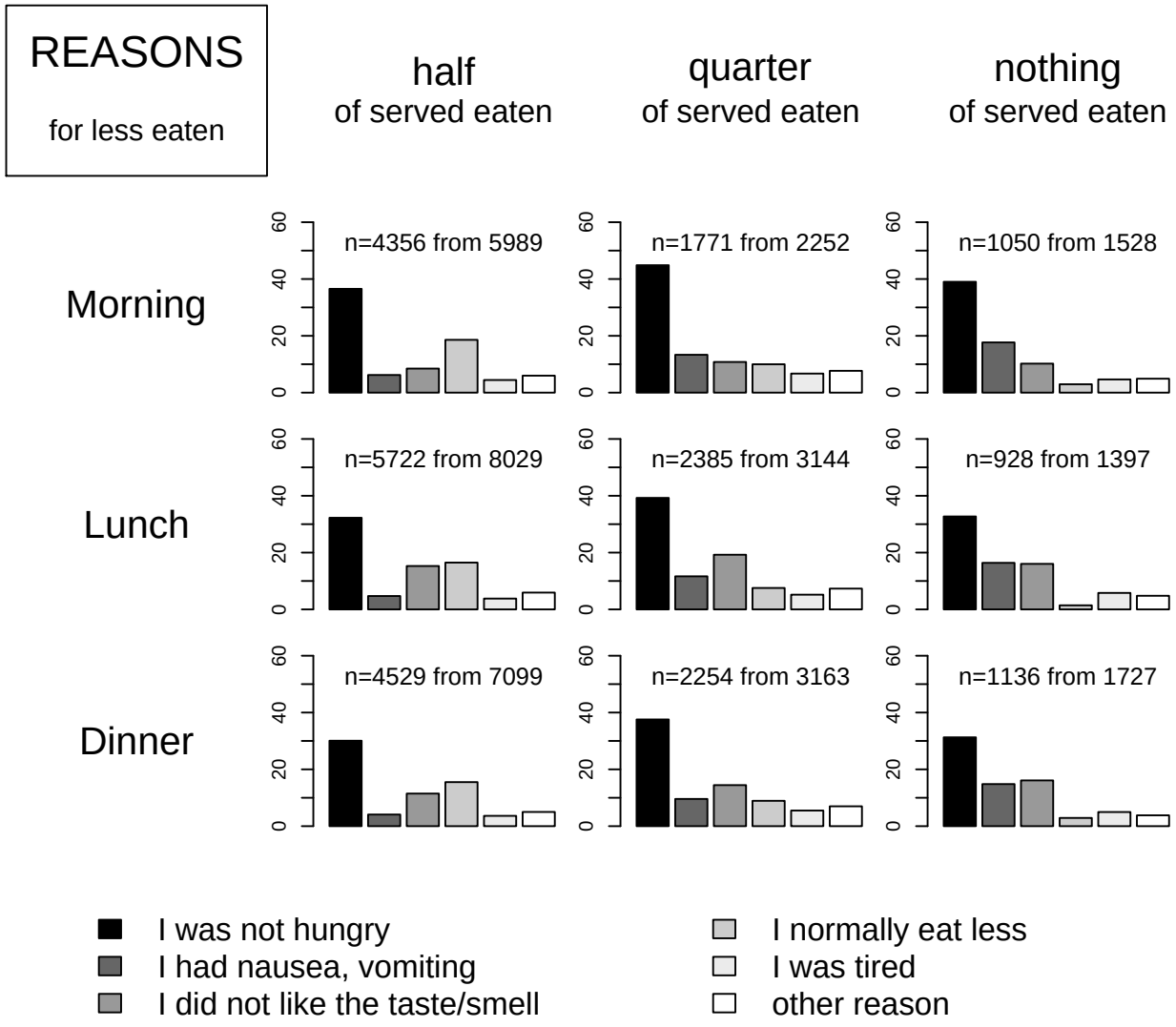

Figure 4.4: Reasons for eating less than the full provided meal in percentages (numbers indicate how many patients provided feedback; multiple answers were possible for this question)

one or two snacks and as much as 18% had more than two snacks. Less than half of the patients (36%) indicated to eat no snack during the day. The most often eaten snack were fresh fruits, indicated by half of the patients eating snacks on nutritionDay. Cakes and biscuits were the second most frequently chosen category stated by 34% of the patients eating snacks. Dairy products were eaten by 29% of the patients, followed by sandwiches and sweets. The number of snacks eaten on nutritionDay was significantly positively correlated with the quantity eaten at lunch (Spearman correlation coefficient r=0.14, p<0.0001), at dinner (r=0.14, p<0.0001) and at morning (r=0.12, p<0.0001). Table 4.4 shows the odds ratios for the multivariate analysis of factors influencing consumption of snacks. Snack consumers were younger. The odds ratio for eating snacks on nutritionDay increased progressively as the amount consumed in the previous week and at lunch on nutritionDay was higher (figure 4.5, table 4.4).

4.1.3 Interpretation and discussion

Meal and snack intake was determined in 29 518 patients at three nutritionDays (2006-2008) in 1804 wards in 26 countries. The data show that 82% of the patients received exclusively hospital food or a special diet. Less than 50% ate the whole lunch or dinner. In the patients perspective "not being hungry" was the main reason for not eating the whole meal. A higher intake at lunch was found in patients with a better nutritional status (BMI>25kg/m^2), a normal food intake in the previous week and with a snack around lunch. In contrast, patients with a BMI below 18kg/m^2, who were older, with a reduced food intake on nutritionDay and the pervious week were less likely to eat at least one snack and more likely to receive a protein supplement.

The data show that there is still cause for concern - as shown before there was a high percentage of hospitalized patients consuming an insufficient amount of the provided meals (Barton et al. (2000a), Dupertuis et al. (2003), Hiesmayr et al. (2009)) suggesting that the nutritional need of the patients were not met and a huge amount of food wasted. The proportion of patients getting exclusively hospital food was similar over the three consecutive years. We observed a relationship with diminished food intake and certain diseases i.e. gastrointestinal tract, the kidneys and urinary tract, diseases of the liver as well as cancer. This is in line with previous publications (Marchesini et al. (2004),

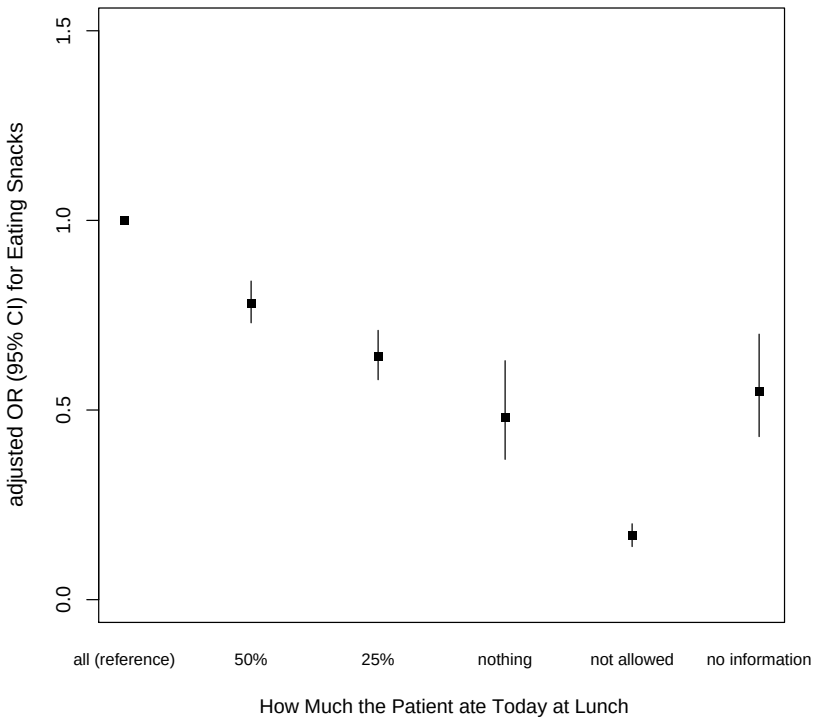

Figure 4.5: Adjusted odds ratio and 95% confidence interval for the probability eating snacks on nutritionDay in the multivariate analysis (n=23221) according to the proportion the patient ate of the provided main meal at lunch in the categories all, half, quarter, nothing, not allowed and missing information

Segura et al. (2005), Carrero et al. (2007), Bozzetti (2009)). There are recommendations and guidelines how food supply, quantitatively and qualitatively, in hospitals should be organized (Kluthe et al. (2004), Council of Europe Committee of Ministers (2003)). The provision of between-meal snacks and/or protein supplements has a potential to increase energy intake (Gall et al. (1998), Barton et al. (2000b), Kondrup (2001)). In an evaluation of daily practice with food provided from a buffet system, the patients at nutritional risk met only one third of the required amount and very little came from snacks (Hansen et al. (2008)). The nutritionDay data also demonstrate that the concept of snacks to increase energy intake is not expanded into every hospital's daily life. The elderly patients, the immobile and those with diminished recent and actual food intake had a smaller chance to eat a snack. The chance for the consumption of at least one snack was even less, the less patients ate.

The challenge of cooking tasty meals and transport and service for the hospitals catering system is widely recognized (Stanga et al. (2003), Donini et al. (2008)). In the nutritionDay evaluation nearly every fifth of the patients ate less because of dislike of taste and/or smell. Dislike of taste and smell certainly can be due to dissatisfying quality of the served meals, but also because of disappointing the patient's expectations and habits. The main reason in the patient's perspective not to eat was the absence of feeling hunger, especially for those patients eating a quarter of the portion and the elderly. The underlying causes can be physiologic and/or disease related but also medical. Polypharmacy and side effects of drugs are a common medical cause for reduced food intake (Pirlich et al. (2006)). In this survey the total number of drugs was requested. There was no association between this information and food intake. However, we did not ask for the class of the substances. It should also be taken into account that not feeling hunger could be associated with the complex psychological challenge and the environmental changes perceived by the patients in connection with hospital admission. To ensure a "eating-friendly" environment in terms of time and kind of communication (Paquet et al. (2008)), and organization of mealtimes (Xia and McCutcheon (2006), Dickinson et al. (2008)) can be challenging for hospitals and their staff. The provision of food was indeed more complex - nearly every fifth of those patients who ate half of the menu stated that they normally eat less. An effective proper "the food chain" from preparation to presentation has to address also issues such as other factors like portion size, texture and variety are essential to make

support patients in eating so that they can meet and cover their nutritional requirements, even with smaller portions. Therefore some meals possibly need being fortified with energy and protein to increase nutrient density e.g. using simple food cream, skim milk powder,. This strategy, as shown by Olin et al. (1996) and Barton et al. (2000b), has the potential to ensure adequate nutritional intakes especially in the elderly. Between-meal snacks are another way of serving additional energy with small-sized foods. In this regard the most preferred snack in the nutritionDay population, the fruits, are a sub-optimal energy source, although they are good for vitamins. It is likely that there are regional and cultural differences regarding acceptance and preferences. It should not be overseen, reduced appetite is not only a main issue during hospital stay – the patients with already reduced food intake in the previous week had also a significant higher chance of not feeling hunger and/or having nausea at nutritionDay. The dissatisfaction with the meals played a minor role in regard to eating the provided meals. Patients at nutritional risk, their relatives and caregivers in the community need to understand the complexity between food intake and recovery, that they can make the most out of the food - also when patients will be discharged home. Taken together these factors can, if overlooked, impairs a patient's nutritional status and makes patients them more vulnerable for diseases.

The combination of caregivers' view of the patients' food intake and patients' view of their actual food intake is also a unique attribute of this study. Finally, consideration of any food intake apart from hospital food shows how daily nutrition routines are organized across Europe. The nutritionDay study has shown how nutrition is organized in daily routine through Europe. The food wastage in hospitals as seen by the percentage eaten less than the full provided meals is enormous. Only a small part of the patients of about 10% did not finish their meals because of too big portion sizes, but absence of hunger, problems with taste or smell of the meal and presence of nausea are the reasons for not completing the provided meal. This survey clearly demonstrates that, snacks are consumed by those patients who already eat their meals and that the potential of snacks to increase nutritional intake of patients with inadequate food is limited. To make snacks a successful concept will also have significant implications for structures of hospital catering services as well as the ward's staff. It is not enough simply to offer choice. The choices offered must not only be acceptable to the patient but the patient must also be motivated and closely monitored and recorded to ensure that what is offered is actually eaten.

4.2 Supplements use in hospitals

The results of this section 4.2 refer to the manuscript, to be submitted:

> Schindler, Pernicka, Bauer, Hiesmayr : Supplements use in hospitals and their impact on outcome - findings from the 2006, 2007, 2008 cross-sectional nutritionDay survey.

The study refers to the same study population as in section 4.1. The aim of this study was the evaluation of the prevalence of supplements use and factors influencing the provision of supplements on one typical day in European hospitals in patients eating by themselves. Secondly, we examined if the use of supplements translate into better outcome in a large observational study, which is presented in section 5.5.

4.2.1 Statistical methods

Influence on the target variable **provision of supplementation (yes/no)** was analyzed with GEE_{binary}. The following nutrition related parameters were studied as influence factors: *"How well have you eaten during the last week?", "Have you lost weight unintentionally within the last 3 months?, intake at nutritionDay (intake at lunch, snacks eaten), "Do you get visits while in hospital?".* The following disease related parameters were studied as influence factors: *age, BMI in categories according to WHO, sex, length of hospital stay prior to the survey, number of drugs, mobility status, ICU stay prior to the survey, affected organs according to the ICD-10 top group, presence of specific comorbidities, specialties of the wards, presence of dieticians, year of survey and country.* Patients with artificial nutrition were excluded from the statistical analysis.

4.2.2 Results

Protein supplements were provided to 6.7% (95% CI [6.4; 7.0]) of the participants. Protein supplements were more likely to be given when dietetic personnel were present at the ward, in older patients with low BMI and in patients with unintended weight loss in the previous three months. Protein supplementation was applied in those patients with

diminished food intake in the week before and on nutritionDay (table 4.5). The frequency of the influence factors in the study population is presented in table 4.6.

Table 4.5: Multivariate analysis showing influence factors for receiving supplements on nutrition Day (binary response), N=28646 analysis is adjusted for number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, mobility, visits, previous icu stay, affected organs, comorbidities, specialty, country and year of survey

Parameter		OR (95% CI)	p-value
Age	Per 10 years	1.05(1.00; 1.10)	0.0204
Gender	For female gender	0.90 (0.78; 1.03)	0.1224
	<18.5	2.25 (1.89; 2.67)	<0.0001
	18.5–25	1.00	reference
	25–30	0.66 (0.58; 0.76)	<.0001
BMI	30–35	0.49 (0.35; 0.70)	<0.0001
	35–40	0.89 (0.78; 1.02)	0.0955
	>40	0.74 (0.51; 1.06)	0.1025
	missing information	0.71 (0.52; 0.99)	0.0410
Have you lost weight unintentionally within the last 3 months?			
	yes	1.62 (1.40; 1.87)	<0.0001
	no	1.00	reference
	no, I have gained weight	1.03 (0.81; 1.31)	0.8176
	I am not sure	1.27 (0.99; 1.63)	0.0641
	missing information	1.14 (0.86; 1.53)	0.3585
How well have you eaten during the last week?			
	normal	1.00	reference
	a bit less than normal	1.14 (1.00; 1.31)	0.0589
	less than half of normal	1.38 (1.17; 1.62)	0.0001
	less than a quarter to nearly nothing	1.44 (1.18; 1.75)	0.0003
	missing information	1.39 (0.94; 2.05)	0.1000
How much the patient ate today at lunch			
	all	1.00	reference
	50%	1.24 (1.08; 1.42)	0.0021
	25%	1.32 (1.10; 1.58)	0.0022
	nothing	1.36 (1.09; 1.70)	0.0066
	not allowed	0.80 (0.59; 1.09)	0.1589
	no information	1.03 (0.79; 1.35)	0.8072
Eating a snack	before or after Lunch	1.01 (0.96; 1.07)	0.6123
Dietetic personal present		1.44 (0.98; 2.13)	0.0160

4.2.3 Interpretation and discussion

Commercial Oral nutrition supplements, containing energy and protein are recommended for any patient not meeting his/her nutritional requirements with food alone. There is evidence that they improve nutritional status in undernourished patients and those at

Table 4.6: Frequency of patients in the parameters presented in table 4.5, N=28646

Parameter		Percentage
Gender	For female gender	50
BMI	<18.5	5
	18.5–25	40
	25–30	32
	30–35	14
	35–40	4
	>40	2
	missing information	4
Have you lost weight unintentionally within the last 3 months?		
	yes	41
	no	40
	no, I have gained weight	9
	I am not sure	7
	missing information	3
How well have you eaten during the last week?		
	normal	49
	a bit less than normal	24
	less than half of normal	14
	less than a quarter to nearly nothing	9
	missing information	4
How much the patient ate today at lunch		
	all	44
	50%	27
	25%	11
	nothing	5
	not allowed	8
	no information	5
Dietetic personal present		44

nutritional risk (Milne et al. (2009)). In the nutritionDay population use of oral nutrition support was reported for 6.7% of the patients. The factors influencing the chance for prescription of a supplement were same as the factors which influenced the indication of a patients being at nutritional risk (Schindler et al. (2010)). It seems that factors, reflecting the history of nutritional problems (low BMI, unintended weight loss) trigger prescription more strongly than those who reflect actual nutritional problems and acute state of disease (previous and actual food intake). However, the chance of receiving a nutritional supplement did increase the less patients ate in the previous week or on nutritionDay. Prescription of supplements was also influenced by structural issues. The presence of a clinical dietitian had a significant impact on provision of supplements. Taken this, together with our previous observation regarding identification of patients at nutritional risk (Schindler et al. (2010)), and that the consumption of in-between snacks was independent of the presence of the clinical dietetic personnel, the nutritionDay data also allow some insight into the actual responsibilities of the clinical dietetic personnel. The data suggest that clinical dietitians are not as much involved in the clinical routine of identification of patients at nutritional risk as well as in the early treatment of patients at nutritional risk. This could be due to a small number of clinical dietitians in most hospitals, insufficient referral of patients to the dietitians (Thoresen et al. (2008)), but also to that dietitians are more technically trained, with less priority to interventions with normal food.

In this survey, supplementation played only a minor role in the practice of hospital nutritional care. However, the factors influencing the provision of protein supplementation indicated that protein supplementation is targeted in patients with nutritional needs. It appears that protein supplementation is given to highly malnourished patients only. The impact of different types of interventions has to be determined by future studies.

4.3 How nutritional risk is assessed and managed

The results of this section 4.3 refer to the published paper:

> Schindler, Pernicka, Laviano, Howard, Schütz, Bauer, Grecu, Jonkers, Kondrup, Ljungqvist, Mouhieddine, Pichard, Singer, Schneider, Schuh, Hiesmayr, The NutritionDay Audit Team.: How Nutritional Risk is Assessed and Managed in European Hospitals: A survey of 21007 patients - Findings from the 2007-2008 cross-sectional nutritionDay survey. Clinical Nutrition, 2010, Apr 29 (Schindler et al. (2010))

Undernutrition is a common cause and consequence of disease with a significant negative impact on patients' outcomes and quality of life as well as on health economics (Norman et al. (2008)). It has been repeatedly demonstrated over many years that disease–related undernutrition occurs in 20 - 60% of hospitalized patients (Bistrian et al. (1974), Hill et al. (1977), McWhirter and Pennington (1994)) and that the patients are not only frequently admitted in an undernourished state but their nutritional status deteriorates during their hospital stay (Bistrian et al. (1974), Kondrup et al. (2002)). The consequences of undernutrition are multifaceted and potentially lethal. Despite such compelling evidence, undernutrition often remains undetected and untreated because it is not considered to be a clinical priority.

Lack of awareness is the only one facet of te problem and insufficient knowledge and training are also the major obstacles to good nutritional care (McWhirter and Pennington (1994), Mowe et al. (2008)). So, when devising strategies to tackle undernutrition and subsequently integrating them into daily clinical routines, many factors have to be considered. These include the influence of the disease per se on both energy/nutrient requirements and food intake, as well as which tools are available for detecting undernourished patients and those at risk of nutritional deficiency. Additionally organisational issues must be considered, for instance how caregivers calculate energy goals and evaluate actual intake.

The influence of disease on energy expenditure is well acknowledged (Gibney (2000), Kulstad and Schoeller (2007)). A variety of screening and assessment instruments has been developed to identify undernourished patients and those at risk (Ferguson et al. (1999), Kondrup et al. (2003b), Elia (2003), Kondrup et al. (2003a), Kruizenga et al.

(2005a)) and these have been widely used to assess the prevalence of disease–related undernutrition in many different countries and patient groups (Bistrian et al. (1974), Kondrup et al. (2003a), Kyle et al. (2006), Meijers et al. (2009), Weekes et al. (2004)). There are also generally accepted standards and guidelines for screening for disease-related malnutrition and for providing nutrition support in hospital (Lochs et al. (2003), Lochs et al. (2006), Bankhead et al. (2009), Ulibarri et al. (2009)). Despite this, uncertainties still exist about whether nutritional risk assessment is integrated within daily clinical practice in all European hospitals, since currently available data only reflect the practice in the Scandinavian region and the Netherlands, where screening is not routinely undertaken (Mowe et al. (2006), Lindorff-Larsen et al. (2007), Mowe et al. (2008), Meijers et al. (2009)). Moreover, no information exists about whether the daily nutritional care in a single unit reflects existing recommendations or expert opinions.

In an attempt to provide more information about these sensitive issues, which may enhance the implementation of effective programs addressing hospital-related undernutrition at all levels of decision making, we aimed to determine how frequently patients are considered to be at nutritional risk across Europe and within Israel, and whether this assessment is translated into specific actions which influence daily nutritional care. In particular, we investigated whether nutrition screening is routinely performed, the type of screening tools which are used and the impact of these on the identification of patients at nutritional risk and their subsequent nutritional care.

4.3.1 Statistical methods

Caregivers were additionally asked to report whether patients were screened for malnutrition on admission to their unit (Yes/No), and which screening tool was used [Nutritional Risk Screening (NRS) 2002, Malnutrition Universal Screening Tool (MUST), national tool, local tool], whether the individual patients were classified at nutritional risk (Yes/No) on nutritionDay, their actual diet/nutrition therapy (hospital food, special diet, protein-energy supplements, enteral nutrition, enteral + parenteral nutrition, parenteral nutrition, other. For this question more than one answer was possible), as well as their energy goal (<1000, 1000-1499, 1500-1999, 2000-2500 kcal/day) and actual energy intake, if recorded (<1000, 1000-1499, 1500-1999, 2000-2500 kcal/day).

A Cochran-Armitage test for trend was performed to compare the energy goals with the caloric intakes of patients who were at nutritional risk. Group comparisons of categorical data were undertaken by comparison of frequencies (Chi- Square-test) and comparison of means by t-test. To enable comparison between European regions and countries, descriptive measures were given for each region following the groupings of the World Health Organization (World Health Organization (2006)).

Regions or countries with an overall patient recruitment rate below 75% of occupied beds were excluded from the multivariate analysis. The target variable was the **subjective classification of patients at nutritional risk**, analyzed with GEE_{binary}. The following parameters were studied as influencing factors: *actual, previous food intake and actual snack intake, unintended weight loss within the last 3 months, visitors, mobility (patients' view), caloric intake(caregivers' view), age, sex, BMI sub divided into categories according to WHO, length of hospital and ICU stay prior to the survey, number of drugs, affected organs and comorbidities, specialties, presence of dietitians and/or dietetic assistants, the presence of nutrition teams, year of the survey, and the European region.* The odds ratios for the categorical variables, specialty and European regions indicate deviations from the average. Interactions between BMI and gender, and between countries and influencing factors were analyzed.

4.3.2 Results

The one-day cross-sectional nutritionDays in 2007 and 2008 consisted of a total of 21007 patients treated in 1217 units from 325 hospitals in 25 countries. Internal medicine and general surgery units represented the majority (64%) of participating units (table 4.7). Approximately half of the patients recruited were female (table 4.8) and the females were on average 2.6 years older ($p<0.0001$).

Table 4.7: Characteristics of the units in participating European regions.

[1]Denmark, Finland, Norway, Sweden

[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom

[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania

[4]Croatia, Serbia, Slovenia

[5]Greece, Italy, Portugal, Spain, Turkey, Israel

	Nordic[1]	Western Europe[2]	CCEE[3]	Southeastern Europe[4]	Southern Europe[5]	All
N	124	599	328	19	147	1217
Maximum beds: mean (std)	25.1 (7.5)	28.6 (10.3)	45.0 (36.8)	51.3 (41.9)	29.1 (19.5)	33.1 (23.6)
Participation rate of occupied beds: mean (std)	89.2 (24.0)	87.3 (21.7)	63.1 (32.5)	85.8 (25.1)	84.7 (32.9)	80.6 (28.8)
Specialty (column percentages)						
Internal medicine	29	42	31	53	40	38
Surgery	33	22	29	26	32	26
Geriatrics and long-term-care	14	13	5	0	6	10
Neurology	5	5	3	0	5	5
Others	19	18	32	21	17	22

Table 4.8: Demographic profile of subjects in participating European regions.

[1]Denmark, Finland, Norway, Sweden

[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom

[3]CCEE Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania

[4]Croatia, Serbia, Slovenia

[5]Greece, Italy, Portugal, Spain, Turkey, Israel

European Region	N	Percent female	age: mean (std)	weight: mean (std)	BMI: mean (std)
Nordic[1]	1720	49.8	65.7 (18.0)	73.8 (18.7)	25.5(5.6)
Western Europe[1]	9746	53.5	64.8 (17.7)	72.7 (18.1)	25.8 (5.8)
CCEE[3]	6700	46.0	58.0 (16.1)	73.7 (17.4)	26.2 (5.6)
Southeastern Europe[4]	576	45.3	59.0 (15.5)	74.2(16.0)	25.3 (4.9)
Southern Europe[5]	2265	49.8	52.2 (17.5)	69.4 (15.8)	25.6 (5.3)
All	21007	50.5	62.5(18.0)	72.8(17.7)	25.9(5.7)

Nutritional Screening on admission as part of the units daily routine

Between 21% and 73% of the participating units in the different European regions stated that they screened patients for malnutrition or risk of malnutrition on admission to hospital. Nutritional screening was most often performed using locally developed tools, the highest proportion being used in the Countries of Central and Eastern Europe (CCEE) region. A national tool or the NRS-2002 (Kondrup et al. (2003b)) was used more frequently in the Nordic and the Southern regions. Overall, the MUST (Elia (2003)) was the tool used least often (figure 4.6). To illustrate the prevalence of screening throughout Europe, the percentage of units screening for malnutrition or risk of malnutrition compared with the percentage of patients at risk is shown for all European regions (figure 4.7). Additionally, countries with more than 1000 participants are shown individually in this figure.

A screening routine existed for 93% of units in the United Kingdom while less than 33% of units in Austria, Germany and the South Eastern region reported that they regularly screened patients for malnutrition on admission (figure 4.7).

Prevalence of patients at nutritional risk in the European regions

The nutritional risk was assessed by caregivers in 91% of the patients. Nearly one third of all patients (27%) were considered to be "at nutritional risk". The proportion of patients being classified as "at risk" differed substantially between European regions and countries. The proportion of patients without information about their nutritional risk was the highest in the rest of the Southern region, in the Nordic countries as well as in Germany, the rest of the Western region and Italy (figure 4.7). The prevalence of malnutrition, as extrapolated by the identification of a nutritional risk, was lowest in Hungary, Austria and Germany while the highest rates were in the United Kingdom, the rest of the Western region, the rest of the Southern region, CCEE and the Nordic countries (figure 4.7).

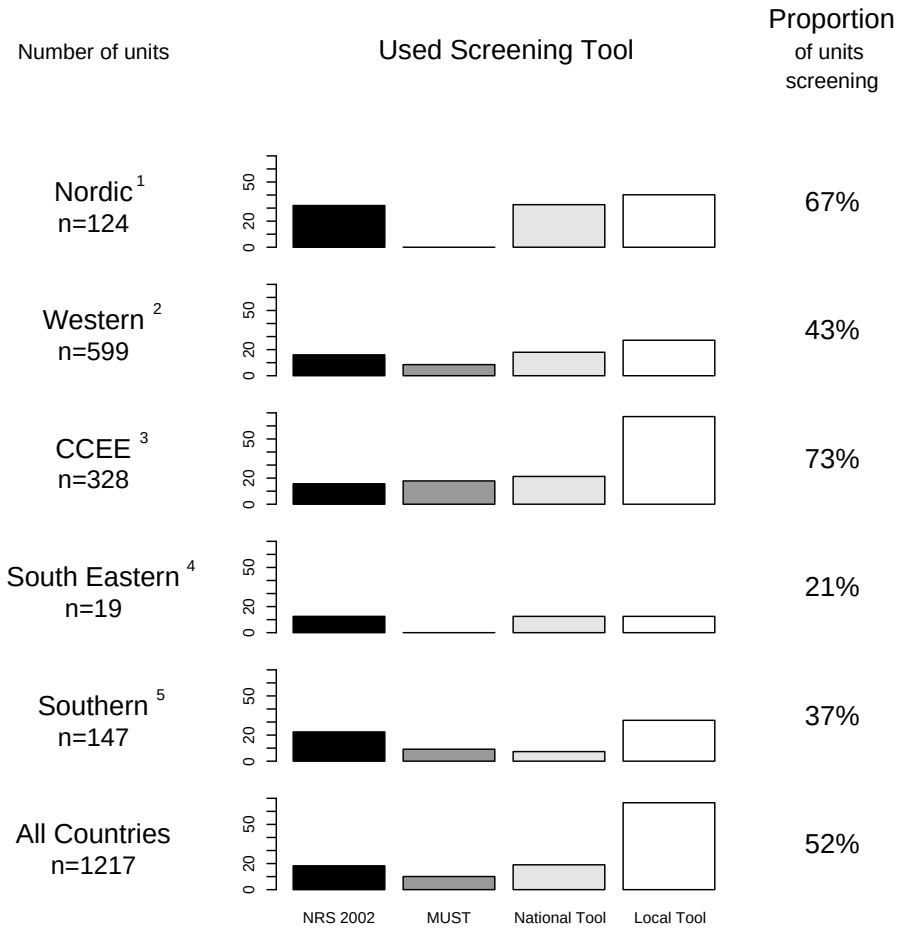

Figure 4.6:

This shows the percentage of units screening for malnutrition on admission to hospital (proportion of units screening) and the percentages for each screening tool show the percentage of the units using this screening tool (of all units). Each unit could specify multiple screening tools.

[1]Denmark, Finland, Norway, Sweden

[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom

[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania

[4]Croatia, Serbia, Slovenia

[5]Greece, Italy, Portugal, Spain, Turkey, Israel

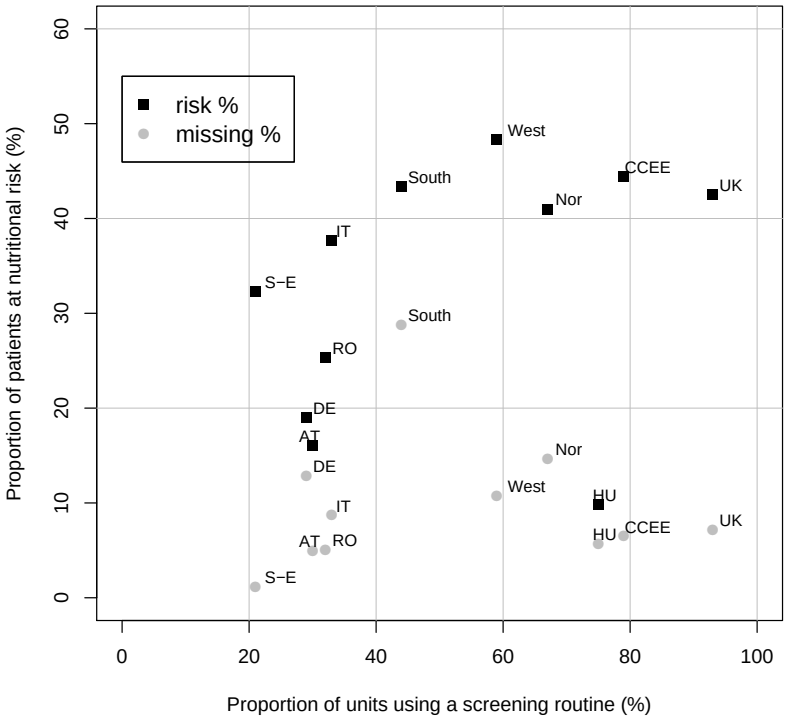

Figure 4.7: UK United Kingdom, DE Germany, IT Italy, AT Austria, HU Hungary, RO Romania, Nor Nordic (Denmark, Finland, Norway, Sweden), West Rest of Western (Belgium, France, Luxemburg, Netherlands, Switzerland). CCEE Rest of CCEE (Bulgaria, Czech Republic, Poland), S-E South-Eastern (Croatia, Serbia, Slovenia), South Rest of Southern (Greece, Portugal, Spain, Turkey, Israel)

Identification of patients at nutritional risk

The multivariate analysis identified that patients who were categorized as being at nutritional risk were older, had a lower BMI, had lost weight in the previous three months, had eaten less during the previous week, and had eaten less on nutritionDay as indicated by the quantity eaten at lunch and by the caloric intake over the day (table 4.9, figure 4.8). The intake of snacks did not differ between the patients at nutritional risk and those not at nutritional risk. Although not significant in the univariate analysis, females had a significantly lower probability of being classified as being at nutritional risk (table 4.9) in the multivariate analysis.

Patients at nutritional risk were less mobile and were more likely to present with affected organs (including the lungs, liver, gastrointestinal tract) and with comorbidities, including diabetes mellitus, cancer and infection. The specialties that more often identified patients at nutritional risk were internal medicine and geriatric medicine. In contrast, neurology patients were less likely to be identified as being at nutritional risk (data not shown). Regional differences were also present in the multivariate adjusted model (lowest $OR_{Western}$=0.58, 95% CI [0.48, 0.71], p<0.0001; highest OR_{CCEE}=1.42 [1.11, 1.81], p=0,0056; table 4.9).

The presence of dietitians and/or dietetic assistants, nutrition teams and having a screening routine on the ward increased the probability of being identified as being at nutritional risk in the multivariate analysis (table 4.9).

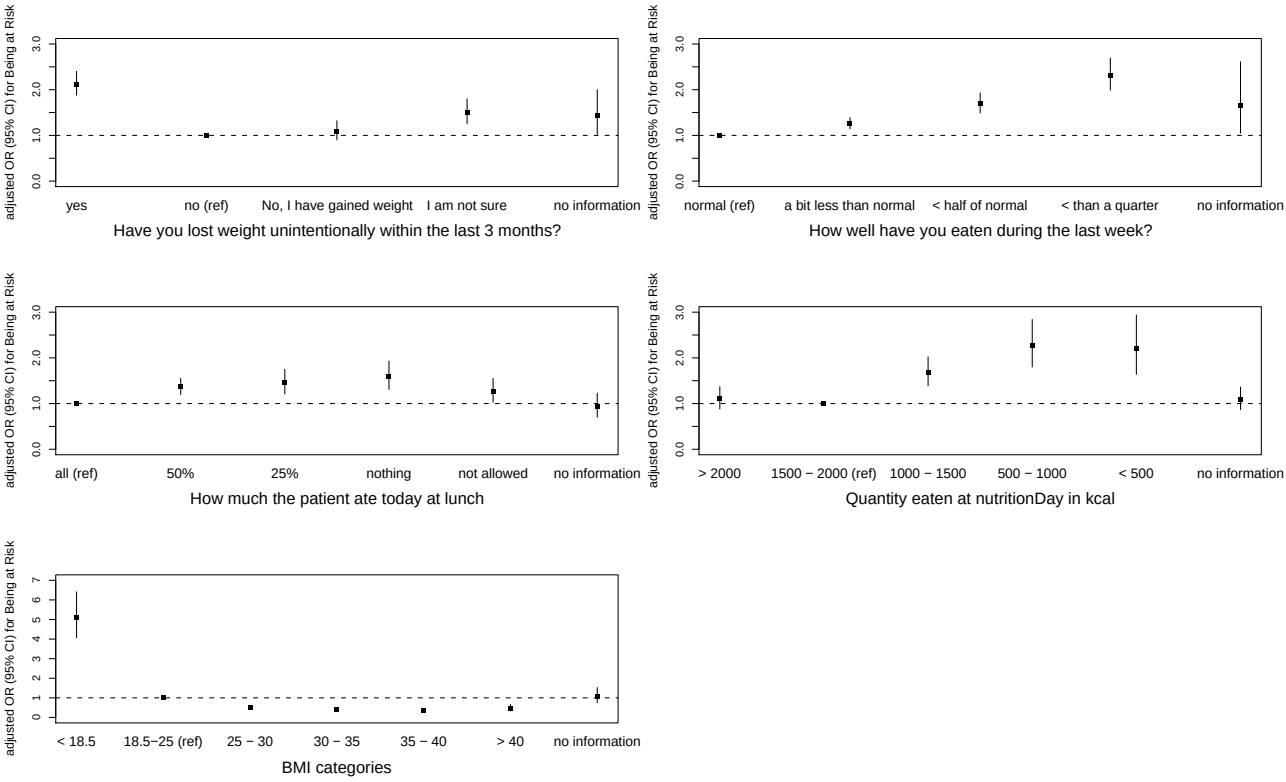

Figure 4.8: Adjusted odds ratio and 95% confidence interval for the probability of being classified as at nutritional risk in the multivariate analysis (n=15043) adjusted for age, gender, European region, dietetic personnel on the ward, nutrition team on the ward, ward screening for malnutrition, type of screening tool used, mobility, number of drugs taken, snacks eaten, length of time the patients spent in hospital prior to the Nutrition Day, previous ICU stay, affected organs, co-morbidities, specialty, visits and year of survey.

Patients Food intake in European regions - planning and monitoring

The energy goal and intake were specified for 73% of the patients (n=12398). The energy goal was defined as 1500 kcal or more in 80% of the patients at nutritional risk and 84% of the patients with no nutritional risk. When the energy goals and intakes were reported, it appeared that 47% of the patients consumed less energy than their estimated requirements, 49% consumed as much as targeted and 4% ate more calories than prescribed (table 4.10).

Table 4.9: Multivariate analysis showing influence factors for being indicated as at nutritional risk (binary response); N=15043

analysis is adjusted for mobility, number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, previous icu stay, affected organs, comorbidities, specialty, visits and year of survey.

[1]Denmark, Finland, Norway, Sweden

[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom

[3]CCEE Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania

[4]Croatia, Serbia, Slovenia

[5]Greece, Italy, Portugal, Spain, Turkey, Israel

OR greater than 1 indicates that the probability of being at nutritional risk is increased.

Variable		% of subjects	OR (95% CI)	p-value
Age	Per 10 years		1.14 (1.09; 1.19)	<0.0001
Gender	For female gender	52	0.81 (0.74; 0.89)	<0.0001
BMI	< 18.5	6	5.11 (4.07; 6.41)	<0.0001
	18.5 - 25	43	1.00	reference
	25 - 30	31	0.51 (0.45; 0.59)	<0.0001
	30 - 35	12	0.41 (0.34; 0.49)	<0.0001
	35 - 40	3	0.35 (0.26; 0.46)	<0.0001
	> 40	2	0.47 (0.33; 0.66)	<0.0001
	missing information	4	1.07 (0.75; 1.52)	0.7082
Have you lost weight unintentionally within the last 3 months?				
	yes	45	2,12 (1,88; 2,40)	<0.0001
	no	36	1.00	reference
	no, I have gained weight	10	1,09 (0,90; 1,32)	0,3927
	I am not sure	7	1,50 (1,25; 1,80)	<0,0001
	missing information	2	1,43 (1,02; 2,00)	0,0369
How well have you eaten during the last week?			0,0166	
	normal	46	1.00	reference
	a bit less than normal	24	1,26 (1,14; 1,39)	<0.0001
	less than half of normal	15	1,70 (1,49; 1,93)	<0.0001
	less than a quarter to nearly nothing	12	2,31 (1,99; 2,69)	<0.0001
	missing information	2	1,66 (1,05; 2,61)	0,0291
How much the patient ate today at lunch				
	all	41	1.00	reference
	50%	27	1,37 (1,20; 1,55)	<0.0001
	25%	11	1,46 (1,21; 1,75)	<0.0001
	nothing	6	1,59 (1,31; 1,93)	<0.0001
	not allowed	11	1,27 (1,03; 1,55)	0,0219
	no information	4	0,93 (0,70; 1,23)	0,6006
Eating a snack	before or after Lunch		0,99 (0,95; 1,03)	0,6643
Energy intake (in kcal) nutritionDay				
	< 500 kcal	6	2,20 (1,64; 2,94)	<0.0001
	500 - 1000 kcal	12	2,26 (1,80; 2,84)	<0.0001
	1000 - 1500 kcal	23	1,68 (1,39; 2,02)	<0.0001
	1500 - 2000 kcal	31	1.00	reference
	≥ 2000 kcal	10	1,10 (0,88; 1,37)	0,4215
	no information	19	1,09 (0,87; 1,36)	0,4005
European region/country				
	Nordic[1]	9	1,27 (0,98; 1,64)	0,0745
	Western[2]	57	0,58 (0,48; 0,71)	<0.0001
	CCEE[3]	17	1,42 (1,11; 1,81)	0,0056
	South Eastern[4]	4	0,88 (0,68; 1,14)	0,3231
	Southern[5]	13	1,09 (0,88; 1,36)	0,4240
Dietetic personnel	present	39	1,42 (1,10; 1,85)	0,0075
Nutrition team	present	64	1,32 (1,05; 1,65)	0 ,0166
Unit screens patients on admission for risk of malnutrition?		48	1,32 (1,08; 1,62)	0,0077

The agreement between energy goal and energy intake was rather low, as indicated by a weighted kappa coefficient of 0.28 (n=12398). The patients classified as at nutritional risk had a significantly lower caloric intake than patients without risk (Cochran-Armitage Trend Test: p<0.0001).

Screening routine on admission did not influence whether or not an energy goal and intake was indicated (the energy goal was not specified in 12% in both groups, n=17009). However, patients hospitalized in units with a screening routine were more likely (OR=1.3 [1.1; 1.6], p=0.0081) to be identified as not reaching their energy goals.

Table 4.10: Percentages in energy intake according to the specified energy goal, row percentages, n=17009. Percentages of participants in the specific category of energy goal who had lower caloric intake than targeted are marked in bold and red. Percentage of participants in the specific category of energy goal, for whom information on energy goal or energy intake was not reported are marked in blue.

		Caloric intake					
		missing	< 1000	1000 - 1499	1500 - 2000	> 2000	all
Energy goal	Missing, n=2078	93.5	2.6	1.4	2.1	0.4	100
	< 1000, n=267	15.0	78.7	3.4	3.0	0.0	100
	1000 - 1499, n=2207	9.3	**30.3**	50.0	9.2	1.2	100
	1500 - 2000, n=8625	12.6	**16.5**	**22.8**	44.8	3.4	100
	> 2000, n=3832	13.7	**13.2**	**15.5**	**25.0**	32.8	100

Patients at nutritional risk and nutritional care routines

Twenty percent of the patients considered to be at nutritional risk received protein supplements as well as 3% of the patients who were not classified at nutritional risk (p<0.0001, N=15417). When adjusted for disease, organisational factors, information about weight trend in the previous 3 months and food intake in the previous week, patients identified as being at nutritional risk were still more likely to receive protein supplements (OR=4.9 ([3.7; 6.3], p<0.0001)) . The presence of a screening routine (screening 26%

vs. non-screening 12% in patients at risk; OR=1.9 [1.4; 2.6], p<0.0001), the presence of a dietitian and/or dietetic assistants (28% vs. 14%, OR=1.9 [1.2; 3.2], p=0.0125) and the presence of a nutrition team (21% vs. 18%, OR 1.5 [1.1; 2.1], p=0.0150) made a significant difference to the provision of protein supplements.

The scenario was different for artificial nutrition. The proportion of artificial nutrition (enteral tube feeding and/or parenteral nutrition) provided was independent of a screening routine on the unit (screening 20% vs. non-screening 23% in patients at risk). In the multivariate analysis, patients identified as being at nutritional risk had a higher probability of receiving artificial nutrition (OR=1.4 [1.1; 1.8], p=0.0031, N=15043).

4.3.3 Interpretation and discussion

The nutritional risk of patients was determined in 21007 patients hospitalized in 325 medical wards from 25 countries which participated in the nutritionDay 2007 and 2008 surveys.

Undernutrition is a common cause and consequence of disease with a significant negative impact on patients' outcomes and quality of life as well as on health economics (Norman et al. (2008)). It has been repeatedly demonstrated over many years that disease–related undernutrition occurs in 20 - 60% of hospitalized patients (Bistrian et al. (1974), Hill et al. (1977), McWhirter and Pennington (1994)) and that the patients are not only frequently admitted in an undernourished state but their nutritional status deteriorates during their hospital stay (Bistrian et al. (1974), Kondrup et al. (2002)). The consequences of undernutrition are multifaceted and potentially lethal. Despite such compelling evidence, undernutrition often remains undetected and untreated because it is not considered to be a clinical priority.

Nutritional Screening on admission

Generally accepted standards and guidelines for the management of hospital nutrition, including nutritional screening and monitoring, exist across Europe (Ferguson et al. (1999), Kondrup et al. (2003b), Elia (2003), Kondrup et al. (2003a), Council of Europe Com-

mittee of Ministers (2003), Lochs et al. (2003), Kruizenga et al. (2005a), Lochs et al. (2006), Bankhead et al. (2009), Ulibarri et al. (2009)). However, our results demonstrate that nutritional screening is only undertaken as part of the daily routine by half of the responding units and that there are differences both between regions and within regions (52%: range 21%-73%). A remarkably high percentage of units implementing a screening policy for malnutrition was found in the United Kingdom. This is likely to be the result of the activities developed by the British Association for Parenteral and Enteral Nutrition (BAPEN) to raise the awareness about hospital malnutrition. This included the Nutrition Screening Week (NSW) (Elia et al. (2008)), which was initiated in 2007 and involves a similar number of units each year.

The percentage of units without a screening policy in the German speaking countries, the South Eastern region, Romania and Italy was surprisingly high. This may indicate that the nutritionDay study recruited units which were not necessarily involved or interested in nutrition. In Austria, for example, nutritionDay was actively promoted through nursing associations with an explicit invitation to units with no specific expertise on clinical nutrition to become involved which supports this interpretation. The same might have also been true for other countries.

Tools used to screen for malnutrition on admission

Screening was most often performed using locally developed tools rather than using national tools, the NRS-2002 or the MUST. Unfortunately, information about these local instruments was not collected during the nutritionDay study. It is likely that they may vary considerably, yielding different sensitivity and specificity in assessing nutritional risk. Considering the extensive use of local tools, more research is needed to clarify and understand how they have been devised. Moreover, by extrapolating the results of the nutritionDay in Nursing Homes. study, it could be postulated that caregivers tend to assess nutritional status only by measuring or asking for body weight and body mass index only, rather than by using a specific tool (Valentini et al. (2009)).

A possible explanation for the lack of a widely used screening tool may lie in the available variety in the literature and on internet, of different recommendations and guidelines.

This could lead to a heterogeneity of local decisions being made by caregivers. Indeed, it is possible for nursing standards for nutritional screening and care to recommend different procedures from the ESPEN guidelines (Kondrup et al. (2003a)) within a single country (Porter et al. (2009), Deutsches Netzwerk für Qualitätsentwicklung in der Pflege (DNQP) (2008)).

Whatever the reasons behind this evidence, the results of the nutritionDay study show that screening for the risk of malnutrition in European hospitals is not always being implemented as recommended best practice. An analysis of the best strategy to achieve more widespread use of screening tools was beyond the scope of this study. It appears that there is benefit in national agencies being involved in the standardisation of the procedures used for nutritional screening. The UK (Elia et al. (2008)) and the Dutch (Meijers et al. (2009)) experience appears to confirm this and suggests that political support from the national healthcare system strengthens recommendations for good nutritional care.

Identification and prevalence of patients at nutritional risk

These data suggest that the number of undernourished patients across European hospitals (27%) remains unacceptably high and is similar to previously reported data (from different countries using different languages and different methodologies, Howard et al. (2006), Pirlich et al. (2006), Mowe et al. (2008)). However, the factors caregivers used to identify patients at 224 nutritional risk were similar to those used in the nutritionDay outcome analysis (Hiesmayr et al. (2009)). Interestingly, unintended weight loss and low BMI influenced the caregivers to a greater extent when assessing patients with nutritional risk than either previous or actual reduced food intake. We deliberately included influence factors which are used in the various screening tools. It is noteworthy that some of the factors identified above have less ability to classify a patient at nutritional risk than organisational factors. These include the type of ward, the presence of dietitian and/or dietetic assistants and the presence of a nutrition team which are most likely to influence the assessment of nutritional risk status.

There were considerable differences between countries. Unexpectedly, the probability of being considered to be at nutritional risk was significantly lower only in Austria and

Germany where fewer patients were classified as being at nutritional risk than were identified in the German Hospital Malnutrition Study (Pirlich et al. (2006)). Contrary to the German speaking countries, the percentage of patients at nutritional risk in the United Kingdom was higher than expected from the results of the Nutrition Screening Week (NSW), where only 28% were found to be at risk for malnutrition (Elia et al. (2008)). Participants in the nutritionDay were, on average, 4 years older and had a lower BMI than NSW patients [NSW: mean age: 63.6 years (sd 19.34) and BMI 26.2 kg/m^2 (sd 6.3)]. This probably reflects the higher proportion of participating geriatric units in the nutritionDay study.

The nutritionDay study also shows considerable differences between countries regarding the lack of the information about the nutritional status of the patients. We believe that the reason behind the failure to provide information about patients' nutritional risk could depend on the individual healthcare professional's education, knowledge and experience and also on the approach used to define patients at nutritional risk.

Planning and monitoring of food intake

Many directives and guidelines indicate that, not only should patients be screened for possible risk of nutritional deficiency, but that their food intake should also be documented, particularly if they have been shown to be at such risk (Howard et al. (2006), Council of Europe Committee of Ministers (2003)). Unfortunately, the nutritionDay study demonstrates that this is rarely done as part of routine clinical practice.

Defining a comprehensive nutrition care plan is not likely to be part of the daily routine of many units. This is because the difficulties inherent defining individual energy goals and monitoring individual energy intake within the frame of the daily routines of clinical care are obvious (Kondrup et al. (2002), Mowe et al. (2008)). However, failure to plan such care can be devastating in view of the fact that 43% of the patients in the nutritionDay cohort consumed less energy than specified while 53% of the patients self-reported an inadequate food intake. Many of these patients were actually malnourished and in need of extra calories and protein. These results are despite the fact that the energy intake was specifically assessed and documented in nearly 80% and an energy goal was specified

for 90% of the patients.

The use of local and national tools warrants further examination and possible validation especially since the multivariate analysis revealed similar risk factors for nutritional risk (Pirlich et al. (2006), Meijers et al. (2009)). Another source of great variability could be the classification on the questionnaires concerning caloric intake and whether or not a patient is at nutritional risk.

Nutritional routines and nutritional care remains poor in Europe and Israel. The nutritionDay study shows huge differences between units in the process of nutritional screening, planning nutritional care and monitoring patients' food intake. The presence of dietitians and/or dietetic assistants and the use of screening tools positively promoted the provision of specialized nutrition to patients at risk of malnutrition. However, the development of universal training tools, without language barriers, which could facilitate these planning and monitoring processes is clearly needed. Enhancement of interprofessional collaboration and identification of the responsibilities for nutrition at both unit and hospital level is also required (Porter et al. (2009), Manthorpe and Watson (2003)). This study shows that establishing proper nutritional risk screening is an important starting point for improving nutritional care in many hospitals in Europe. It also highlights need for well designed intervention studies.

4.4 Regional aspects in hospital nutrition

4.4.1 Statistical methods

To enable comparison between European regions and countries, descriptive measures were given for each region following the groupings of the WHO (World Health Organization (2006)).

4.4.2 Results

In figure 4.9, the distribution of the proportion of BMI in the groupings < 20, $[20 - 25)$, $[25 - 30)$, $[30 - 35)$, ≥ 30 for European regions are given for patients where BMI was available (n=28009). The distribution of BMI was stable across the European regions and the years of survey.

For all patients taking part at the nutritionDay surveys 2006, 2007 and 2008 and for whom a nutrition therapeutic code at sheet 2 (figure 2.3) was indicated, n=33576, the proportion of patients with artificial nutrition is given in table 4.11. Patients could be fed with enteral nutrition, parenteral nutriton or both. The proportion of patients fed with enteral nutrition or with parenteral nutrition was highly variable across the European regions. In Nordic countries, the proportion of patients with parenteral nutrition was highest, reaching over 10% and in Countries of Central and Eastern Europe, the proportion of patients with enteral nutrition was highest, reaching over 15%.

For the following analysis, patients with artificial nutrition were excluded to enable comparison between patients eating by themselves.

The answers to the question "How well have you eaten during the last week?" is displayed in figure 4.10. No differences in European regions for the quantity eaten in the previous week before were detected.

In figure 4.11, the barcharts for the quantity eaten at each meal stratified for European regions are given. At morning, the breakfast was eaten completely by more than half of the patients in all regions except in patients from South–Eastern countries, where only 40% of

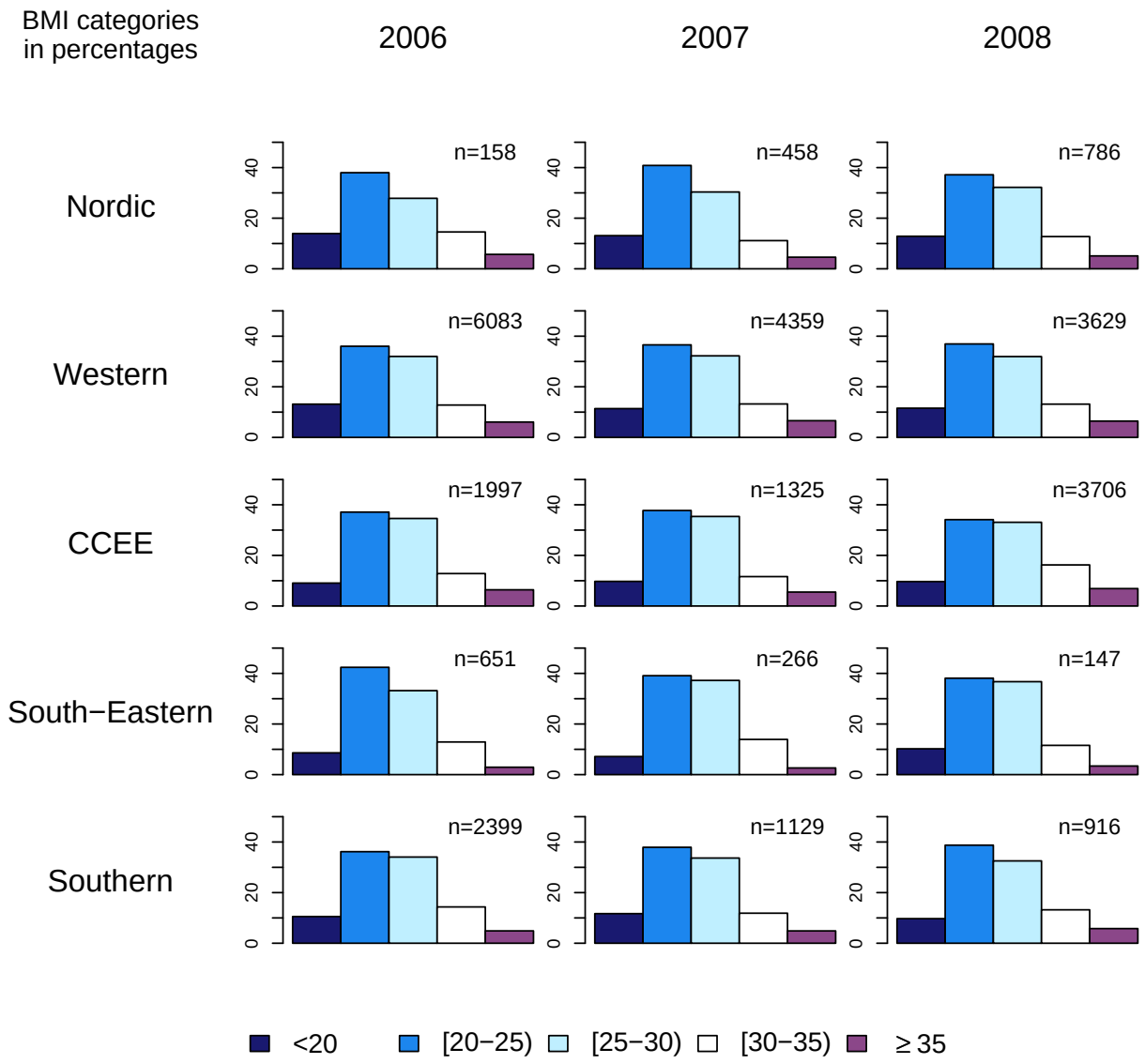

Figure 4.9: BMI in European regions, n=28009 - The percentages in each category of BMI is shown stratified for region and year of survey

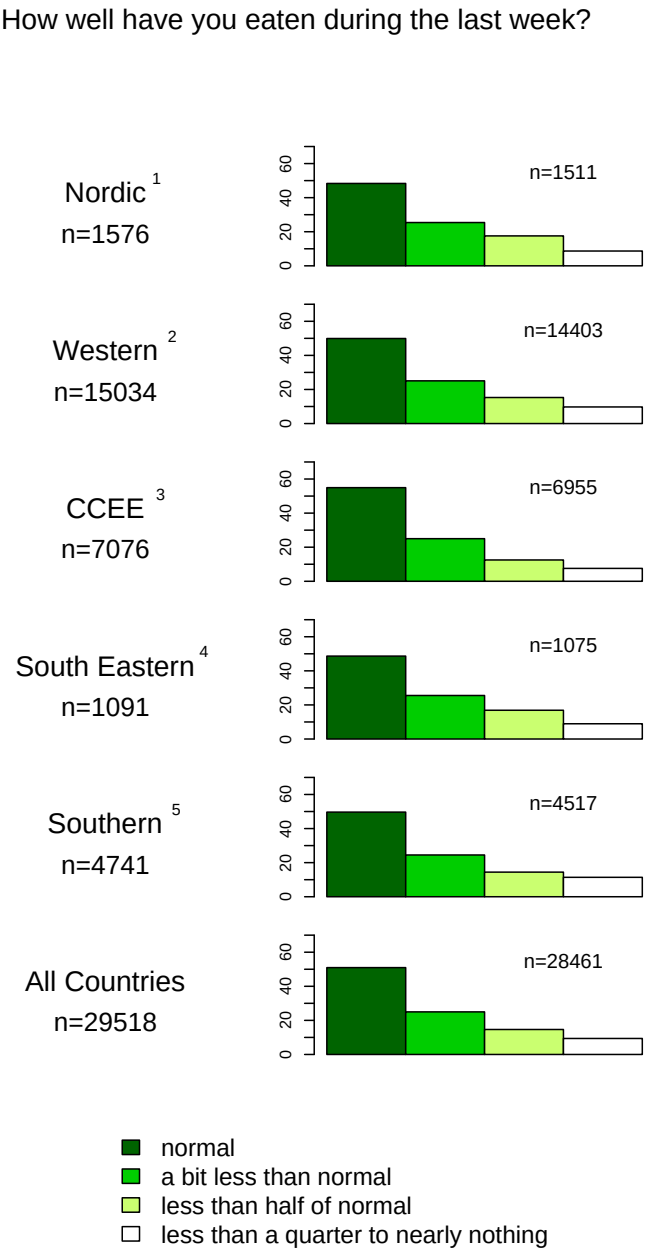

Figure 4.10: Quantity eaten in previous week in European regions - Percentage in each category

the number of patients within the regions is given on the left side, at each barchart the number of patients without missing information is given

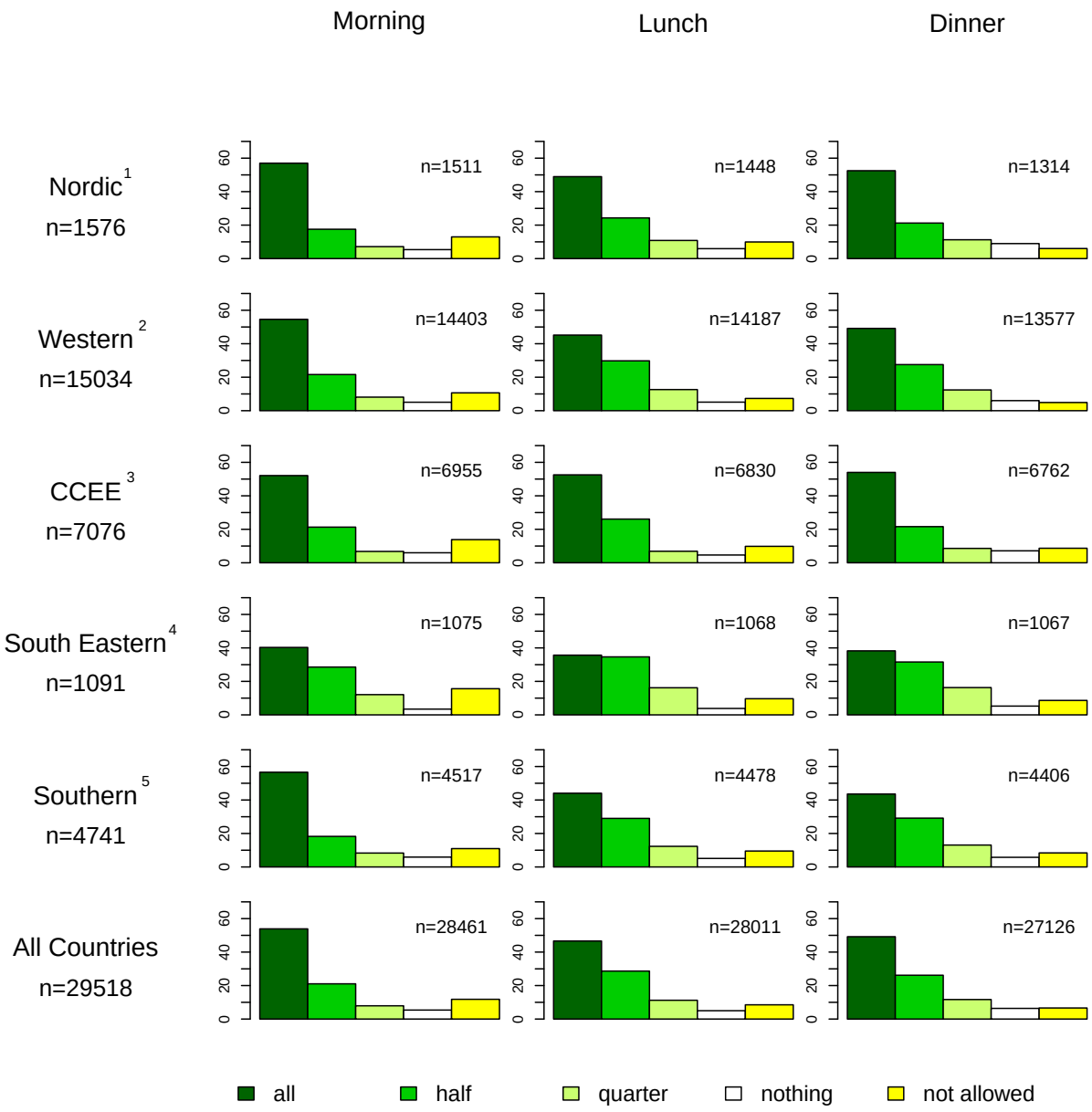

Figure 4.11: Quantity eaten at main meals in European regions - Percentage in each category,
the number of patients within the regions is given on the left side, at each barchart the number of patients without missing information is given

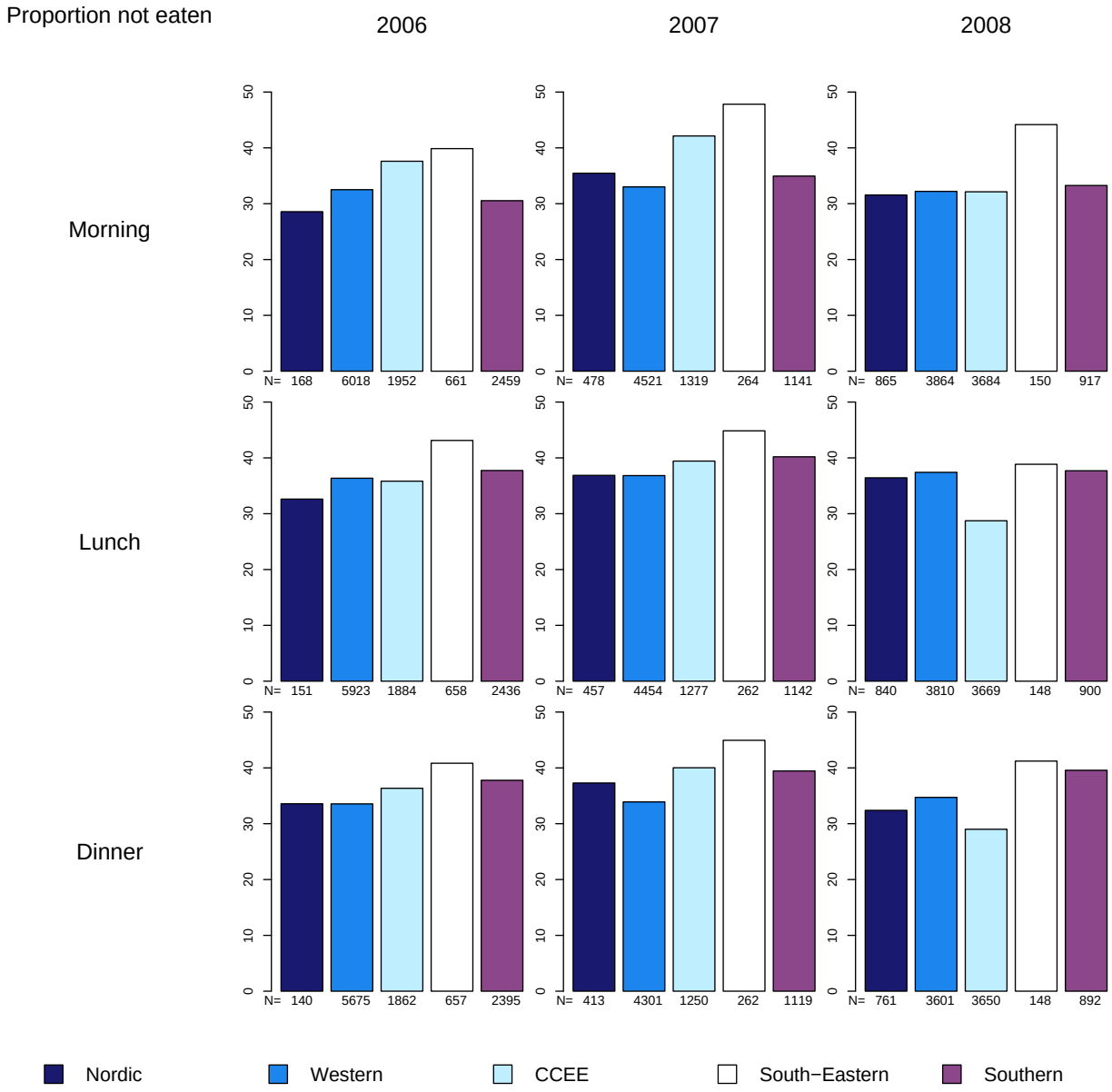

Figure 4.12: Proportion of the provided hospital meal not eaten in European regions stratified for meal and year of survey, N indicates the number of patients, from which the proportion of food not eaten was calculated.

Table 4.11: Artificial nutrition in European regions, in percentages
[1]Denmark, Finland, Norway, Sweden
[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom
[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania
[4]Croatia, Serbia, Slovenia
[5]Greece, Italy, Portugal, Spain, Turkey, Israel

European region	enteral nutrition	parenteral nutriton	enteral and parenteral nutriton	overall artificial nutrition
Nordic[1],n=1913	6.9	11.1	2.0	20.0
Western[2],n=16425	8.2	3.0	1.0	12.2
CCEE[3],n=8952	16.9	3.5	1.9	22.3
Southeastern[4],n=1280	9.2	6.3	2.3	17.8
Southern[5],n=5006	4.1	6.4	1.4	11.9
All countries,n=33576	9.8	4.2	1.5	15.5

the patients consumed the whole breakfast. The patients from South–Eastern countries specified that they did only eat half of the served meal to a greater extent that patients from other regions also at lunch or dinner. The proportion of patients being not allowed to eat was highest in South–Eastern countries and CCEE countries. In figure 4.12, the barcharts for the proportion of the provided hospital food not eaten for European regions are given. The proportion not eaten was quite stable across the European regions, type of meal and the years of survey. This figure is based on patients with information on the fraction of food consumed (n=28461 at morning, n=28011 at lunch, n=27126 at dinner). For each region, the number of patients, from which the proportion of food not eaten could be calculated, is given. The food waste was highest in South–Eastern countries.

The use of supplements (protein or energy supplements) are given for the European regions in table 4.12. The overall proportion of patients using supplements and the proportion stratified for type of specialty is presented. For each region, the proportion of patiens with the according number of patients used for the analysis is indicated in table 4.12. Interestingly, the difference in proportion of patients consuming supplements between the European regions are very similar in internal and surgical wards. In the Nordic countries, supplements use in more frequently than in other European regions. In Countries of Central and Eastern Europe, South–Eastern countries and Southern countries, the use of supplements is lower than five percent.

On sheet 3a (figure 2.4), the question "Do you eat any food apart from hospital food?"

Table 4.12: Use of supplements in European regions - Proportion of patients with supplements use, the proportion within each region and specialty is given and for each proportion, the number of target patients from which the proportion is calculated is presented (proportion within n)
[1]Denmark, Finland, Norway, Sweden
[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom
[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania
[4]Croatia, Serbia, Slovenia
[5]Greece, Italy, Portugal, Spain, Turkey, Israel

European region	protein/energy supplement, % of n	specialty of the ward				
		Internal medicine % of n	Surgery % of n	Geriatrics and long-term-care % of n	Neurology % of n	Others % of n
Nordic[1]	17.4 (n=1576)	16.9 (n=432)	21.4 (n=524)	26.8 (n=228)	15.4 (n=65)	5.5 (n=327)
Western[2]	8.2 (n=15034)	7.9 (n=5997)	5.1 (n=3660)	17.3 (n=1748)	2.7 (n=865)	8.8 (n=2764)
CCEE[3]	3.4 (n=7076)	3.7 (n=2326)	2.3 (n=2619)	9.2 (n=314)	1.5 (n=131)	3.9 (n=1686)
Southeastern[4]	4.1 (n=1091)	4.2(n=552)	4.4 (n=435)	n.a. (n=0)	0.0 (n=38)	4.6 (n=66)
Southern[5]	3.9 (n=4741)	4.8 (n=2095)	2.2 (n=1732)	10.4 (n=163)	0.5 (n=200)	5.3 (n=551)
All countries	6.7 (n=29518)	6.6 (n=11401)	4.6 (n=8970)	16.7 (n=2453)	2.8 (n=1299)	6.7 (n=5394)

was asked. In figure 4.13, the answers to the type of food ticked by the patients in the European regions are displayed. Each patient could specify, if he/she eats cakes, biscuits, sweets, fresh fruits, fruit juice, sandwich, dairy products or others. As changes has occurred to this question, only the participants from the nutritionDay surveys of the year 2007 and 2008 are included in the analyses. In the survey of the year 2006, a question about the products visitors bring in and which of the products are consumed by the patients was asked. The question was changed to "Do you eat any food apart from hospital food?" in the survey 2007. In the surveys of the years 2007 and 2008, the question was similar, but the answers were not exactly the same. In 2008, the answer category "my favorite dish" was added and for the analysis, the answer categories were combined. In the data of the survey 2008, the answers "my favorite dish" and "others" were taken as the category "others". From the 29518 patients participating in the surveys 2006, 2007 and 2008, 17525 were left, if patients from the survey 2006 were excluded. In total, 8397 of the 17525 patients answered that they eat apart from hospital food. In the figure 4.13, the proportion of patients eating apart from hospital food is given for the European regions. Of the patients, stating that they eat apart from hospital food, the type of food eaten apart from hospital food is given in the barcharts in figure 4.13. In countries of Central and Eastern Europe and South–Eastern countries, the proportion of patients eating food apart from the hospital food exceeded 50%. Overall, cakes/biscuits/sweets and fresh fruits are the main foods eaten apart from the food provided by the hospital. In table 4.13, the number of different types of food eaten apart from hospital food is given. Outstanding was the high proportion of patients eating cakes/biscuits/sweets in Finland and the United Kingdom (data not shown).

On sheet 3b (figure 2.5), the snacks consumed on the day of the survey were assessed. Again, the analysis are given for the participants in the surveys of the years 2007 and 2008 due to changes in the questionnaires. Possible answers were cakes, biscuits, sweets, fresh fruits, sandwich, dairy products, nothing and others. If patients did not tick the snack "nothing" on any part of the three in–between snacks during the day of the survey and additionally did not tick any of the type of snacks, the answer of snacks of the patients was counted as missing. From all patients in the three years of survey, n=29518, only n=23759 patients gave answers to the snacks consumed on nutritionDay. If patients of the survey 2006 were excluded, n=14367 patients were left for analysis. Of the patients

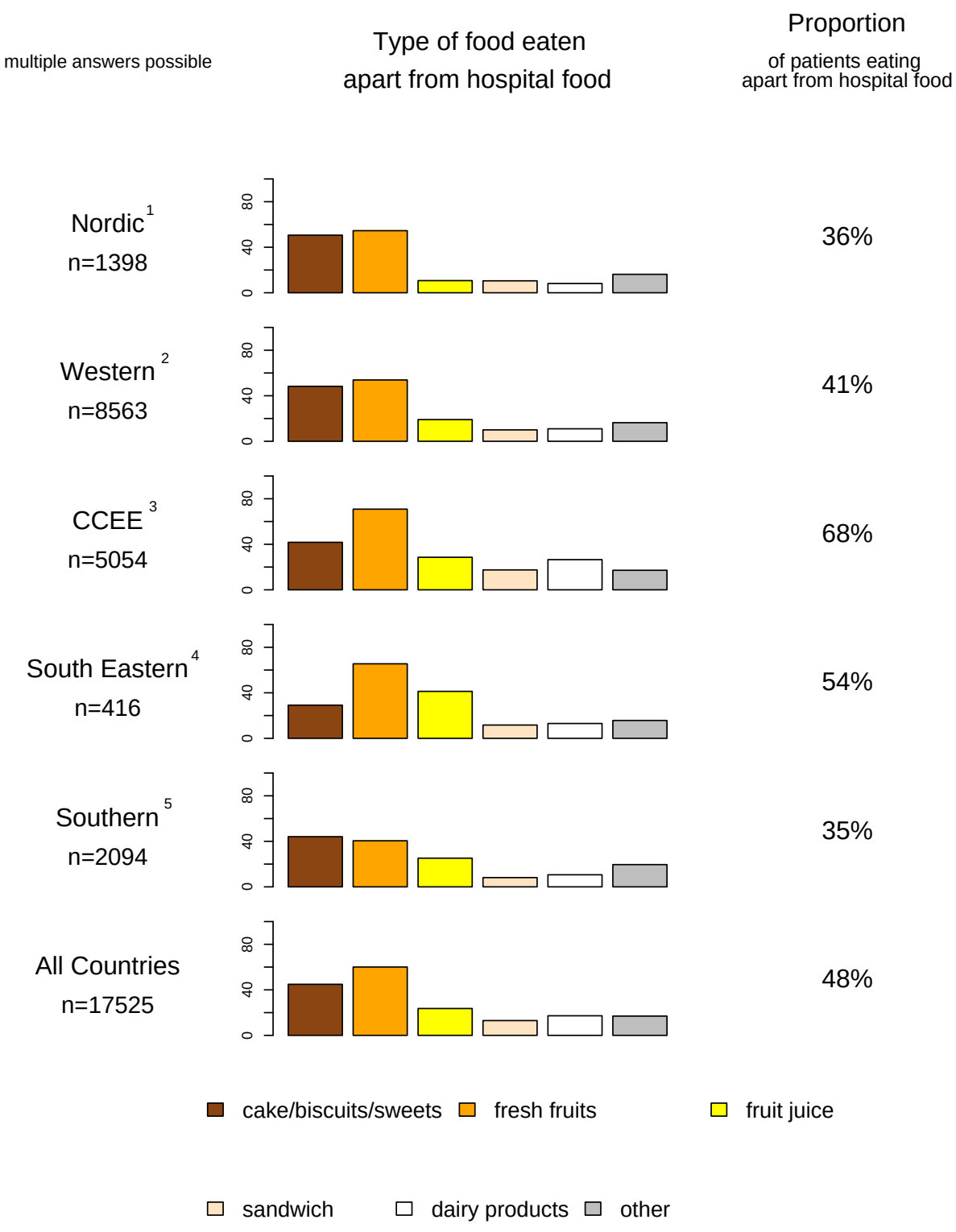

Figure 4.13: Type of food eaten apart from hospital food in European regions. The proportion out of the surveyed patients (n is given for each region) presented on the right side of the figure shows the proportion of patients eating foods apart from hospital food. The barchart in restricted to all patients indicating that they ate apart from hospital food. Multiple answers were possible.

Table 4.13: Number of different types of foods generally eaten apart from hospital food in percentages within each European region (proportion within each region)
[1]Denmark, Finland, Norway, Sweden
[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom
[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania
[4]Croatia, Serbia, Slovenia
[5]Greece, Italy, Portugal, Spain, Turkey, Israel

European region	no food	1	2	>2 different types of foods generally eaten apart from hospital food
Nordic[1],n=1398	64	22	9	5
Western[2],n=8563	59	21	13	7
CCEE[3],n=5054	32	24	22	22
Southeastern[4],n=416	46	23	21	10
Southern[5],n=2094	66	21	8	5
All countries,n= 17525	52	22	15	11

(n=14367), n=9666 indicated that they had eaten at least one snack on the day of the survey. In the figure 4.14, the proportion of patients eating snacks on the nutritionDay for the European regions is given. Of the patients, stating that they had eaten snacks, the type of food eaten apart from hospital food is displayed in the barcharts in figure 4.14.

Table 4.14: Number of different types of snacks eaten at nutritionDay in European regions in percentages within each European region (proportion within each region)
[1]Denmark, Finland, Norway, Sweden
[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom
[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania
[4]Croatia, Serbia, Slovenia
[5]Greece, Italy, Portugal, Spain, Turkey, Israel

European region	no snack	1	2	>2 different types of snacks eaten on day of survey
Nordic[1],n=1123	17	34	27	22
Western[2],n=6435	35	31	20	14
CCEE[3],n=4736	27	20	21	32
Southeastern[4],n=377	42	14	16	28
Southern[5],n=1696	48	24	16	12
All countries,n=14367	33	26	21	20

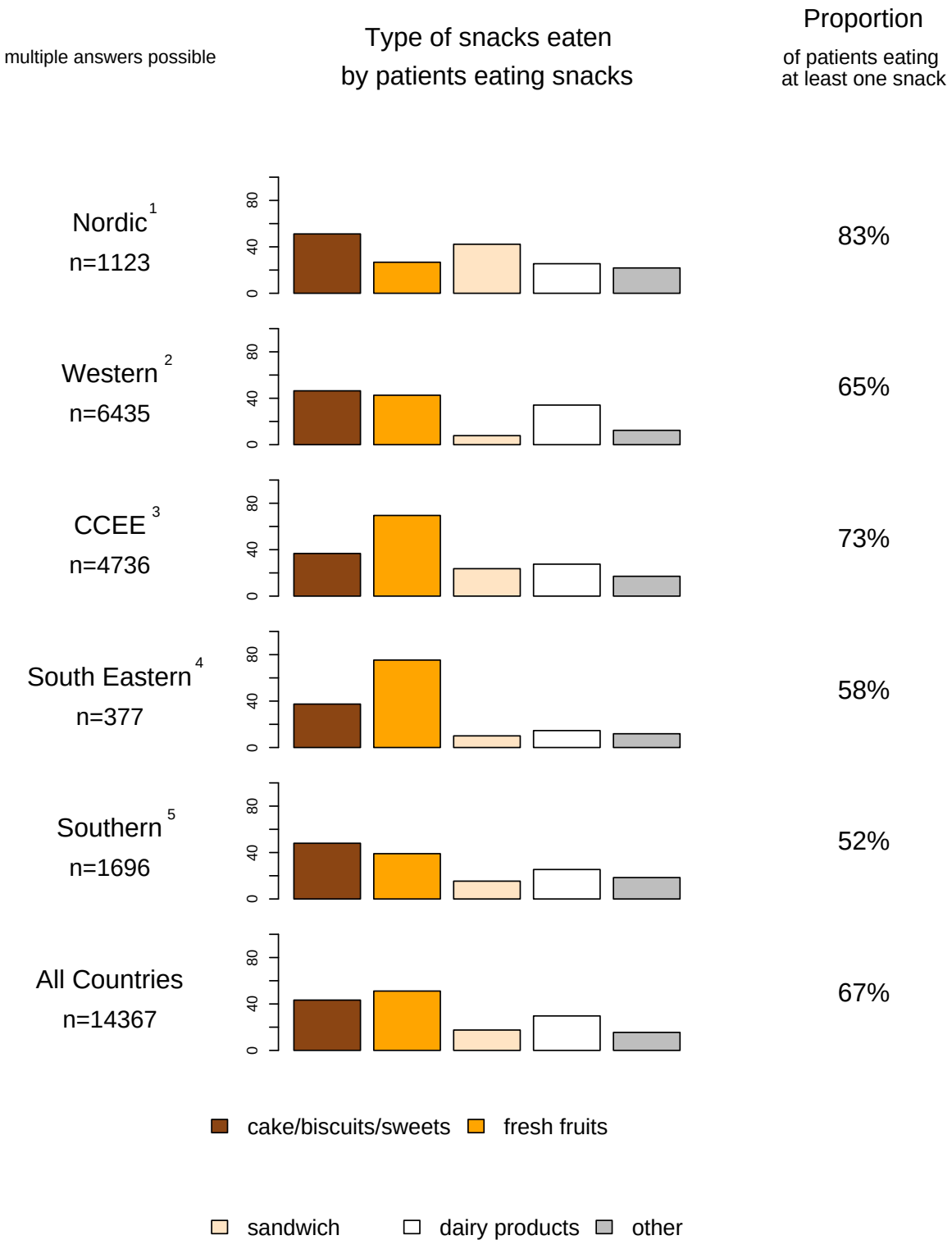

Figure 4.14: Type of snacks eaten at nutritionDay in European regions The proportion out of the surveyed patients (n is given for each region) presented on the right side of the figure shows the proportion of patients eating at least one snack on the day of the survey. The barchart in restricted to all patients indicating that they ate at least one snack. Multiple answers were possible.

4.4.3 Interpretation and discussion

The comparison of regions across Europe in their nutrition in hospitals has to be interpreted with care. Although, the number of participants is high with more than 1000 subjects in each region, it is not clear if the participants are representative for the subjects in the regions. Smaller countries had a particular patient cluster with the number of participants not being proportional to the population size. In addition the overall estimate shown for completeness is not necessarily representative for all of Europe, particularly in terms of demography and local healthcare provision.

However, the stable distribution of BMI across the countries and year of surveys was surprising. Additionally, no difference was detects in the quantity eaten in the previous week. The quantity eaten at the actual survey day across the European regions provided plausible results. The food wastage was high exceeding 30% of the served meal for all regions in Europe. Stratified for the European regions the wastage of the served meal was between 30% and 40%.

The proportions of patients receiving supplements was similar in internal and surgery wards, which suggests that the participating wards have been selected in the same manner for different specialties of wards. It seems that the participating wards are representative of the region because similar results have been obtained for the European regions when stratified for type of ward. The use of supplements is highest in Nordic countries and lowest in Countries of Central and Eastern Europe, South–Eastern countries and Southern countries.

In Nordic countries, 83% of the patients stated that they had eaten a snack on the day of the survey. In comparison, only 36% of the patients stated that they had eaten apart from hospital food (figure 4.13). In Western and Southern countries, the proportion of patients eating snacks was also higher than the proportion of patients indicating that they eat apart from hospital food. This suggests that especially in Nordic countries, but also in Western and Southern countries snacks are provided by the hospital. In countries of Central and Eastern Europe and South–Eastern countries, the proportion of snack eaters was only marginal higher than the proportion of patients eating apart from hospital food, which suggests that snacks are not provided by the hospital. A comparison between the type of

snacks eaten on nutritionDay in figure 4.14 and the type of snacks generally eaten apart from hospital food in figure 4.13 shows similarities in countries of Central and Eastern Europe and South–Eastern countries. Dairy products were consumed more frequently on the nutritionDay in Nordic and Western countries than the snacks provided by the hospitals. It seems that in Nordic and Western countries, dairy products are provided by the hospital.

4.5 Resource based versus population based sampling

Patients recruited in a cross-sectional way are representative for the patients lying in hospital on one day (sampling per patient day, for resource management), but not for the general population of patients recruited in consecutive way (sampling per patient, population–based view). A patient lying in hospital for three days has three times the probability to be in hospital on the day of the survey than a patient with a hospital stay of one day. Nevertheless, patients with longer length of stay occupy beds longer and need more resources. Therefore, patients sampled in a cross–sectional way give a snapshot of patients lying in hospital on a day. The original achieved proportions of patients based on the cross–sectional sampling give valid estimates for the proportions important for resource allocation and cost effectiveness. For example, the proportion of food not eaten on one day in hospitalized patients in figure 4.12 can be used for calculation of food waste in hospital.

However, for conclusion of population–based estimates, the length bias (section 2.3) in cross–sectional studies leads to biased results, as the patients with long LOS prior to the survey have higher probability to be included in the study than in consecutive sampling. To derive population–based estimates, an adjustment procedure was applied (section 5.1.3). The estimates for the proportions received from original (resource–based) or from adjusted (population–based) sampling are given in table 4.15. All patients giving informed consent, who received the nutritionDay questionnaires in the surveys of the years 2006, 2007 and 2008 and were able to eat by themselves were included. For the adjustment procedure, the LOS has to be available and therefore, the analysis is based on patients with information on LOS (n=22046). The adjustment procedure is based on the originally received LOS data.

In figure 4.15 the proportion of patients with weight loss is given for the European regions. In the left column (unadjusted), the proportions in the original samples are given. In the right column (adjusted) proportions adjusted for length bias, based on population–based estimates, are given.

For each variable, the number of patients with available answers from the analyzed sample (n=22046) is presented in table 4.15. No difference in the distribution of BMI was found

Table 4.15: Proportions in the original data and adjusted for length bias based on LOS

Variable Variable	% of subjects, original (resource–based estimates)	% of subjects, adjusted (population–based estimates)
BMI in categories, n=21138		
< 20	11	10
$[20 - 25)$	37	37
$[25 - 30)$	33	34
$[30 - 35)$	13	13
≥ 35	6	6
Can you walk without assistance?, n=21243		
yes	69	78
no, only with assistance	20	14
no, I stay in bed	11	8
Have you lost weight unintentionally within the last 3 months?, n=21468		
yes	42	36
no	40	45
no, I have gained weight	11	13
I am not sure	7	6
How well have you eaten during the last week?, n=21221		
normal	50	55
a bit less than normal	25	24
less than half of normal	15	13
less than a quarter to nearly nothing	10	8
How much the patient ate today at morning, n=21201		
all	54	52
50%	21	19
25%	8	7
nothing (allowed + not allowed)	17 (5+12)	22 (5+17)
How much the patient ate today at lunch, n=20820		
all	46	47
50%	29	27
25%	12	11
nothing (allowed + not allowed)	13 (5+8)	15 (4+11)
How much the patient ate today at dinner, n=20114		
all	49	50
50%	27	25
25%	12	11
nothing (allowed + not allowed)	12 (6+6)	14 (6+8)

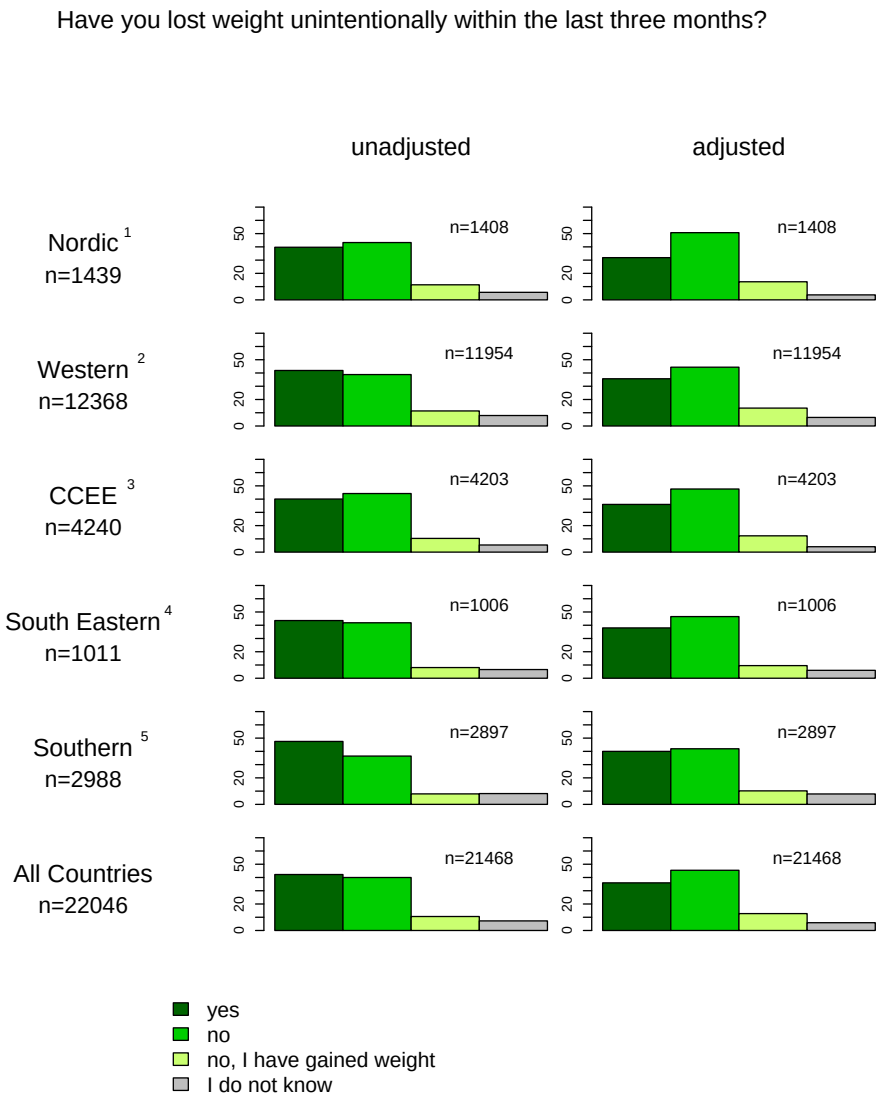

Figure 4.15: Proportion of patients with weightloss in European regions

[1]Denmark, Finland, Norway, Sweden

[2]Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland, United Kingdom

[3]Countries of Central and Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland, Romania

[4]Croatia, Serbia, Slovenia

[5]Greece, Italy, Portugal, Spain, Turkey, Israel

between original sampling and results adjusted for length bias. The proportion of patients able to walk was clearly lower in original sampling and the proportion of bedridden patients was higher. Bedridden patients have higher LOS and are therefore, more easily included in the nutritionDay study. Roughly, being bedridden can be seen as a proxy for severity of disease. It seems that the patients catched in the nutritionDay survey have higher degree of severity of disease than general hospital patients based on population–based surveys. The difference between original and adjusted proportions concerning the nutrition variables was not as big as in the mobility variables. In the nutritionDay sample more patients with weight loss in the previous three months and less with normal food intake in the previous week were present. Concerning the actual food intake, assessed as quarters of the provided hospital meal, the difference was minor. Striking was the fact, that more patients were not allowed to eat in adjusted estimates, especially in the morning. It can be explained by the fact that patients are often not allowed to eat in the beginning of the hospital stay. Patients not allowed to eat were defined as patients who gave the reasons for not eating "I had an examination/surgery and missed my meal" and "I was not allowed to eat". Examinations for which patients are either not allowed to eat or who made them missing their meal are conducted mostly in the beginning the hospital stay. As patients with short LOS are less likely to be in the nutritionDay sample compared to consecutive sampling, the results are plausible.

4.6 Gender differences in hospital nutrition

The results of this section 4.6 refer to the submitted paper:

> Pernicka, Schindler, Bauer, Hiesmayr : Gender Differences in Hospital Nutrition – a View of Caregivers and Patients; Results of the nutritionDay Cross-Sectional Study 2006, 2007, 2008 and 2009

Recently, more attention was put on gender differences in health policy, medical science and clinical care. In the field of cardiovascular diseases and osteoporosis, gender differences are already recognized. In the recent past also gender aspects in the regulation of energy balance, body fat distribution and metabolic diseases are studied (Kautzky-Willer and Handisurya (2009)). Beside research on gender related effects on the development and progression of diseases, it is interesting if there exist gender differences the type and level of clinical care. More overall hospitalization rates for men were found, especially in normal weight groups (Han et al. (2009)). In intensive care, men received increased level of care and underwent more invasive procedures, while no effect of care on outcome was found (Valentin et al. (2003)). The objective of this study was to investigate gender differences in the type of nutritional care given by the caregivers and in the consumption of the provided food from the patient's point of view. Generally, nutrition and malnutrition in hospital is a widely unrecognized field in clinical practice. Although an association between nutrition and patient outcome is evident (Kruizenga et al. (2005b), Kagansky et al. (2005), Stratton et al. (2006), Hiesmayr et al. (2009), Quinten et al. (2009)), still too less attention is given to nutrition in hospitals. One major disadvantage of observational studies in this field is that they cannot prove a causal relationship between inefficient nutrition and outcome of a patient. The role of disease and nutritional intake per se is hard to distinguish (Quinten et al. (2009), Hiesmayr et al. (2009)). Clinical trials, preferential randomized clinical trials (ClinicalTrials.gov (2010b), ClinicalTrials.gov (2010a)) are rare. In spite of these uncertainties, the quantity of nutritional intake is easy accessible and a clear association between nutrition and outcome in general hospitalized patients was shown (Hiesmayr et al. (2009)). Anyhow, several malnutrition screening tools and guidelines how to detect and react to under-nutrition have been developed. To increase the awareness and knowledge of under-nutrition in hospitals, the nutritionDay study was initiated in 2006. The large-scale

observational cross-sectional nutritionDay study gives insight in the population catched on one typical day in European hospitals. It was objected to gain a snapshot of nutritional care viewed from caregivers as well as from patients in daily routine on a typical day in hospitals through Europe. In particular, we investigated whether nutritional care differs between men and women and if there are sex-specific behaviours according to the quantity eaten at hospital in over 40000 patients.

4.6.1 Statistical methods

The effect of gender on nutritional behavious in hospital was assessed in several univariate and multivariate adjusted models. The following proxies for nutritional behaviour were analyzed: Ordinal target variables were **energy intake (<500 kcal, 500–999 kcal, 1000–1499 kcal, 1500–1999 kcal, >2000 kcal, higher classes were modeled)** and **energy needs (<1000 kcal, 1000–1499 kcal, 1500–1999 kcal, >2000 kcal, higher classes were modeled)**, analyzed with $\text{GEE}_{ordinal}$. Further ordinal target variables were **weight loss (gained weight, no, yes, yes was modeled)**, **quantity eating in the previous week (normal, a bit less than normal, less than half of normal, less than a quarter to nearly nothing, classes with lower intake were modeled)** and **quantity eaten at morning (all, half, quarter, nothing, classes with lower intake were modeled)** analyzed with $\text{GEE}_{ordinal}$. The same was applied for the **quantity eaten at lunch**, **dinner** and **number of snacks eaten at nutritionDay (no snack, 1 or 2, more than 2 snacks, lower snack intake was modeled)**. Dichotomous target variables were **being at nutritional risk (yes, no)** and **ticking a specific reason for consuming less**, analyzed with GEE_{binary}. Patients consuming less in the previous week or less than the provided meal by the hospital could specify the reason for their reduced intake. Among the target population of patients consuming less, each reason was analyzed separately.

In multivariate models, various adjustment variables were taken into account: *demographic variables (age), disease related variables (ICD–10 top category, presence of comorbidities, duration since hospital admission, previous ICU stay, number of drugs), structural factors (type of hospital ward, presence of specific nutritional care person, presence of nutrition support team), nutrition related factors (dependent on target variable: quan-*

tity eaten at main meal(s), snacks, fluid status, receiving supplementation, BMI, quantity eaten in previous week, weight loss) and others (mobility, visits, year of survey).

To illustrate the association between proportion females and the corresponding mean age or time since hospital admission throughout geographic regions, countries with more than 500 participants are shown individually in the figures. The figures relating age to height, weight or BMI were restricted to patients 95 years old or lower because of too few patients with higher age. Data analysis was performed using the Statistical Software of SAS Institute Inc., version 9.1.

4.6.2 Results

Gender specific aspects in the recruitment of patients

So far, the nutritionDay took place four times, always on a Thursday in January (19.01.2006, 25.01.2007, 31.01.2008 and on 29.01.2009). As much as N=42494 patients could be recruited for the nutritionDay study in Europe and Israel in the four years of survey and were available for analysis. Demographic and disease specific characteristics of the patients are presented in table 4.16 and table 4.17. Obviously, female patients were older. Also, a high correlation between mean age and proportion of women within a country was found (R^2=0.66, N=20 countries or regions including n=42494 patients, figure 4.16). For both sexes the median days [lower, upper quartile] the patients were already in hospital on the day of the cross–sectional survey were 6 [3; 13]. Patients being already longer in hospital on the day of the survey are older without any gender specific difference (figure 4.17).

Table 4.16: Demographic profile of participants

	Female	Male
Age: Mean ± std (N)	64.0 ± 18.1 (21081)	61.3 ± 16.9 (21413)
BMI: Mean ± std (N)	26.6 ± 7.6 (21081)	26.4 ± 7.2 (21413)
Weight in kg: Mean ± std (N)	68.0 ± 18.0 (21081)	74.9 ± 18.0 (21413)
Weight lost in previous 5 years in kg: Mean ± std (N)	-2.2 ± 11.0 (16266)	-3.3 ± 10.9 (17138)

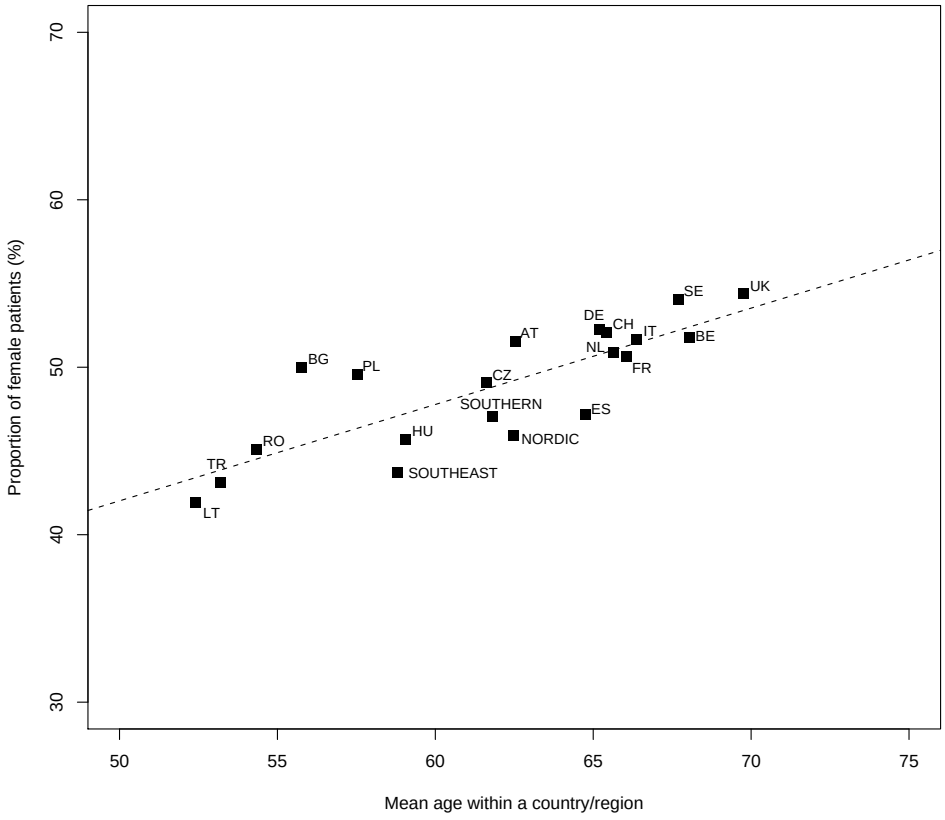

Figure 4.16: Proportion of female patients in the different countries/regions related to the according mean age

AT Austria, BE Belgium, BG Bulgaria, CH Switzerland, CZ Czech Republic, DE Germany, ES Spain, FR France, HU Hungary, IT Italy, LT Lithuania, NL Netherlands, PL Poland, RO Romania, SE Sweden, TR Turkey, UK United Kingdom, NORDIC: Denmark, Finland, Norway, SOUTHERN: Greece, Portugal, Israel , SOUTHEAST: Croatia, Serbia, Slovenia

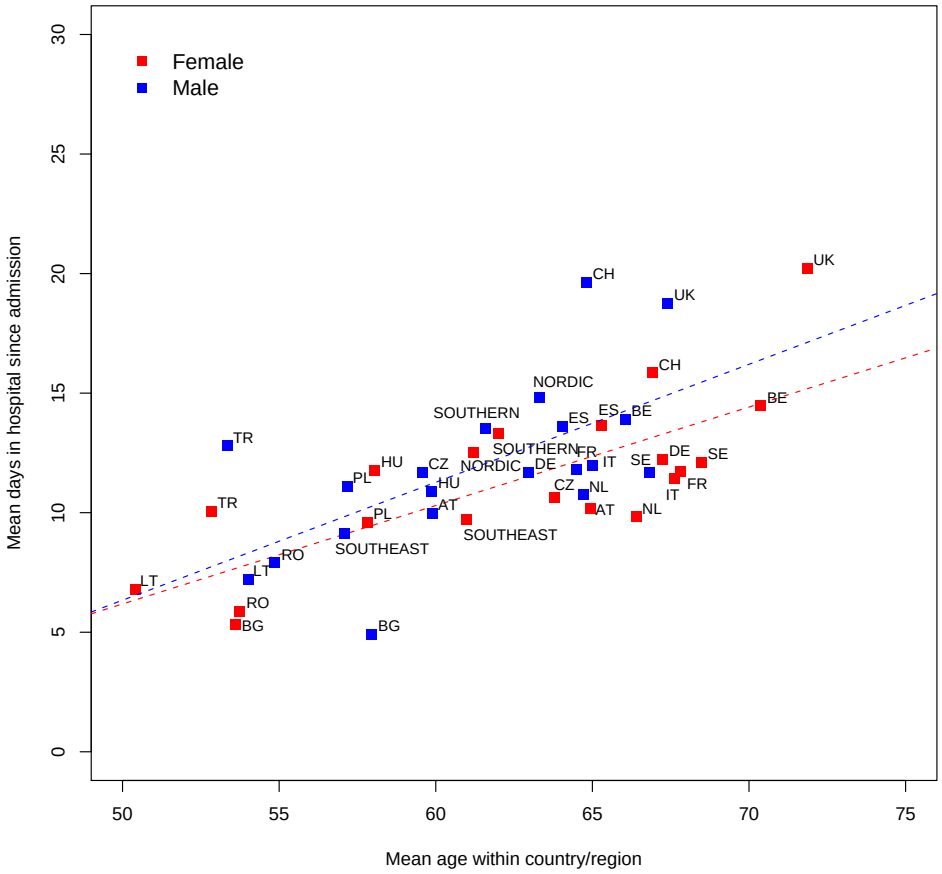

Figure 4.17: Mean age in the different countries/regions related to the according mean days since hospital admission

AT Austria, BE Belgium, BG Bulgaria, CH Switzerland, CZ Czech Republic, DE Germany, ES Spain, FR France, HU Hungary, IT Italy, LT Lithuania, NL Netherlands, PL Poland, RO Romania, SE Sweden, TR Turkey, UK United Kingdom, NORDIC: Denmark, Finland, Norway, SOUTHERN: Greece, Portugal, Israel , SOUTHEAST: Croatia, Serbia, Slovenia

Table 4.17: Patient characteristics of participants

Affected organ according to ICD-10 top category, Multiple answers possible	% of Female, N=21081	% of Male, N=21413
Brain, nerves	14.4	13.0
Eye, ear	2.6	2.6
Nose, throat	2.8	4.9
Heart, circulation	22.7	21.7
Lung	11.8	13.1
Liver	6.3	7.5
Gastrointestinal tract	22.3	22.6
Kidney, urinary tract	10.3	10.9
Endocrine system	7.9	6.1
Skeleton, bone, muscle	19.3	14.5
Blood, bone marrow	4.0	4.0
Skin	3.2	3.0
Ischaemia	1.6	2.0
Cancer	15.5	17.2
Infection	5.7	5.9
Others	7.6	6.5

Age related time course in height, weight and BMI

There was a similar age–related height reduction for men and women, with men being taller. The function between age and weight is not linear, but curved with increasing weight until 65 years old and decreasing weight after for inpatients. Despite an invariant higher weight for men, the type of trend is similar between men and women for age related weight (figure 4.18). Interestingly, there is no linear, but curved association between age and BMI, which is equally for both sexes (figure 4.19). The curved age–related time course of BMI is explained by the association between age and weight. Men have more weight and are taller, and consequently the calculation of BMI (kg/m^2) reduces the differences between the sexes.

Gender similarities and differences in hospital nutrition according to the caregivers view

Half of the 42 494 patients were female (N=21081) and half male (N=21413). An equal proportion of women and men were fed with artificial nutrition (14.7% women vs. 15.5% men), which was defined as enteral, parenteral or enteral and parenteral nutrition. The type of nutritional care given to patients able eating by themselves (N=36075, excluding

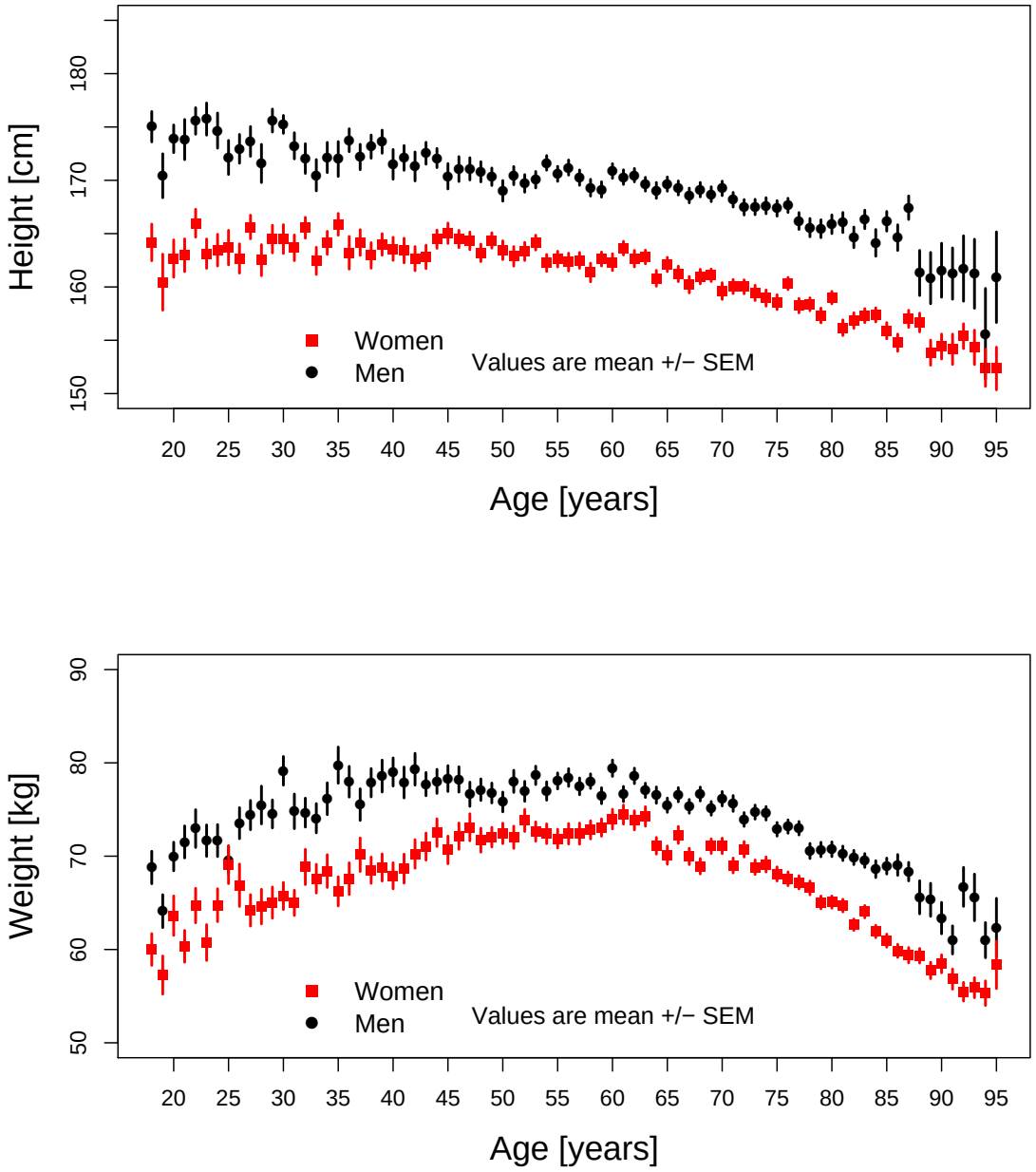

Figure 4.18: Mean height and weight with standard error of the mean for each year of life stratified for gender, n=42324

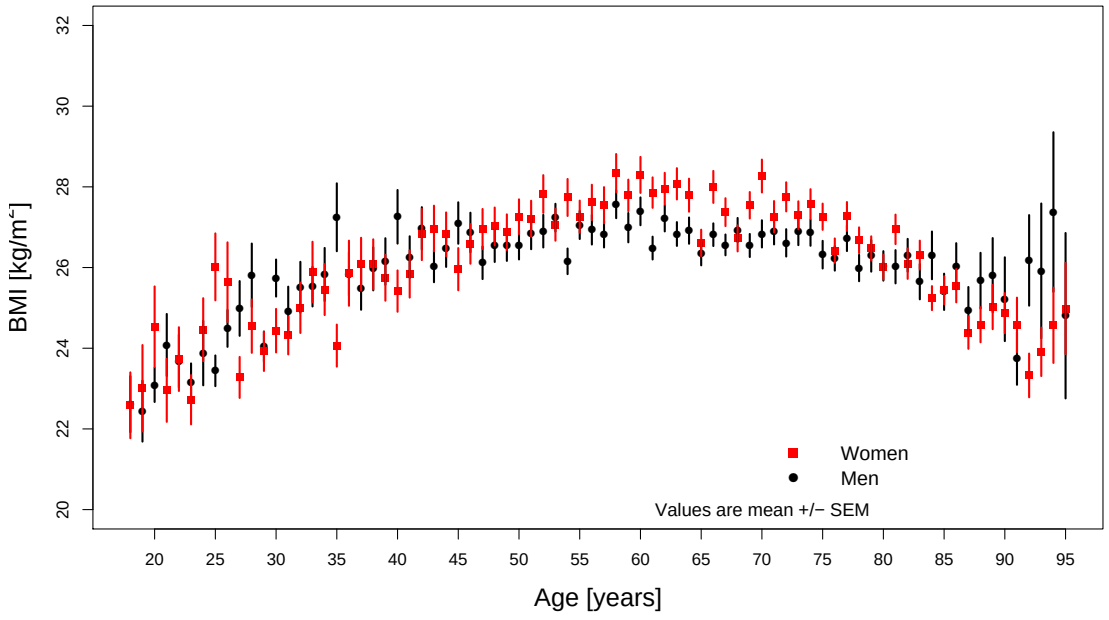

Figure 4.19: Mean BMI with standard error of the mean for each year of life stratified for gender, n=42324

patients with artificial nutrition) is given in table 4.18. There was no sex specific difference in type of nutritional care given by the caregivers.

Table 4.18: Practice of nutritional care, N=17975 Women and N=18100 Men

Type of nutritional care	% of Female	% of Male
Exclusively hospital food	67.9	67.9
Exclusively special diet	14.5	14.9
Other type of nutrition care - not specified	3.8	4.1
Combination of hospital food and supplements	3.7	3.2
Protein supplements	2.6	2.5
Combination of hospital food and other type of nutrition care - not specified	2.6	2.8
Other combination	2.1	1.9
No information on type of nutritional care	2.8	2.7

In the surveys beginning from 2007, questions about the caloric intake and energy need of the patients in categories of kcal were asked. Additionally, the question "if the patient is at nutritional risk" was added. There were 24201 patients participating in the surveys 2007, 2008 and 2009 when excluding subjects with artificial nutrition. Women had lower

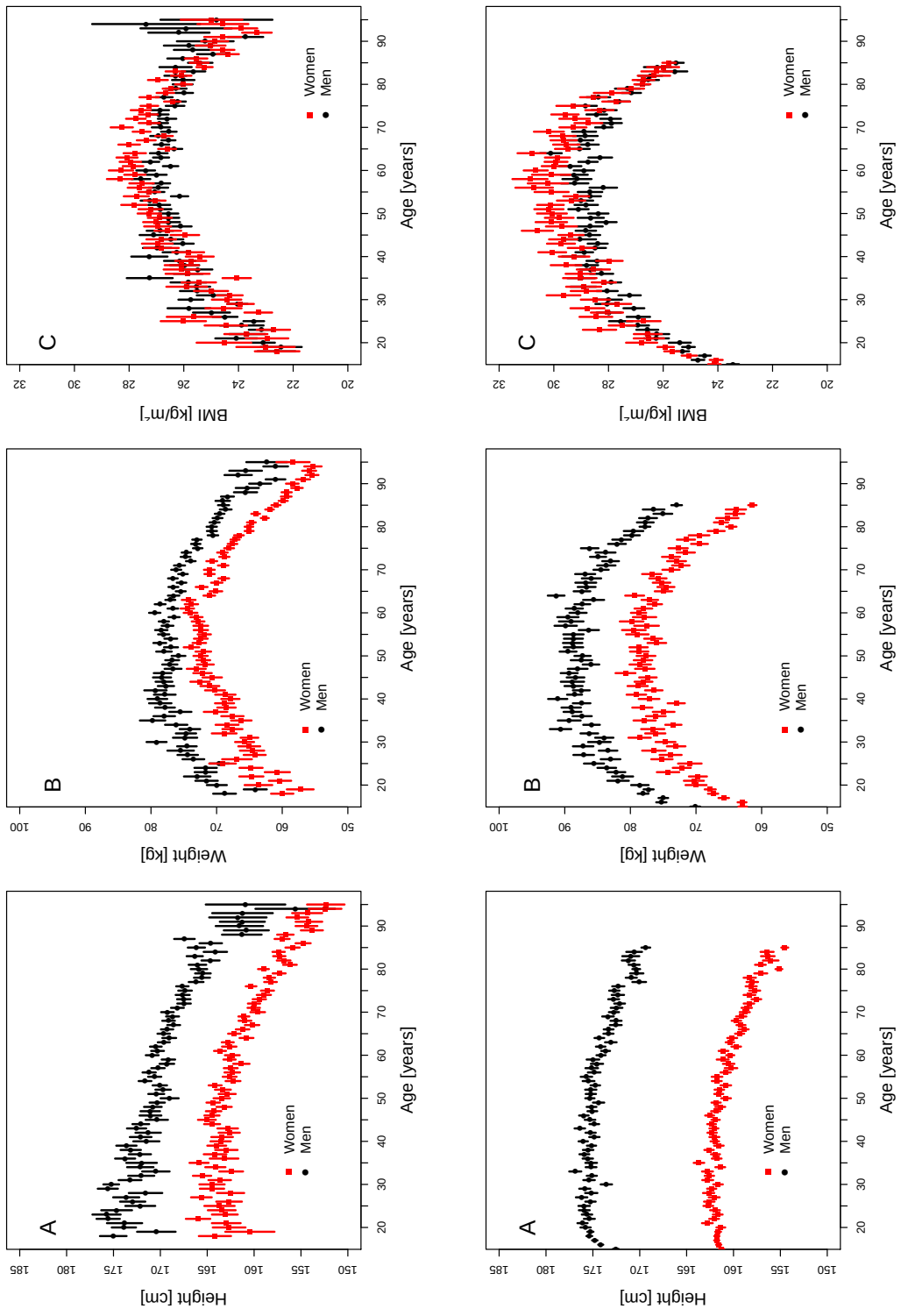

Figure 4.20: Mean height,weight and BMI stratified for gender in the nutritionDay data (n=42324) and NHANES data (n=44006)
(A) Mean height with standard error of the mean for each year of life stratified for gender
(B) Mean weight with standard error of the mean for each year of life stratified for gender
(C) Mean BMI with standard error of the mean for each year of life stratified for gender
In the upper row, the data of the nutritionDay data are given, in the lower row, the data of the NHANES 1999-2008 data are given

OR for being classified in a higher energy need category (OR=0.52 [0.45; 0.60], p<0.0001, N=21208, 4.21). In the multivariate adjusted model, this observation was still present (OR=0.53 [0.45; 0.63], p<0.0001, N=16510). Similarly, women were classified as consuming less energy (OR=0.68 [0.61; 0.75], p<0.0001, N=18678, figure 4.21). Also in the multivariate adjusted analyses, females had lower probabilities for being in higher caloric intake categories (OR=0.71 [0.64; 0.79], p<0.0001, N=14753).

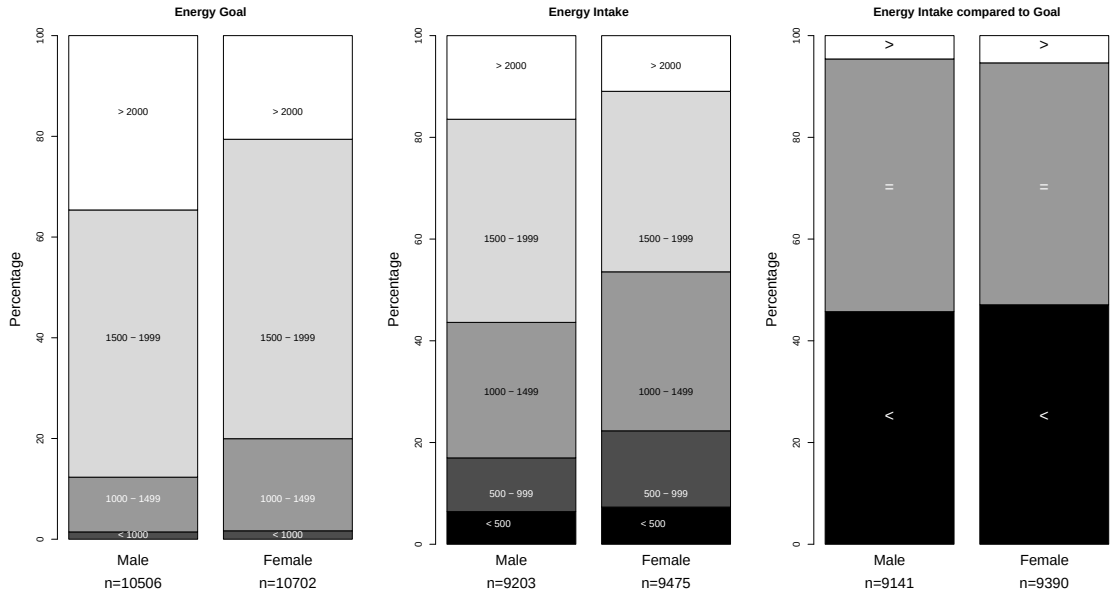

Figure 4.21: The caregivers view of energy goal and energy intake in kcal at nutritionDay

Patients with lower energy intake than energy needs were considered as patients with undernutrition, patients with equal energy intake and need as patients with appropriate energy intake and patients with higher energy intake than needs were considered as patients with overnutrition. In univariate and multivariate analyses, sex had no significant influence on the probability for being in the group of undernutrition (47.1% women vs. 45.7% men, univariate: OR=1.03 [0.95; 1.13], p=0.4532, N=18531; multivariate: OR=0.94 [0.86; 1.03], p=0. 1704, N=14672).

The proportion of patients classified as being at nutritional risk was also not different among females and males (28.5% women vs. 27.7% men, OR=1.00 [0.93; 1.07], p=0. 9892, N=21610). Interestingly, females were less likely regarded as being at nutritional risk than men, when adjusted for food intake, BMI and other covariables (OR=0.85 [0.79; 0.93], p=0. 0001, N=16519).

Gender similarities and differences in hospital nutrition according to the patients view

Women were more likely to state that they have eaten less than normal in the previous week (OR=1.29 [1.23; 1.35], p<0. 0001, N= 34963). This observation was not altered by stratified analyses according to the time the patient is already in hospital (figure 4.22) and by multivariate adjustment (OR=1.19 [1.13; 1.26], p<0. 0001, N= 22904).

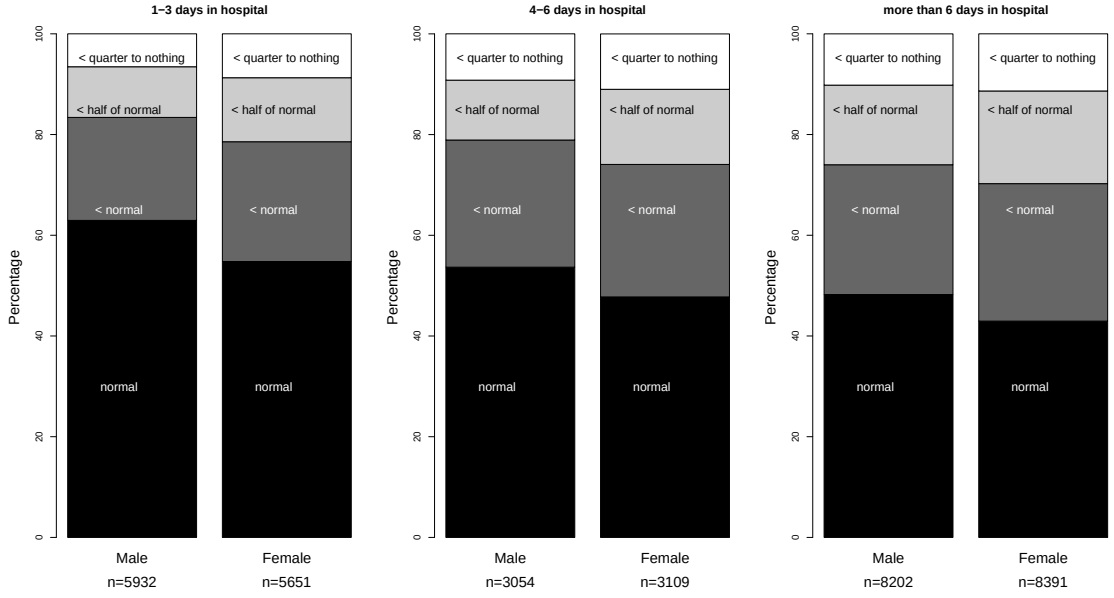

Figure 4.22: The patients' view of quantity eaten in the previous week

Irrespectively if patients were in the hospital already in the previous week or have been admitted to the hospital during the last 7 days, females stated that they reduced their food intake in the previous week compared to normal state because of absent of hunger or nausea. Adjustment for disease specific covariables and others did not change these results (table 4.19).

Female patients were more likely to indicate lower intake at the main meals at morning, lunch and dinner in univariate (OR=1.30 [1.23; 1.48], p<0. 0001, N=34248; 1.46 [1.37; 1.55], p<0. 0001, N=34090; 1.44 [1.34; 1.53], p<0. 0001, N=32549, figure 4.23) and multivariate adjusted models (OR=1.43 [1.30; 1.56], p<0. 0001, N=23627; 1.49 [1.36; 1.64], p<0. 0001, N=23542; 1.40 [1.28; 1.54], p<0. 0001, N=22904).

Females were more likely to tick the reason "I normally eat less" in the morning, at lunch

Table 4.19: Influence of sex on ticking a specific reason for reduced intake in patients eating less than normal in the previous week, OR for female gender, separate analyses are performed for each reason

	1-3 days in hospital		4-6 days in hospital		>6 days in hospital	
Reason for eating less than normal in previous week	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]
I was not hungry	1.16 [1.02; 1.31] 0.0211 4753	1.21 [1.05; 1.40] 0.0082 0.0063 3893	1.23 [1.06; 1.42] 0.0114 3039	1.26 [1.05; 1.50] 0.0063 2550	1.12 [1.03; 1.22] 0.0141 9033	1.12 [1.02; 1.23] 7555
Nausea	1.18 [0.99; 1.40] 0.0634 4753	1.21 [0.98; 1.48] 0.0703 3893	1.34 [1.09; 1.65] 0.0053 3039	1.31 [1.02; 1.67] 0.0336 2550	1.32 [1.17; 1.48] <0.0001 9033	1.40 [1.23; 1.60] <0.0001 7555

[1] Multivariate analysis adjusted for age, fluid status (overloaded, normal, dehydrated), mobility, affected organ(s) according to ICD–10 top category, presence of comorbidity, BMI, visits, drugs, quantity eaten in previous week (normal, a bit less than normal, less than half of normal, less than a quarter to nearly nothing), weight loss in previous 3 months (yes, no, gained weight, not known), previous ICU stay, presence of specific nutritional care person, presence of nutrition support team, type of hospital ward (internal, surgery, neurology, geriatrics, other), year of survey.

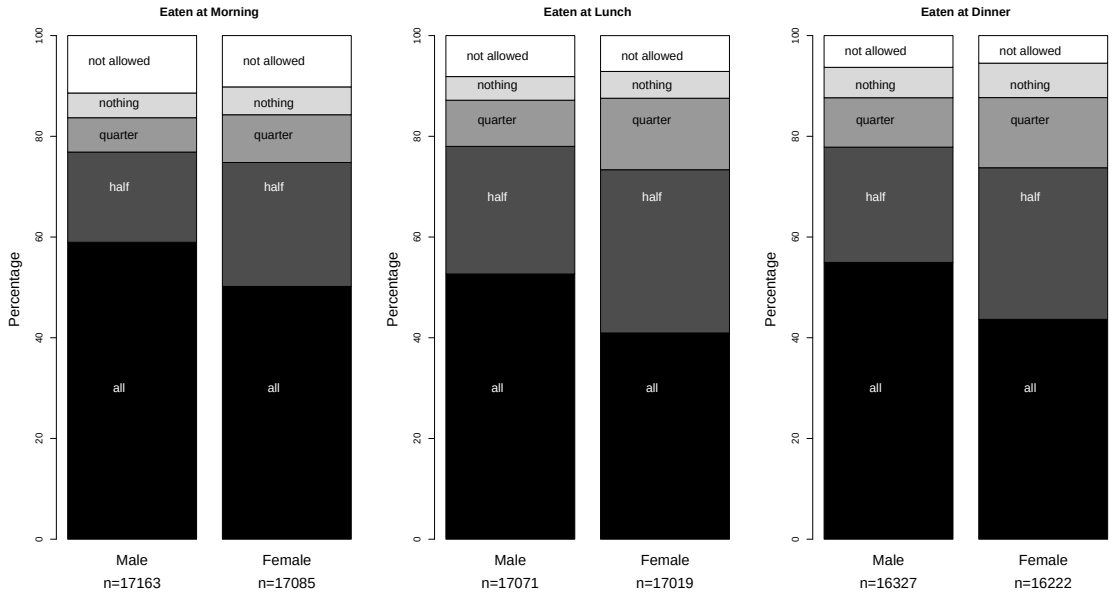

Figure 4.23: The patients' view of quantity at the main meals provided by the hospital at nutritionDay

and at dinner. Similarly, women with diminished food intake specified they had nausea or vomiting more often than men during the nutritionDay. At dinner, male patients complained more about the taste and smell of the food and decreased therefore their food intake. Interestingly, female patients were less likely to state the reasons "I was not allowed to eat" (10.8% women and 14.8% men, OR=0.71 [0.64; 0.79], p<0. 0001, N=15504) or "I had an examination/surgery and missed my meal" (11.0% women and 14.8% men, OR=0.73 [0.67; 0.81], p<0. 0001, N=15504, table 4.20) at morning. Also in analyses stratified for type of specialty, male patients were more often not allowed to eat (women vs. men: internal: 10.3% vs. 12.6%; surgery: 16.5% vs. 20.9%; geriatrics: 3.6% vs. 7.0%; others: 7.9% vs. 11.0%)

Although women indicated reduced food intake in the previous week and during the whole day of survey, the number of snacks did not differ between women and men (OR=1.03 [0.98; 1.10], p=2504, N=29317; multivariate adjusted: OR=0.99 [0.93; 1.06], p= 0.8351, N= 22904).

Table 4.20: Influence of sex on ticking a specific reason for reduced intake in patients eating less than provided by the hospital at each main meal at nutritionDay, OR for female gender, seperate analyses are performed for each reason

	At morning		At lunch		At dinner	
Reason for eating less on the day of the survey	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]	OR [95% CI] p-value N univariat	OR [95% CI] p-value N multivariat[1]
I normally eat less	1.32 [1.14; 1.52] 0.0002 15504	1.16 [1.00; 1.34] 0.0474 11450	1.32 [1.18; 1.47] <0.0001 18099	1.22 [1.07; 1.39] 0.0021 13451	1.33 [1.19; 1.49] <0.0001 16470	1.24 [1.09; 1.42] 0.0010 12932
I did not like the taste or smell	0.92 [0.81; 1.05] 0.2112 15504	0.95 [0.81; 1.11] 0.5385 11450	0.94 [0.85; 1.03] 0.2059 18099	0.93 [0.84; 1.02] 0.1266 13451	0.84 [0.75; 0.93] 0.0014 16470	0.85 [0.76; 0.95] 0.0036 12932
I was not hungry	1.09 [1.01; 1.17] 0.0235 15504	1.00 [0.92; 1.10] 0.9193 11450	1.03 [0.96; 1.11] 0.4643 18099	1.00 [0.91; 1.10] 0.9958 13451	1.08 [1.00; 1.16] 0.0418 16470	1.02 [0.94; 1.11] 0.6712 12932
I had nausea or vomiting	1.27 [1.12; 1.44] 0.0002 15504	1.25 [1.08; 1.45] 0.0027 11450	1.23[1.10; 1.38] 0.0004 18099	1.23[1.07; 1.42] 0.0042 13451	1.16 [1.03; 1.31] 0.0186 16470	1.18 [1.02; 1.37] 0.0254 12932
I was not allowed to eat or vomiting	0.71 [0.64; 0.79] <0.0001 15504	0.76 [0.67; 0.86] <0.0001 11450	0.70 [0.62; 0.78] <0.0001 18099	0.73 [0.63; 0.86] 0.0001 13451	0.67 [0.59; 0.76] <0.0001 16470	0.70 [0.59; 0.82] <0.0001 12932
I had an examination surgery and missed my meal	0.73 [0.67; 0.81] <0.0001 15504	0.83 [0.73; 0.93] 0.0022 11450	0.72 [0.64; 0.81] <0.0001 18099	0.81 [0.71; 0.93] 0.0026 13451	0.76 [0.66; 0.88] 0.0003 16470	0.93 [0.80; 1.09] 0.3915 12932

[1] Multivariate analysis adjusted for age, quantity eaten less at dinner (half, quarter or nothing), number of snacks consumed during the nutritionDay, fluid status (overloaded, normal, dehydrated), mobility, receiving supplementation, duration since hospital admission, affected organ(s) according to ICD-10 top category, presence of comorbidity, BMI, visits, drugs, quantity eaten in previous week (normal, a bit less than normal, less than half of normal, less than a quarter to nearly nothing), weight loss in previous 3 months (yes, no, gained weight, not known), previous ICU stay, presence of specific nutritional care person, presence of nutrition support team, type of hospital ward (internal, surgery, neurology, geriatrics, other), year of survey

4.6.3 Interpretation and discussion

In the hospital population catched in the cross-sectional nutritionDay survey, female patients were on average 2.7 years older. Women have higher life expectancy of about 3.3 years at the age of 65 in the EU-25 region (European Commission (2010)), therefore it is plausible that older women are also more frequently present in the hospital and that the demographic composition of hospital patients is similar to the overall population. However, the association between gender and age in hospital patients was never shown in such a large survey. Patients recruited in a cross–sectional way are representative for the patients lying in hospital on one day (sampling per patient day), but not for the general population of patients recruited in consecutive way (sampling per patient). A patient lying in hospital for three days has three times the probability to be in hospital on the day of the survey than a patient with a hospital stay of one day. Nevertheless, patients with longer length of stay occupy beds longer and need more resources. Therefore, patients sampled in a cross–sectional way give a snapshot of patients lying in hospital on a day. There was a high correlation between the mean age and proportion of females within participating countries. The association between mean age and proportion of females gets stronger with increasing length of stay of the patients (data not shown). Clearly, older patients have also longer length of stay and therefore, the age difference between men and women gets bigger, when considering patients with longer length of stay.

Female and male patients were similar in BMI. Surprisingly, the types of affected organs were also similar distributed among the sexes. Only the diseased organ skeleton/bone/muscle was more often found in women. For all other affected organs, which were defined as the top group of ICD-10 code, no difference in the frequency between men and women lying in hospital were found.

The decrease in height with age and in weight in patients older than 65 years old is in line with other publications (Perissinotto et al. (2002)). The non–linear association between age and weight or BMI was also shown in the National Health and Nutrition Examination Survey 1999–2008 (Centers for Disease Control and Prevention (2010)), by reproducing figure 4.20 with available data of over 40000 participants. However, it was not investigated in a huge sample of patients in normal hospital wards. The non–linear association between age and weight or BMI was mainly explained by the function of weight with age. It is

possible that patients born before 1930 (older than 80 years), in which a dramatically decrease of BMI was observed, did not gained as much weight in their life than patients born afterwards. Therefore, the effect could be partly explained by the time the patients were born. Patients over 80 years old in hospital are subjects who already survived until the age of 80. It could be possible that patients with higher BMI already died before the age of 80 and these older patients represent the survivors with lower BMI. It may also be possible that body function and body size is decreased before death, especially in older age, and the decrease in body mass assessed as BMI in patients older than 80 years is reflecting this.

There was no difference in type of nutritional care between men and women. The proportion of patients fed artificially was equal as well as the distribution of nutritional care among patients eating autonomous. From the caregivers' view, females were more often classified in lower energy intake and energy need categories than men. This did not affect the probability of eating less energy than needed defined by the caregivers. Also, the proportion of patients being at nutritional risk defined by the caregivers was not different between the sexes. However, in the multivariate analysis, which is adjusted for food intake, BMI and others, females had significantly lower risk for being subjectively classified as at nutritional risk. Using height, weight and the interactions with gender directly as independent variables instead of BMI, gender differences lost significance and the odds ratio changed direction (OR>1). It shows that women with similar food intake and BMI as men are less likely regarded as at nutritional risk. Other studies showed than more women were at nutritional risk when assessing the nutritional risk status by malnutrition scores (Castel et al. (2006)). The question "Patient at nutritional risk" was subjective answered and factors influencing that a patient was classified as at nutritional risk were recently published (Schindler et al. (2010)). Mainly factors easily captured by just looking at the patient (BMI) caused caregivers to group a patient as at nutritional risk. Although BMI was similar distributed between men and women, it seems that men with low BMI are considered as more at nutritional risk.

Women ate significantly less and ticked the reason that they normally eat less more often. The question about the quantity eaten on nutritionDay was based on the served meal by hospital. Assumed that few to no hospitals adapt the served meal size on sex specific

energy needs, it is not surprising, that more women did not finish their meal. However, the quantity eaten in the previous week was based on the "normal" intake individually for each patient. Female patients stated that they reduced their intake in the previous week compared to normal more often than men. This observation was not altered when taking into account if the patient was already in hospital or at home in the previous week. It appears that women are more sensitive to the issue of nutrition and are more likely to reduce their food intake in disease state than men. In the survey of Health, Ageing and Retirement in Europe (Rueda et al. (2008)) in community–residing people aged 65–85 years, 14% of men were living alone and 37% of women. It is possible that men, who are still living with partners, are provided with food of their female partners and therefore, do not decrease their food intake to such a great extent than women.

The stated reasons for reduced food intake pointed out gender specific behavior. In patients with prevalent haemodialysis, female patients reported decreased self–reported appetite (Carrero et al. (2007)). Not being hungry or having nausea were more often the reasons for reduced food intake in the previous week for women. At the day of the survey, women had higher probability to reduce their food intake because of too big portion sizes or having nausea. Men were more often not allowed to eat or did not eat from the main meals because they missed the meal due to an examination or surgery. The effect of gender on the probability to miss the meal due to examination or surgery was attenuated when taking into disease related covariables and others. However, it is not clear, why men were more often not allowed to eat. In internal, surgery and geriatric wards, the finding was present. Male patients received increased level of care and underwent more intensive procedures in a survey of critically ill patients (Valentin et al. (2003)). It is possible that similar reasons lead to the fact that male patients are more often not allowed to eat in normal hospital patients.

Men were more likely to reduce their food intake at dinner because of bad taste of the food. Female patients are more likely to eat half portions of the served meal in hospital. This is in line with the lower energy need and intake by women stated by the caregivers. However, with increasing age, requirements for most nutrients do not decrease (Elmadfa and Meyer (2008)) and therefore, females are more prone to not achieve their nutrient requirement with hospital food. In this survey, the number of snacks consumed did not

differ between men and women. However, it is possible that females are more interested in several smaller portions than few big portions and could increase their nutrient intake by snacking. Also nutrient fortification could increase the nutrient intake in women or in both sexes. Further research is needed how patients react to the choice of more snacks available.

The huge sample size allows to detect differences between groups, even if they are small. However, statistical significance has to be interpreted with care and medical relevance has to be taken into account. For example, a comparison in proportions with a sample size of 15 000 in each group, has 93% power to detect a difference of 49% vs. 51% (Chi–Sqare Test).

4.7 Limitations

The nutritionDay study is a large-scale observational study. Besides the high number of participants, the study could be affected by selection bias. Units were mainly recruited, on a voluntary basis, through the national and international societies for clinical nutrition. This probably resulted in the recruitment of units with a special interest, either clinical educational or scientific, in nutritional care. Furthermore, there are organizational barriers to participation in such a project, since it is easier to undertake studies of this kind on wards where the patients stay for longer periods of time, are not taken off the ward so often for tests, and where the staff are more familiar with them and probably have more time to take on the additional workload. Another shortcoming is that no representative random sample could be identified neither a region nor an individual country. The number of participants differed between European regions. Some of the smaller countries had a particular patient cluster with the number of participants not being proportional to the population size. In addition, the overall estimate shown for completeness is not necessarily representative for all of Europe, particularly in terms of demography and local healthcare provision.

However, the participating units represented a wide range of specialities, which makes the inclusion of non-specialized/general units more likely. Additionally, as previously mentioned, the proportion of wards screening their patients for malnutrition on admission was lower than the expected suggesting that there is minimal interest in nutritional care in many of the surveyed units. Recruitment of patients within units was good (table 4.7), indicating that scientifically trained staff was not necessary for effective participation in the study. Much effort was put to decrease the barriers to participate. Questionnaires were available in more than 30 languages (www.nutritionday.org), the questionnaires were simple and did not need specialists in nutrition or science to be used. The combination of caregivers' view of the patients' food intake and patients' view of their actual food intake is also a unique attribute of this study.

Another limitation occurred because of the direct data acquisition from the patients, which did not allow to precisely quantifying total food intake over the whole day. Furthermore, it was not possible to assess the quality of the food in such a large–scale observational

study.

The recruitment process was similar for men and women and if any selection bias happened, both sexes are equally affected and a comparison between the sexes is valid.

5 Nutrition in hospital and outcome

Poor nutritional status in hospital has been identified as an indicator for an increased likelihood of complications (Sullivan et al. (1999), Allison (2000), Correia and Campos (2003), Norman et al. (2008)). A poor nutrient intake was associated with a higher rate of infections, poor wound healing, more frequent cardiac complications and hence prolonged hospital stay (Allison (2000), Kyle et al. (2004), de Luis and Guzman (2006), Kruizenga et al. (2006), Pirlich et al. (2006), Singh et al. (2006), Correia and Campos (2003), Waitzberg et al. (2001)). Simple interventions to increase food intake such as protected meal times, more menu choices, and additional snacks, motivation of patients or sip feedings have been proposed to prevent or reverse a further loss in body weight (Delmi et al. (1990), Olin et al. (1996)).

Insufficient nutritional intake in hospital was addressed in 2003 by a resolution from the European Council (Council of Europe Committee of Ministers (2003)) and in 2006 by guidelines by UK's National Institute for Health and Clinical Excellence (National Institute for Health and Clinical Excellence (2006)): however, it is unknown whether these initiatives have had any impact on nutrition care in European hospitals.

Studies assessing the association between malnutrition in hospital and mortality rate in hospital are limited. The overall mortality rate in general hospital wards is low and therefore, huge sample sizes are needed to identify factors influencing hospital mortality. The effect of the fraction of the meal eaten on mortality has not been determined on a large scale. The nutritionDay Study was designed to assess the effect of food intake on all cause 30-day mortality in a large number of hospitalized patients in addition to nutritional and clinical risk factors.

5.1 Statistical methods

5.1.1 Kaplan–Meier

In figure 5.1, the "1 – the Kaplan–Meier estimator" for the three types of outcome is given on the left side. Therefore, each outcome is treated separately as outcome of interest and failures from the competing causes are treated as censored observations. The three curves for the outcome of interest "discharged home", "transferred" and "death in hospital" are displayed in one figure (figure 5.1 on the left side). Obviously, the probabilities for the three types of outcome add to more than 100%, which is clearly impossible, since patients can only experience one of the three types of outcomes. This results, because the assumption of independence of the censoring distribution is violated. The competing events are counted as censoring and the competing event time distribution is treated as independent of the distribution of time to the event of interest. The censored events are considered as representative of all censoring events. This implies that at each time point, the hazards of the event of interest is the same for subjects that have not yet failed as for subjects that have experienced a competing event by that time. Of course, this is impossible, as a patients with a competing event can not experience the event of interest (Putter et al. (2007)). For example, a patient that died in hospital can not get discharged home. Or a patient that was discharged home cannot die in hospital within the same hospital stay. In the Kaplan–Meier method, patients with competing events are censored and are therefore treated as they could fail. Therefore, the Kaplan–Meier function overestimated the probability of failure as shown in figure 5.1. In comparison to censoring because of end of follow-up, patients could still experience an event of interest at a later time point. As in the nutritionDay study, where the outcome of patients was assessed 30 days after the survey, 9% of the patients were still in hospital at the day of outcome evaluation. For these patients, the type of outcome is not known and it is possible for these patients to experience one of the competing events. The time till the outcome on the x–axis (t) is the time the patient is already in hospital on the day of the survey plus the time from the day of the survey until the outcome.

The Kaplan–Meier estimator is given as

$$\hat{S}(t) = \prod_{j:t_j \leq t} (1 - \frac{d_j}{n_j})$$

where d_j is the number of events and n_j is the number at risk. One outcome of interest is taken as event and the others are treated as censored.
$1 - \hat{S}(t)$ is labeled *"1-KM ND sampling"* in figures in this thesis.

5.1.2 Competing risk

To account for the competing risk situation, the cumulative incidence function was developed (Fine and Gray (1999)). The cumulative incidence function of cause k, is defined by the probability of failing from cause k before time t. The cumulative incidence functions for the types of outcomes in the nutritionDay study are given in figure 5.1 on the right side. In the case of only competing events and no censoring, the cumulative incidence function at time t, the number of events of type k until time t is divided by the total sample size. Hence, individuals remain in the denominator, even though they have experienced a competing event. Analogue to the log rank test to compare two groups in their Kaplan–Meier curve, a Grays test to compare cumulative incidence curves was developed (Gray (1988)). Analogue to Cox proportional hazard models, where the effect of covariates on survival is tested, a competing risk regression, which tests the effect of covariates on cause-specific failure is of interest was published by Fine and Gray (1999).

The Cumulative incidence of cause k at t is given as

$$\hat{CI}_k(t) = \sum_{j:t_j \leq t} \frac{d_{k_j}}{n_j} \hat{S}(t_{j-1})^{all}$$

where $\frac{d_{k_j}}{n_j}$ is the proportion of subjects that fail from cause k and $\hat{S}(t_{j-1})^{all}$ is the Kaplan–Meier estimator where all types of events are counted as event.
$\hat{CI}_k(t)$ is labeled *"CI ND sampling"* in figures in this thesis.

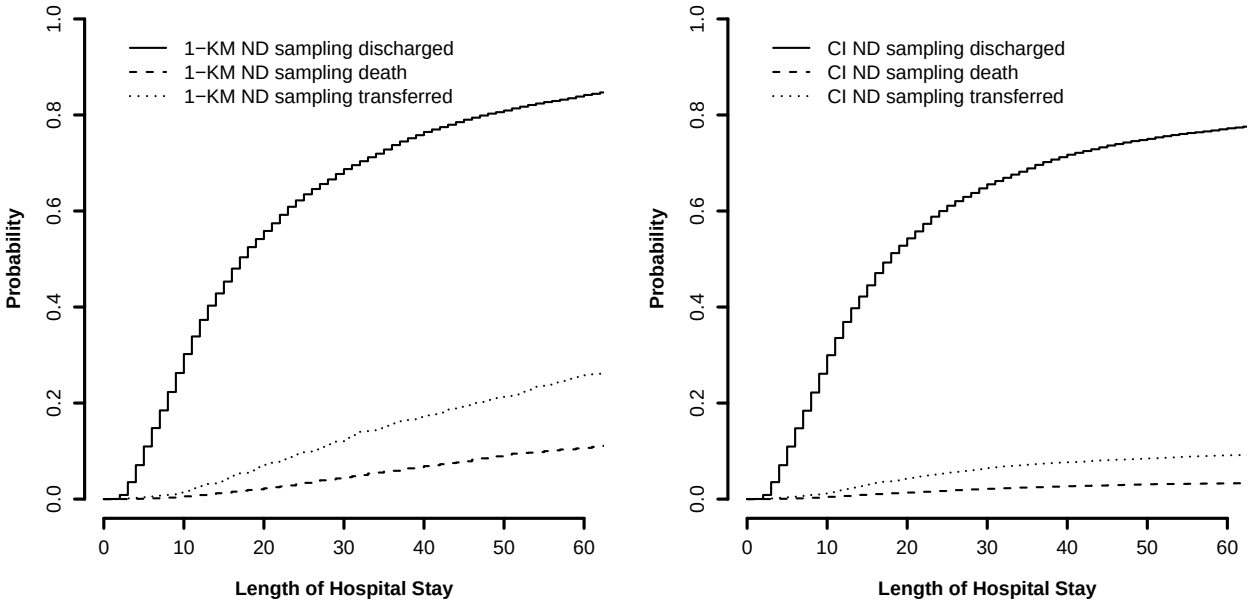

Figure 5.1: Why Kaplan–Meier is wrong

Table 5.1: Outcome evaluation within 30 days in the nutritionDay, n=33249

Type of outcome	% of patients
Patients discharged home	78%
Patients transferred to another hospital/ long–term–care/rehabilitaion	10%
Patients died in hospital	3%
Censored = Patients are still in hospital	9%

5.1.3 Length bias

Una-Alvarez (2004), published a method for adjusting the length bias in cross–sectional study. For each patient, a weight W_i is calculated by giving more weights to patients with shorter LOS:

$$W_i = \frac{1}{n} 1_{\{Z_i \leq \tau\}} + \frac{\delta_i Z_i}{n\tau} 1_{\{Z_i > \tau\}}, \qquad 1 \leq i \leq n.$$

$$\tilde{W}_i = \frac{W_i Z_i^{-1}}{\sum_{j=1}^{n} W_j Z_j^{-1}}, \qquad 1 \leq i \leq n.$$

$$\hat{F}(y) = \sum_{i=1}^{n} \tilde{W}_i 1_{\{Z_i \leq y\}}$$

$\hat{F}(y)$ is the Nonparametric Maximum Likelihood Estimator (NPMLE) according Una-Alvarez (2004) with the property $\sum_{i=1}^{n} \tilde{W}_i = 1$.

The notation is as following:
Y = lifetime of ultimate interest
C = right-censored time = $(C = T + \tau)$
T = truncation time
τ = duration of follow-up period after recruitment
$Z = \min(Y, C)$
$\delta = 1_{\{Y \leq C\}}$

The assumptions for the NPMLE are that Y is independent from T and that T is uniformed distributed. T is the time, the patient was already in hospital on nutritionDay. In other words, T is the time since hospital admission at nutritionDay. C is the time between day of admission and day 30 after nutritionDay. Patients which are still in hospital on the follow-up day 30 days after the nutritionDay, are called right–censored. For right–censored patients, C is the given censored LOS. For patients, with an outcome before day 30 after nutritionDay or at day 30 after nutritionDay, Y is the the time between admission and outcome. In other words, Y is the full observed LOS a patient was in

hospital, from admission to discharge and is only given for non-censored patients. τ is 30 in the nutritionDay study, because the follow-up time after nutritionDay was 30 days. The outcome was assessed at day of outcome or latest 30 days after the nutritionDay. Z is the given LOS per patient. If a patient is not right–censored, Z is Y. If a patient is right–censored, Z is C, then Z is the given right-censored time. In figure 5.2, T is marked in red on the left side, Y is marked in green in the middle and C is shown in blue on the right side of the figure.

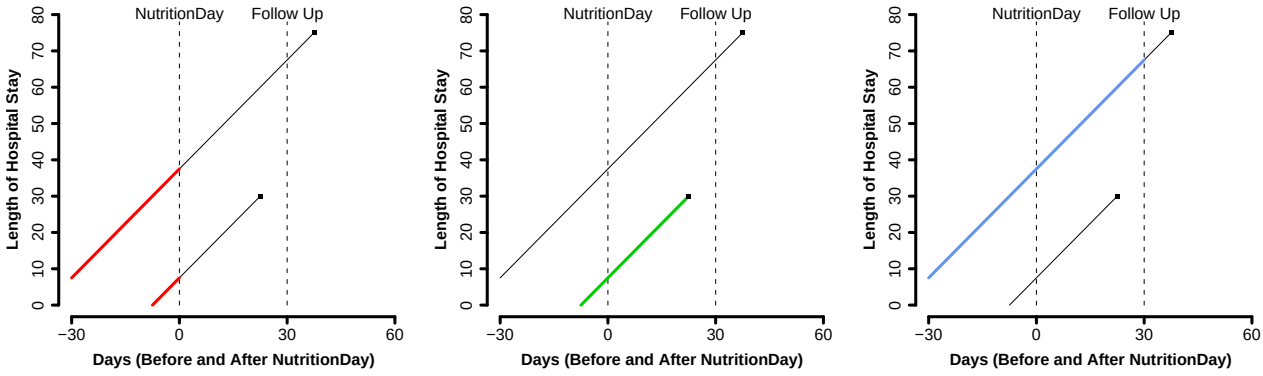

Figure 5.2: Notation

For adapting the NPMLE to competing risk setting, the adjusted Cumulative Incidence was developed as following: The adjusted Cumulative incidence of cause k at t used in this doctoral thesis were defined as

$$\hat{CI}_k(t)^{adj} = \sum_{j:t_j \leq t} \frac{d_{k_j}}{d_j} \tilde{W}_j^{all}$$

where $\frac{d_{k_j}}{d_j}$ is the proportion of failures that fail from cause k. The proportion of the event of interest of all events at a specific time point was used to split the length–bias adjusted weights and cumulate them. Hence, the adjustment procedure is based on the length of stay distribution only and not on the competing risk situation. The different types of outcomes are taken into account by splitting up the length–bias adjusted distribution. $\hat{CI}_k(t)^{adj}$ is labeled *"CI adjusted 1"* in figures in this thesis.

5.1.4 Validation sample from AKH Vienna

Simplifying the mathematical arguments for the method used for compensation of length bias, weights are calculated for each patient and higher weights is given to patients with shorter LOS. Censoring at day 30 is also taking into account. It means that patients with shorter LOS have more weights in the analysis and the length bias, which favors patients with longer LOS to be more likely in the sample, is compensated. Additionally, it was considered that patients could have different outcomes. The results of the outcome evaluation 30 days after the nutritionDay is given in table 5.1. For the patients in the four years of the survey from 2006 to 2009 (N=36335), where the outcome was available, the date of the outcome was available for N=33249 patients.

In figure 5.3, the probability for getting discharged home in the nutritionDay study is given for different methods. In lightblue the probability for getting discharged home is given with the Kaplan–Meier (KM) method (*"1-KM ND sampling"*). In this case, the competing events are censored and 1–KM estimator is presented for the original obtained data in the nutritionDay study. The curve for the cumulative incidence function for getting discharged home is displayed in darkblue (*"CI ND sampling"*). Here, the competing risk setting is taken into account. As the competing events ("death in hospital" and "transferred") are rare, the lightblue and darkblue curves are quite similar. However, there is a huge difference to the curves that adjust the probability for getting discharged home for length bias in the nutritionDay study sampling. In red, the adjusted cumulative incidence curves, as proposed in section 5.1.3 is given (*"CI adjusted 1"*). Additionally, the adjusted cumulative incidence curves as proposed in Una-Alvarez and Rodriguez-Casal (2007) is given in orange (*"CI adjusted 2"*). The method proposed in Una-Alvarez and Rodriguez-Casal (2007) is based on an Expectation Maximization algorithm, which assumes the independence of Y and competing risk events. This assumption might be unrealistic in the data of the nutritionDay study and may lead to problems in estimation.

In figure 5.4, the probability for getting transferred to another institution in the nutritionDay study is given for two different methods. Again, the curve for the cumulative incidence function is displayed in darkblue (*"CI ND sampling"*) and in red, the adjusted cumulative incidence curves (*"CI adjusted 1"*), as proposed in section 5.1.3 is given.

In figure 5.5, the probability for dying in hospital within 30 days of follow–up in the nutritionDay study is given for two different methods. Again, the curve for the cumulative incidence function is displayed in darkblue (*"CI ND sampling"*) and in red, the adjusted cumulative incidence curves (*"CI adjusted 1"*), as proposed in section 5.1.3 is given.

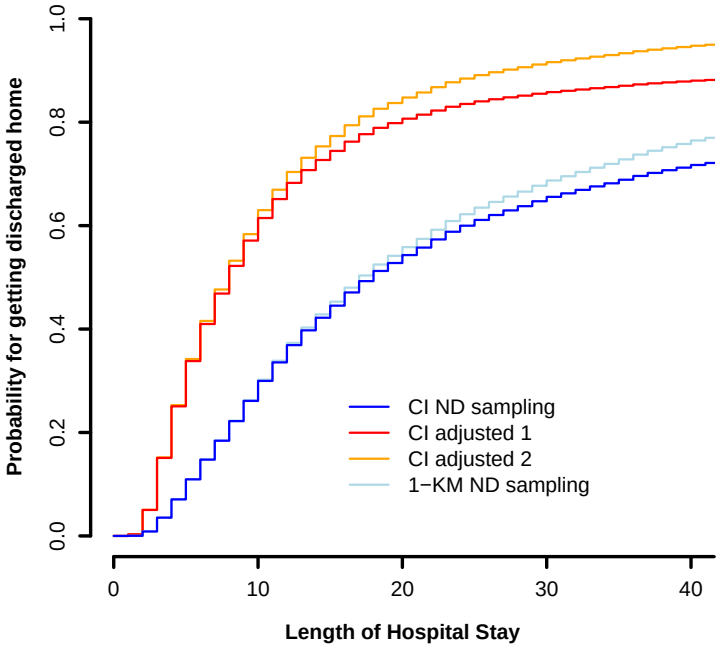

Figure 5.3: Probability for getting discharged home in the nutritionDay study

To investigate if the applied methods are appropriate, the methods were applied in a validation sample, where the adjusted cumulative incidence curves are known. Therefore, data from the registry of the General Hospital Vienna (AKH) were used. In this registry, the admission data and type and date of outcome of each inpatient of the AKH is recorded. The data of the hospital discharge is given as well as the reason for leaving the hospital ("discharged home", "death in hospital", "transferred to another institution", table 5.2). All patients admitted to the AKH in years 2005, 2007, 2008 and 2009 (until august) were available for analysis. For patients with several hospital stays, only the first hospital stay in this registry was considered. In total, n=170 598 individuals were admitted to the AKH in this time period. The cumulative incidence for getting discharged home, for getting transferred and for death in hospital can be calculated from this sample. For all

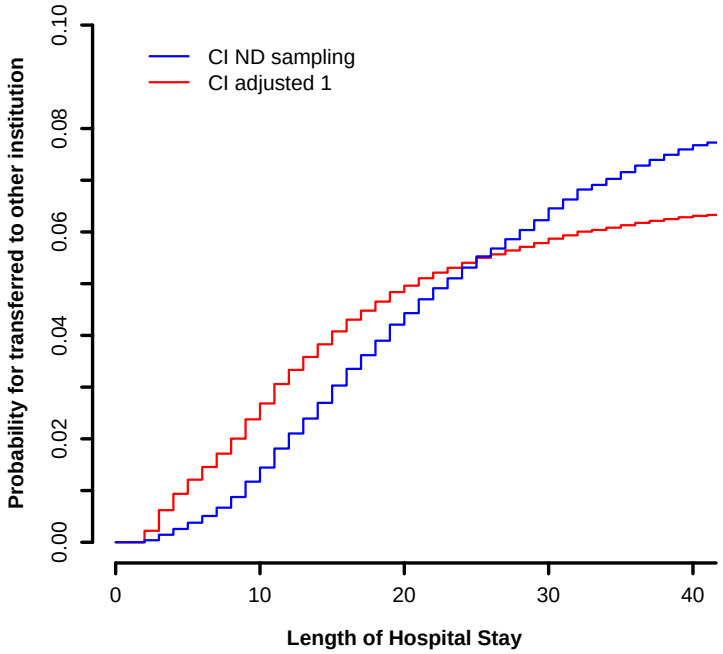

Figure 5.4: Probability for getting transferred in the nutritionDay study

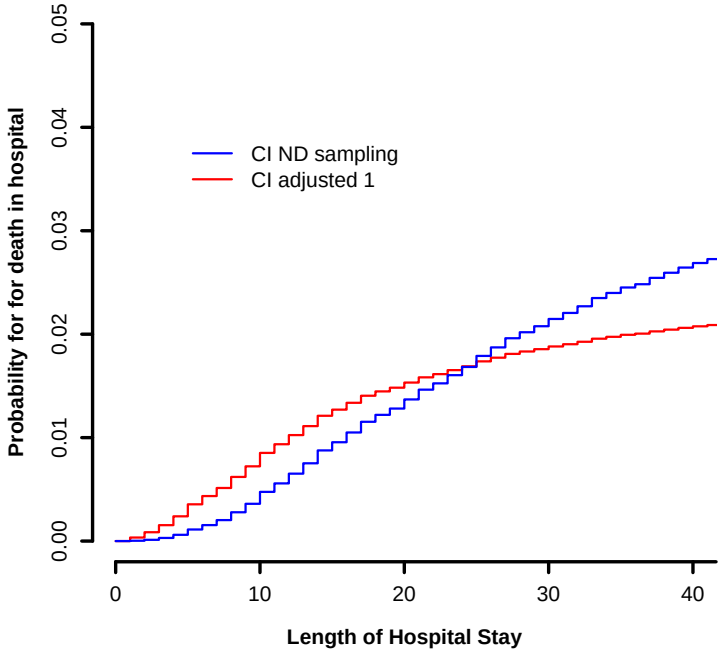

Figure 5.5: Probability for death in hospital in the nutritionDay study

patients an outcome was recorded, so there was no censoring. As all patients consecutively admitted to the hospital are registered, no length bias occurred in this validation sample. The mean LOS was 8.4 ± 12.8 and the median LOS with the lower and upper quartile was 5 (2;9). The mean age of the patients was 47 years old.

Table 5.2: Outcome evaluation in the validation sample of the AKH, n=170598

Type of outcome	% of patients
Patients discharged home	95.9%
Patients transferred to another institution	2.6%
Patients died in hospital	1.5%

From the validation sample of the AKH, cross-sectional samples were drawn. All patients lying in the AKH on a special day were selected and artificial truncation was applied after 30 days of this selection survey day. The date of the nutritionDay (a special Thursday in January in the years 2006, 2007, 2008 and 2009) was chosen as day of survey and all patients lying in the AKH on this survey day were selected for the cross–sectional sample drawn from the validation sample of the AKH. For completeness, several survey days were chosen and the method was applied separately for these days: a Monday in April, a Tuesday in June, a Wednesday in January, and a Thursday in January ("nutritionDay" data). Additionally, a Monday and Friday in February was chosen as survey day for supplemental analysis of the rare event death in hospital.

On the specific Monday in April, n=4629 patients were lying in the AKH. Only one specific day in each year was chosen for each of the years 2005, 2007, 2008 and 2009, similar to the nutritionDay study sampling. On the hypothetical survey on a specific Monday in April, the mean LOS was 23.8 ± 25.2 and the median LOS with the lower and upper quartile was 14 [7; 34]. The mean age of the patients was 49 years old. Of the patients from the hypothetical survey on a specific Monday in April, 82.5% were discharged home, 4.1% were transferred, 2.1% died in hospital and 11.3% were censored.

On the specific Tuesday in June, n=4518 patients were lying in the AKH. On the hypothetical survey on a specific Tuesday in June, the mean LOS was 23.5 ± 25.8 and the

median LOS with the lower and upper quartile was 13 [6; 33]. The mean age of the patients was 49 years old. Of the patients from the hypothetical survey on a specific Tuesday in June, 86.0% were discharged home, 3.9% were transferred, 1.9% died in hospital and 8.2% were censored.

On the specific Wednesday in January, n=4888 patients were lying in the AKH. On the hypothetical survey on a specific Wednesday in January, the mean LOS was 22.0 ± 23.4 and the median LOS with the lower and upper quartile was 13 [6; 31]. The mean age of the patients was 50 years old. Of the patients from the hypothetical survey on a specific Wednesday in January, 81.8% were discharged home, 3.9% were transferred, 2.3% died in hospital and 12.0% were censored.

On the specific Thursday in January, n=5260 patients were lying in the AKH. On the hypothetical survey on a specific Thursday in January, the mean LOS was 19.7 ± 20.8 and the median LOS with the lower and upper quartile was 12 [6; 28]. The mean age of the patients was 50 years old. Of the patients from the hypothetical survey on a specific Thursday in January, 83.8% were discharged home, 3.2% were transferred, 2.3% died in hospital and 10.7% were censored.

In figure 5.6, the probability for getting discharged in the validation sample of the AKH is given for different methods. The cumulative incidence function for the obtained data of the hypothetical survey is displayed in darkblue (*"CI cross-sectional sampling"*). In green, the cumulative incidence function for getting discharged home for the whole validation sample of the AKH (*"CI consecutive sampling"*), without cross-sectional sampling and censoring is given. Hence, the green line gives estimates for the probability of getting discharged home from hospital in this cohort without length bias and without censoring after end of follow-up period. In red, the adjusted cumulative incidence curves, as proposed in section 5.1.3 is given (*"CI adjusted 1"*). Additionally, the adjusted cumulative incidence curves as proposed in Una-Alvarez and Rodriguez-Casal (2007) is given in orange (*"CI adjusted 2"*). Obviously, the methods for compensating for the length bias work well and the adjusted cumulative incidence curves are appropriate estimates for consecutive sampling. There was hardly any difference in the two methods for adjustment (*"CI adjusted 1"* in 5.1.3 and *"CI adjusted 2"* in Una-Alvarez and Rodriguez-Casal (2007)) for the outcome discharged home, despite a small better fit for the method *"CI adjusted 1"* in section 5.1.3.

However, for rare events like "death in hospital" and "transferred to another institution", the proposed method *"CI adjusted 1"* in section 5.1.3 provided obviously better fits and was therefore preferred.

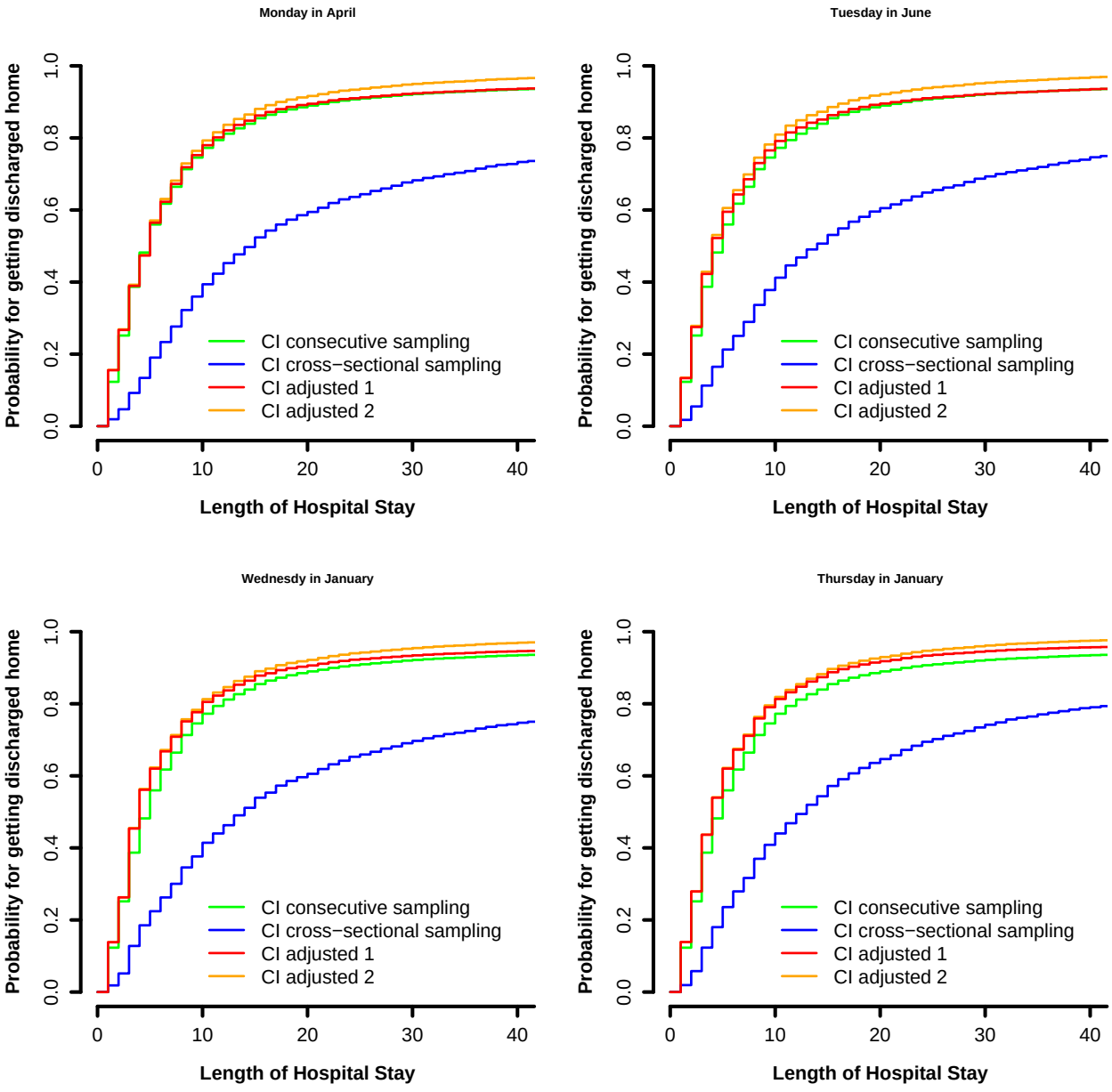

Figure 5.6: Probability for getting discharged home in the validation sample of AKH

In figure 5.7, the probability for getting transferred to another institution in the validation sample of the AKH is given. Again, the curve for the cumulative incidence function for getting transferred in the hypothetical survey is displayed in darkblue (*"CI cross-sectional*

sampling") separately for the chosen days of survey. In green, the cumulative incidence function for getting transferred for the whole validation sample of the AKH, without cross-sectional sampling and censoring is given (*"CI consecutive sampling"*) . In red, the adjusted cumulative incidence curves (*"CI adjusted 1"*), as proposed in section 5.1.3 is given. For the outcome "transferred to another institution", the adjusted cumulative incidence function in red (*"CI adjusted 1"*) gives a proper fit for consecutive sampling (*"CI consecutive sampling"*) compared to the cross–sectional sampling with length bias (*"CI cross-sectional sampling"*). However, the fit is not as good as for the frequent outcome "getting dicharged home".

In figure 5.8, the probability for death in hospital in the validation sample of the AKH is given. The curve for the cumulative incidence function for death in hospital in the hypothetical survey is displayed in darkblue (*"CI cross-sectional sampling"*) separately for the chosen days of survey. In green, the cumulative incidence function for death in hospital for the whole validation sample of the AKH, without cross-sectional sampling and censoring is given (*"CI consecutive sampling"*) . In red, the adjusted cumulative incidence curves (*"CI adjusted 1"*), as proposed in section 5.1.3 is given. For the outcome "death in hospital", the adjusted cumulative incidence function in red (*"CI adjusted 1"*) shows similar course of the function like for consecutive sampling (*"CI consecutive sampling"*). However, the function tends to be to flat and the cumulative incidence function is underestimated. Nevertheless, the adjusted method (*"CI adjusted 1"*) works good to show the course of the function and fits much better than the function in the cross–sectional sampling (*"CI cross-sectional sampling"*), where length bias and censoring is present. For further investigation, additional two sampling days were chosen and the results are presented in figure 5.9. The same observations were made except that the survey on a specific Monday in February resulted in excellent adjusted estimates.

On the survey day "Wednesday in January" on figure 5.8, the fit of the adjustment procedure was good and on the survey day "Tuesday in June", the fit was good in the first four days of hospital stay. However, between day 4 and 7 of hospital stay, no events of interest ("deaths in hospital") occurred and therefore, the adjusted cumulative incidence function was stable in this period. Only after this period, the adjusted cumulative incidence function rised again. The difference between the adjusted cumulative incidence

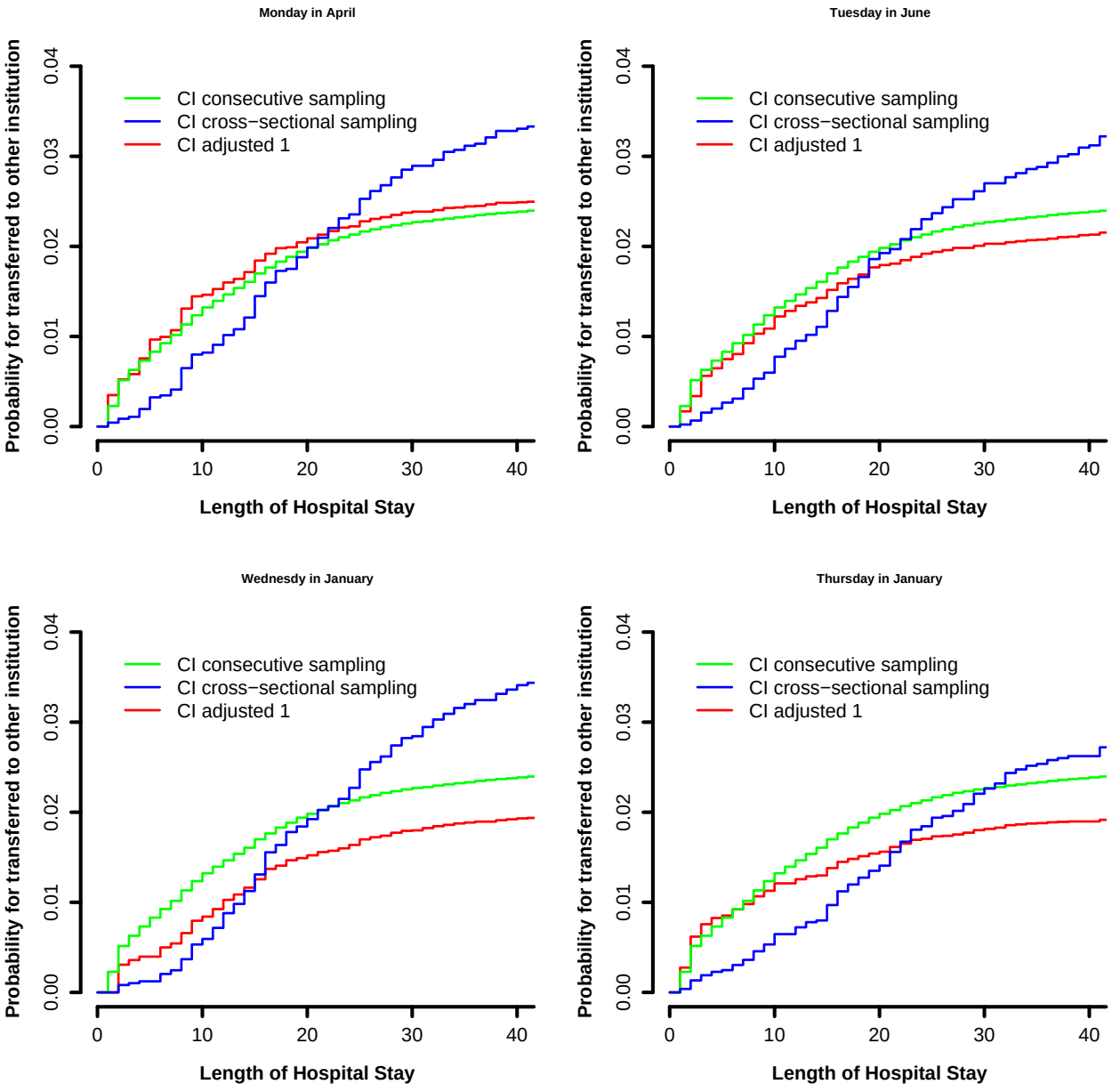

Figure 5.7: Probability for getting transferred to another institution within 30 days of follow–up in the validation sample of AKH

function (*"CI adjusted 1"*) and the cumulative incidence function in the whole validation sample (*"CI consecutive sampling"*) kept stable for the rest of observation time. Also on the survey days "Monday in April" and "Thursday in January", the events have been to rare in the first 4 days of observation and therefore, the adjustment methods was unable to compensate the length bias in this period. It seems that if more deaths would have occurred in the earlier days, the adjustment procedure would fit well. However, as death in hospital is a rare event in general hospitalized patients, it is highly variable how many events occur in the first few days of observation in sample sizes of 5000 like in the cross–sectional samples of the validation data. Also Una-Alvarez and Rodriguez-Casal (2007) found in his simulation results that the NPMLE tends to overestimate the survival.

In conclusion, cross–sectional studies of that type have a length bias. The analysis showed that adjustment for length bias leads to very different estimates than the estimates of the original cross–sectional data. The proposed adjustment method results in appropriate estimates. There are still some problems with rare outcomes, where the compensation is not complete.

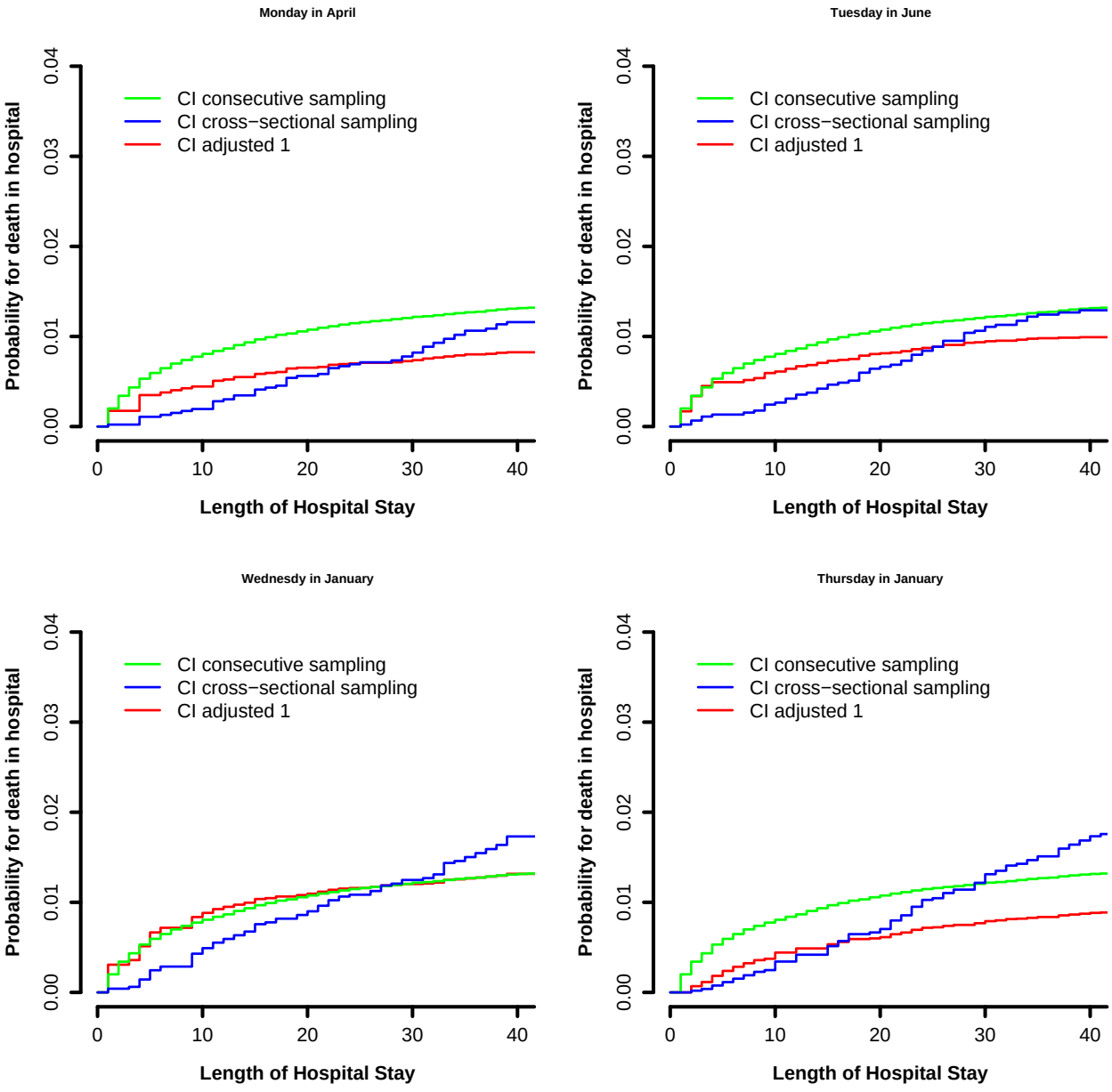

Figure 5.8: Probability for death in hospital within 30 days of follow–up in the validation sample of AKH

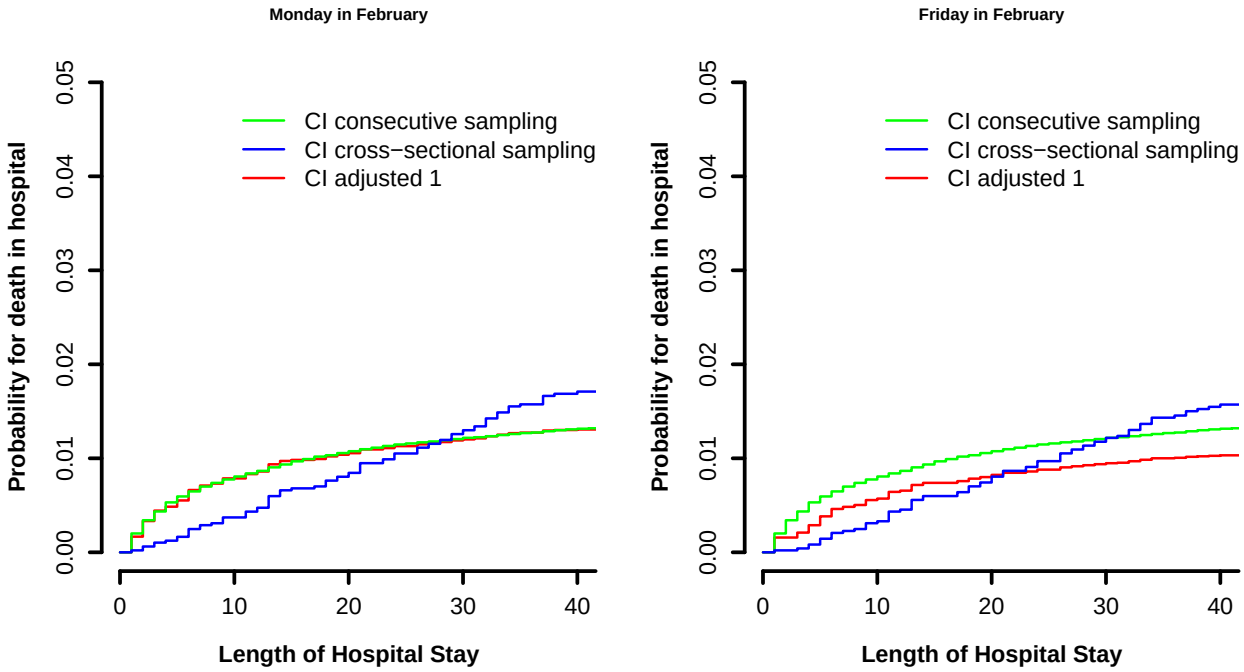

Figure 5.9: Probability for death in hospital within 30 days of follow–up in the validation sample of AKH

5.1.5 Applied statistical methods

The effect of risk indicators on mortality was quantified with crude odds ratios for dying in hospital within 30 days. Participants had several possible outcomes (to get discharged home, to die, to be transferred to other institution or to be still in hospital) and these competing events removed the subject from being at risk to die in the hospital. The probability of dying in hospital was calculated by applying competing risk methodology (Putter et al. (2007)) using the risk set of patients still remaining in hospital on a given day after hospital admission. For univariate association between a risk factor and the risk for dying in hospital within 30 days, unadjusted cumulative probabilities for dying in hospital were calculated based on the original cross-sectional prevalence data (see $\hat{CI}_k(t)$ in section 5.1.2). In a cross-sectional survey, patients with longer length of stay are more likely to be included in the surveyed population. Adjusted cumulative probabilities for dying in hospital were based on estimated incidence data, by accounting for the length bias of cross-sectional sampling and censoring at day 30, resulting in different weighting of each individual case (Una-Alvarez (2004), see $\hat{CI}_k(t)^{adj}$ in section 5.1.3). For between group comparisons permutation tests were performed based on 1500 random permutations using the difference in 30-day mortality as a test statistic. Per risk factor Bonferroni correction was used for multiple comparisons with a reference group.

For multivariate survival analysis the proportional subdistribution hazards' regression model of Fine and Gray was used including time since ward admission as a covariable (Fine and Gray (1999)). We included all variables which reached significance in the univariate analyses and in a joint non-stepwise multivariate analysis. We entered two patient factors related to demographic factors (age, gender), five disease related factors (disease affected organ systems, comorbidities, previous ICU stay, number of days that the patients had already spent in hospital before NutritionDay, number of drugs taken daily), three factors related to the ward (its specialty, the number of beds in the ward, the presence of dedicated individual or team-based nutritional care provision), two factors concerning patient's autonomy (ability to walk, help needed to fill patient questionnaire), and five indicators related to nutritional status (BMI in seven categories, weight loss in the previous 3 months, amount eaten during the last week, fraction of meal eaten on NutritionDay, number of snacks eaten on NutritionDay), as well as the interaction

between eating behaviour (amount eaten during the last week, how much they ate on NutritionDay) and age, and the interaction between eating behaviour and number of days the patient had already spent in hospital previous to NutritionDay. We present results only for the fraction for food intake at lunch. Fraction of the meal eaten at lunch was highly positively correlated with intake at other meals with a Kendall's correlation coefficient of 0.6 and larger. For all the above calculations, sensitivity analyses were performed with a restricted data set including only wards with more than five beds, with at least 50% of patients participating on NutritionDay and at least 90% of outcomes recorded. P-values less than 0.05 were considered statistically significant. 95% confidence intervals (CI) are given for odds ratios (OR) and hazard rates (HR).

5.2 Results

The results of this section 5.2 refer to the published paper:

> Hiesmayr, Schindler, Pernicka, Schuh, Schoeniger-Hekele, Bauer, Laviano, Lovell, Mouhieddine, Schuetz, Schneider, Singer, Pichard, Howard, Jonkers, Grecu, Ljungqvist, NutritionDay Audit Team.: Decreased food intake is a risk factor for mortality in hospitalized patients: the NutritionDay survey 2006. Clinical Nutrition, 2009, Oct;28(5):484-91. (Hiesmayr et al. (2009))

The following results are based on the nutritionDay survey 2006 because it refers to the above mentioned publication.

Outcome and date of the outcome were recorded at hospital discharge or Day 30 after NutritionDay in 14,447 patients. A total of 634 patients (3.9%) died.

A low BMI < 18.5 was found in 6%, a normal BMI [18.5 - 25) in 40%, a moderately elevated BMI [25 - 30) in 30%, a severely elevated BMI [30 - 40) in 15%, an extremely elevated BMI ≥ 40 in 2% and in 9% the BMI could not be calculated due to missing data. Compared with participants with a normal BMI, the odds ratio for dying was increased to 2.0 (95% CI 1.6; 2.6) for participants with a very low BMI and reduced to 0.5 (95% CI 0.4; 0.6) in moderately or severely obese patient with a BMI between 25 and 40. Weight loss in the previous 3 months was reported in 42% of participants and was larger than 6 kg in nearly half of these patients. Eating less than usual during the previous week was self-reported by 51% of patients. Both weight loss in the previous 3 months and eating less than usual during the previous week were associated with an increased risk of death (figure 5.10).

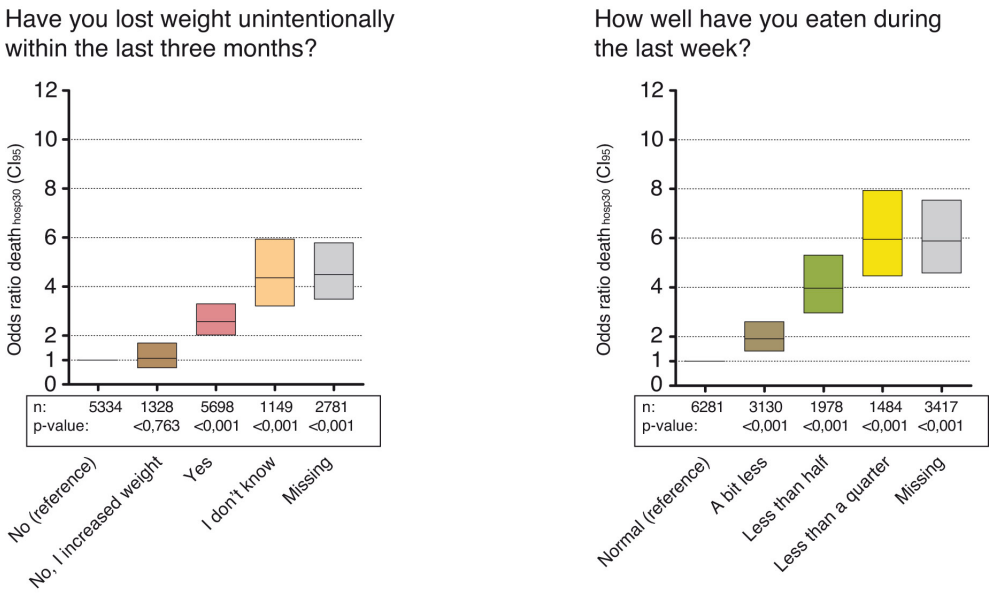

Figure 5.10: Relation between weight loss within the last 3-6 month or decreased nutrient intake last week and odds ratio for death in the hospital up to 30 days of follow-up, n=16290

The odds ratio for dying within 30 days while in hospital increased progressively as the amount consumed during NutritionDay decreased (figure 5.11). After adjustment for length bias the cumulative incidence of death increased from less than 1% for those eating their full meals to nearly 9% for those eating nothing on NutritionDay, despite being allowed to eat (permutation test p-value < 0.001) (figure 5.12). Consuming half of the food provided on NutritionDay was only associated with a trend for increased mortality (permutation test p-value 0.033) but eating a quarter increased significantly the risk for dying (permutation test p-value < 0.001). Those patients who were not allowed to eat anything, or who missed the meal because they were attending an examination, did not affect the cumulative incidence curve (permutation test p-value 0.960) for death within 30 days.

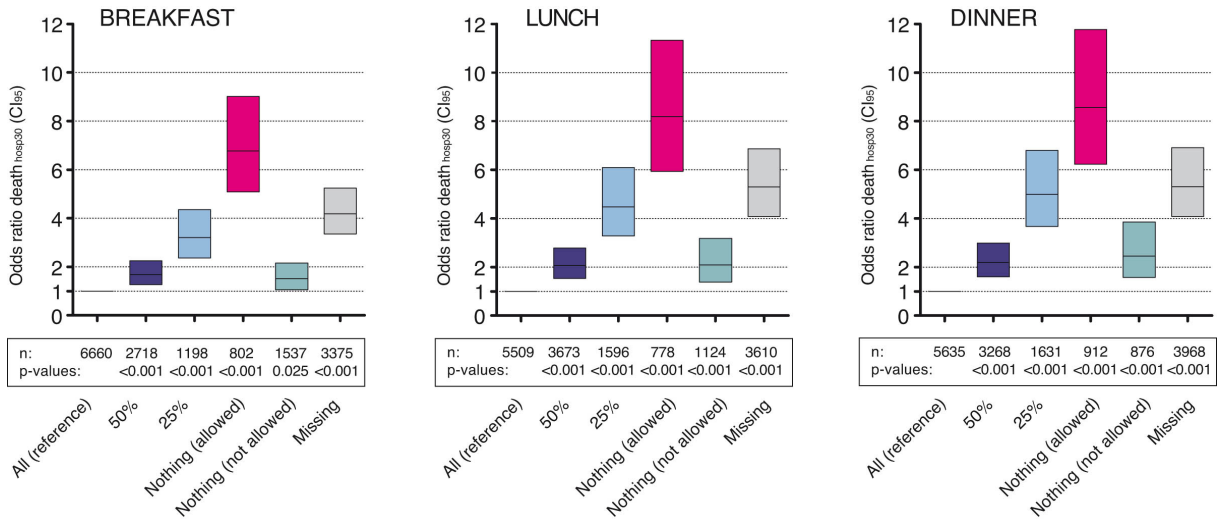

Figure 5.11: Relation between actual nutrient intake at breakfast, lunch and dinner and death in the hospital up to 30 days of follow-up after nutritionDay. Patients that did not eat anything were divided into those allowed to eat and those who were not allowed to eat or had an examination, n=16290

The cumulative incidence of death adjusted for length bias increased from less than 1% for those eating normally during the previous week to more than 6% for those eating less than 25% of their usual amount during the previous week (permutation test p-value <0.001).

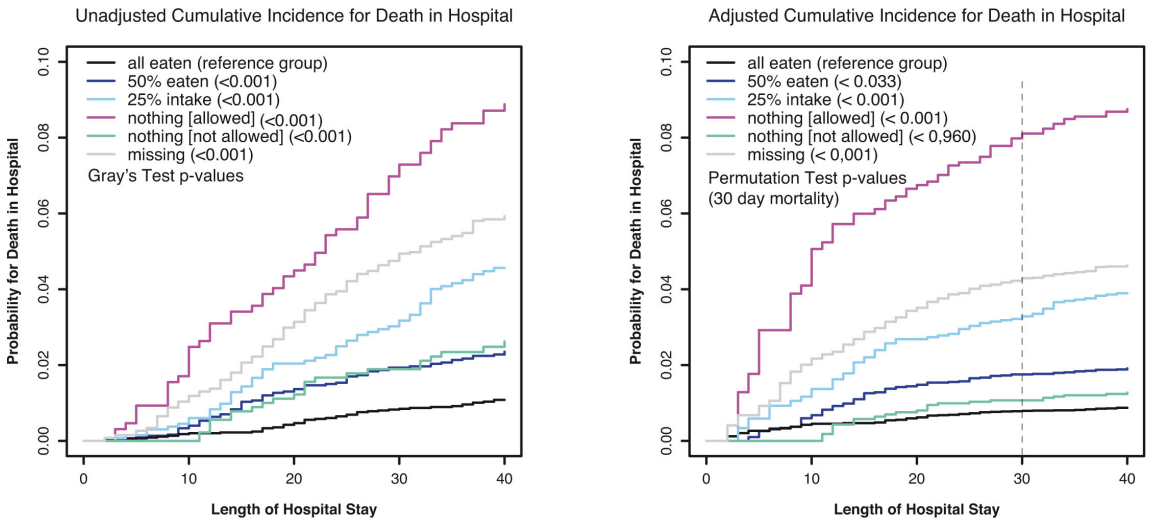

Figure 5.12: Unadjusted and adjusted cumulative incidence of death depending on actual nutrient intake at lunch versus length of stay in hospital. Adjustment is for sampling bias of the cross-sectional data collection and censoring at day 30 after inclusion, n=12 727

To exclude an effect of age we analyzed the time course of the cumulative incidence of death separately for each of four age quartiles. The association of an increased cumulative incidence curve for death with decreased food intake was present in all four age groups. The impact of previous or actual food intake on mortality was dramatically increased with increasing age (figure 5.13, figure 5.14).

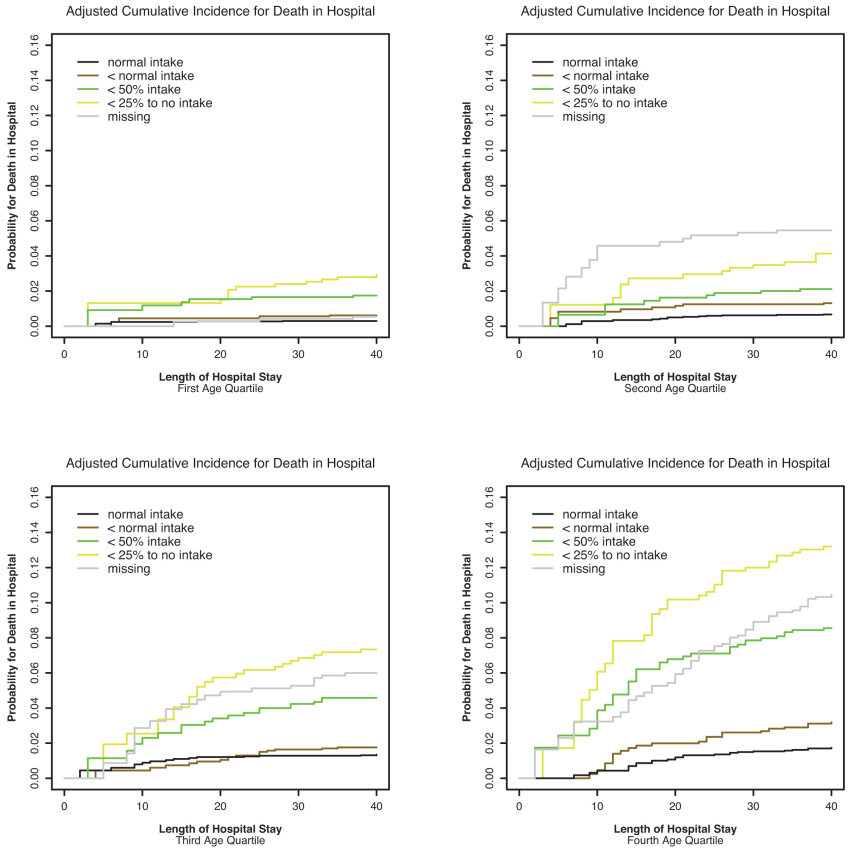

Figure 5.13: Adjusted cumulative incidence for death depending on age and on food intake last week. Patients have been divided into quartiles of age. Quartile 1 included patients from 18 to 52 years old, n= 3263, quartile 2 from 53 to 66 years, n= 3125, quartile 3 from 67 to 77 years, n= 3153, quartile 4 from 78 to 103 years, n= 3186. Adjustment is for sampling bias of the cross-sectional data collection and censoring at day 30 after inclusion.

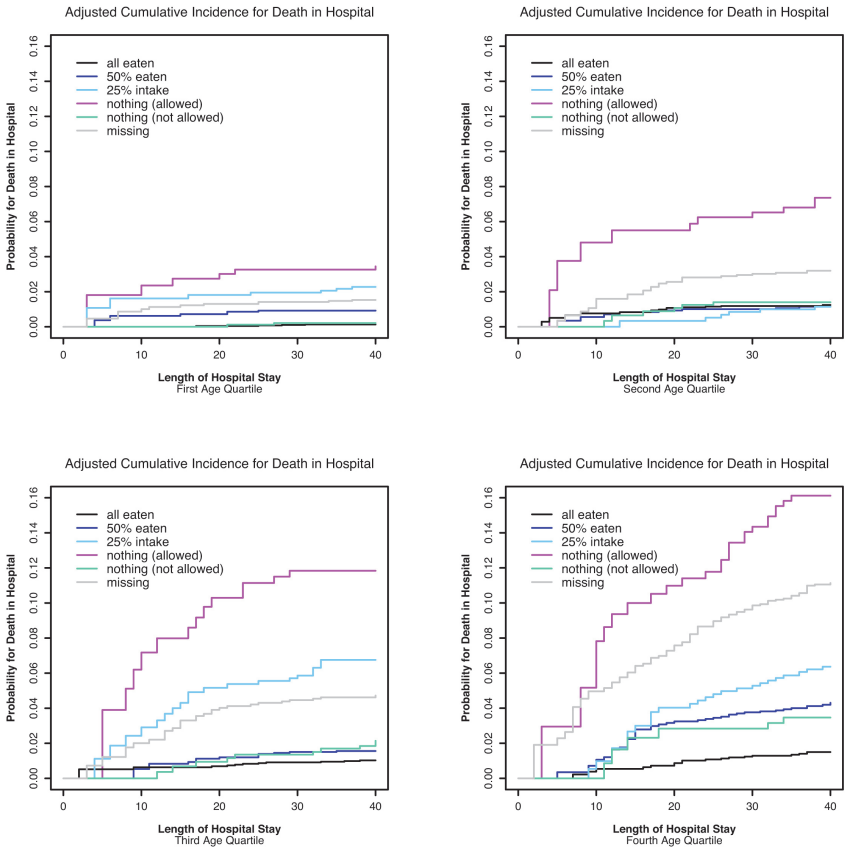

Figure 5.14: Adjusted cumulative incidence for death depending on age and on food intake at lunch. Patients have been divided into quartiles of age. Quartile 1 included patients from 18 to 52 years old, n=3263, quartile 2 from 53 to 66 years, n=3125, quartile 3 from 67 to 77 years, n=3153, quartile 4 from 78 to 103 years, n=3186. Adjustment is for sampling bias of the cross-sectional data collection and censoring at day 30 after inclusion.

BMI, the fraction eaten on NutritionDay, total number of snacks eaten on NutritionDay and the amount eaten during the previous week were all significant predictors for dying in hospital up to 30 days after NutritionDay. In addition to the four out of five nutritional factors, one out of two demographic factors, three out of five disease related factors, one factor related to the medical specialty of the ward, and both factors related to the patient's autonomy, remained in the final model (tables 5.3 and 5.4). In the multivariate analyses, essentially the same results were obtained when food intake at lunch was replaced by food intake at breakfast or dinner. Inclusion of hospitals or countries as independent factor did not have a noticeable effect on the model estimates. Hospitals had a significant effect whereas countries did not contribute significantly to the model. The multivariate analyses restricted to data fulfilling the sensitivity criteria showed similar results.

Table 5.3: Multivariate analysis of the association between risk indicators and mortality (n=12727)

Variable	HR (95% CI)	p-value
Demographic		
Age[a]	1.28 (1.21; 1.37)	<0.0001
Gender		n.s
Disease related		
Affected organ (ICD-10 groups)[b]		
Cancer (n=1940)	1.84 (1.46; 2.31)	<0.0001
Lung (n=1818)	1.31 (1.06; 1.61)	0.012
Liver (n=912)	1.77 (1.37; 2.29)	<0.0001
Endocrine system (n=744)	0.57 (0.35; 0.93)	0.025
Skeleton/bone/muscle (n=1850)	0.60 (0.44; 0.82)	0.014
Comorbidity		
No comorbidity marked (n=5313)	1.00	Reference
Cardiac insufficiency (n=1266)	1.37 (1.09; 1.73)	0.007
Diabetes, stroke, COPD, Myocardial infarction, others		n.s
Any ICU stay before NutritionDay		n.s
Days already in hospital on NutritionDay[c]	1.02 (1.01; 1.04)	0.006
How many drugs do you take each day?		n.s
Structural factor		
Specialty[d]		
General internal medicine (n=2631)	1.00	Reference
Neurology (n=584)	0.38 (0.20; 0.72)	0.003
Surgery (n=2096)	0.54 (0.38; 0.76)	0.0004
Unit size (maximum beds)		n.s
Nutrition care services		n.s
Autonomy		
Can you walk without assistance?		
Yes (n=7237)	1.00	Reference
No, only with assistance (n=2161)	2.04 (1.52; 2.74)	<0.0001
No, I stay in bed (n=1302)	3.39 (2.52; 4.57)	<0.0001
Missing (n=2027)	2.65 (1.77; 3.95)	<0.0001
Did anyone help you to complete this questionnaire?		
No (n=5896)	1.00	Reference
Yes (n=5887)	1.45 (1.11; 1.89)	0.007
Missing (n=944)	0.63 (0.47; 0.86)	0.003

[a] HR for 10 years.
[b] Affected organs analysed: brain/nerves, eye/ear, nose/throat, heart/circulation, lung, liver, gastrointestinal tract, kidney/urinary tract, endocrine system, keleton/ bone/muscle, blood/bone marrow, skin, ischaemia, cancer, infection, others. Hazard ratios indicate deviation from mean of all organs affected.
[c] HR per week.
[d] Specialties analysed: general internal medicine, gastroenterology, oncology, cardiology, infectious diseases, geriatrics, neurology, ear–nose–throat, general surgery, cardiothoracic surgery, orthopedic surgery, trauma surgery, neurosurgery, gynecology, long–term care, others, missing. Hazard ratios indicate deviation from the reference group, which is general internal medicine.

Table 5.4: Multivariate analysis of the association between risk indicators and mortality (n=12727), continued of 5.3

Variable	HR (95% CI)	p-value
Patient and nutrition		
BMI		
Underweight <18.5 kg/m^2 (n=815)	1.46 (1.12; 1.91)	0.004
Normal 18.5–25 kg/m^2 (n=5331)	1.00	Reference
Overweight 25–30 kg/m^2 (n=3797)	0.80 (0.64; 1.00)	0.054
Obese 1 30–35 kg/m^2 (n=1502)	0.62 (0.43; 0.89)	0.010
Obese 2 35–40 kg/m^2 (n=441)	0.68 (0.35; 1.29)	0.238
Obese 3 >40 kg/m^2 (n=204)	1.21 (0.59; 2.51)	0.602
Missing (n=637)	1.09 (0.81; 1.47)	0.580
Have you lost weight unintentionally within the last 3 months?		n.s
How well have you eaten during the last week?		
Normal (n=5013)	1.00	Reference
A bit less than normal (n=2611)	1.54 (1.11; 2.13)	0.009
Less than half of normal (n=1646)	2.01 (1.47; 2.75)	<0.0001
Less than a quarter to nothing (n=1250)	1.93 (1.40; 2.66)	0.0001
Missing (n=2207)	2.39 (1.63; 3.50)	<0.0001
Part of dish patient ate at lunch		
All (n=4477)	1.00	Reference
About 50% (n=2999)	1.28 (0.93; 1.75)	0.123
About 25% (n=1323)	1.97 (1.42; 2.71)	<0.0001
Nothing (eating allowed, n=644)	2.71 (1.88; 3.91)	<0.0001
Nothing (eating not allowed/examination, n=898)	1.62 (1.03; 2.53)	0.036
Missing (n=2386)	1.90 (1.28; 2.82)	0.001
Number of snacks eaten during the NutritionDay		
Number of snacks	0.81 (0.70; 0.93)	0.0023
Missing (n=3730)	0.98 (0.75; 1.28)	0.899

5.3 Interpretation and discussion

The NutritionDay Study 2006 was designed to determine the effect of decreased food intake and other common nutritional risk factors on the outcomes of hospitalized patients. We found that, in this single-day audit of food intake, even when taking into account other variables, a progressive increase of 30-day mortality was associated with decreased food intake. Clearly, nutritional intake is reduced and subsequently absent in end stage disease. We are fully aware that, in respect of the association between food intake and risk for death, food intake is likely to be a surrogate for severity of disease. However, the clearness and reproducibility of the relationship between decreased food intake and risk for dying in hospital were surprising. In univariate analysis, after adjustment for the higher probability to be in the Nutrition- Day survey for patients with a longer length of stay (figure 5.14) or adjustment for age (figure 5.12) and in the multivariate model accounting for severity of disease, the increasing risk for dying in hospital with decreasing reported food intake on NutritionDay and during the previous week (figure 5.13) was a consistent finding. We did not attempt to determine what amount of food intake would be appropriate in relation to BMI, to the course of disease or timing after surgery because considerable variation in practice has been found between individual hospitals. Moreover, no universal practice agreement exists about what is the appropriate amount to be eaten on a given day before or after an intervention or surgery. The possible benefit of changing traditional nutrition care after abdominal surgery is illustrated by the "enhanced recovery after surgery" program where length of stay decreased by more than 25% without side effects (Fearon et al. (2005)). We used food intake at one meal as an indicator for total food intake because the effect on outcome was similar for all three meals and the food intake at the three meals was significantly positively correlated. We think that total food intake can only be determined with the help of specialized personnel in dietetics and the hospital kitchen or food provider. Thus, we did not try to calculate total food intake because the weight to be given to individual meals would be quite arbitrary. Noteworthy, there is no universal measure for severity of illness in normal hospital ward patients. We therefore used ability to walk, help needed to complete the patient questionnaire, disease affected organs, previous ICU stay, number of days spent in hospital before the NutritionDay, the numbers of drugs taken daily, and the presence of comorbidities as

proxies for severity in the multivariate analysis.

We found that the effect of decreased food intake on mortality remains significant even after adjustment for an altered nutritional status and a history of undernutrition. Only one study reported a similar effect of actual decreased food intake on mortality (Sullivan et al. (1999)) but they did not stratify this effect according to the level of decreased intake and did not evaluate the impact of an altered nutritional status or history of recent undernutrition. Many other large studies found the prevalence of an altered nutritional status and history of undernutrition (Allison (2000), Kyle et al. (2004), de Luis and Guzman (2006), Kruizenga et al. (2006), Pirlich et al. (2006), Singh et al. (2006), Correia and Campos (2003), Waitzberg et al. (2001)) to be between 7 and 50%. Only a few studies have also investigated the effect on mortality (Correia and Campos (2003), Norman et al. (2008), Fearon et al. (2005)).

We did not determine the prevalence of the malnutrition based on a scoring system or expert opinion because our focus was to quantify the independent effect of single nutrition related factors on outcome. Based on the cross-sectional design of the survey we can only state associations but cannot determine causalities (von Elm et al. (2008)).

As expected, body mass index (BMI) remained in the multivariate model as a risk factor for 30-day mortality. BMI is used in most hospital systems to justify an intervention. However, somewhat differently to previous studies that found only low BMI to be associated with poor outcome (Pirlich et al. (2006), Elia (2003), Kruizenga et al. (2005a), Kyle et al. (2003), McWhirter and Pennington (1994)), our results revealed a U-shaped relationship between BMI and 30-day mortality, sometimes quoted as reverse epidemiology (Adams et al. (2006)). In fact, obese patients with a BMI in the range of 25–40 kg/m^2 had on average a better outcome when compared with patients with a normal BMI. However, the lowest range of BMI was indeed still most strongly associated with an increased risk of death.

Weight loss in the previous 3 months, however, did not remain a key risk factor in the multivariate analysis, despite being related to mortality in the univariate analysis. Even a weight loss of more than 5% and more than 10% was not significantly associated with the risk of dying in the multivariate analyses. There may be previous weight loss is correlated with other risk factors which may mask its influence in the multivariate model, patients

may not be aware of their weight changes, because regular weighing is not common, and weight loss may also be intentional before certain interventions.

In summary, the NutritionDay Study 2006 clearly shows that decreased food intake were associated with increased mortality risk. Patients who do not finish their meals should be considered to be at an increased risk of acquiring a worse clinical outcome, and that they should immediately be considered for nutritional care. Our data do not allow recommendations how to react to decreased food intake but current evidence based guidelines from the National Institute for Clinical Excellence in the UK (NICE) exist and recommend fortified food, additional snacks and/or sip feeds, enteral tube feeding or parenteral nutrition. Specific nutritional interventions were effective in specific clinical situations; this effect was confirmed in a recent metaanalysis. We believe that nutritional intake in hospital, for example as fractions of the meal eaten, at least for one meal, should be considered to be included in patient charts, very much like temperature or blood pressure, because this information is easily obtained, does not require personnel specialized in nutrition, is associated with outcome and may trigger early nutritional intervention, if recorded daily.

5.4 Application to nutritionDay surveys 2006-2008

The nutritionDay data presented in this section consists of three one-day cross-sectional audits (2006, 2007, and 2008) of food intake by hospitalized patients. The analysis was restricted to patients who can eat by themselves similar to section 4.1. From the patients, n=29518, the type and date of outcome was given in n=21481 subjects. The data of the outcome was specified for 21481 of the 23913 participants with information on type of outcome. The competing risk regression, which is based on the type and date of the outcome, was applied (see section 5.1.5). The results of the multivariate analyses, investigating the effect of the quantity eaten at lunch on death in hospital, is given in table 5.5. The multivariate analysis is adjusted for age, gender, number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, previous icu stay, affected organs, comorbidities, specialty, mobility, BMI, quantity eaten in previous week and weight loss. Although, patients with artificial nutrition were excluded from this analysis, similar to the section 4.1 and contrary to the section 5.2, the results were

similar to table 5.4, where patients with artificial nutrition where included in the analysis. Similarly, the probability for death in hospital is increasing with decreasing amount of eating from the provided hospital food in the data of the surveys of the years 2006, 2007 and 2008. The probability for dying decreased with snacking.

Table 5.5: Multivariate analyses, data three years, n=21481

adjusted for age, gender, number of drugs taken, length of stay the patients spent in hospital prior to the Nutrition Day, previous icu stay, affected organs, comorbidities, specialty, mobility, BMI, quanitity eaten in previous week and weight loss

Variable	HR (95% CI)	p-value
Patient and nutrition		
Part of dish patient ate at lunch		
All (n=9275)	1.00	Reference
About 50% (n=5819)	1.43 (1.14; 1.78)	0.0019
About 25% (n=2351)	2.19 (1.72; 2.78)	<0.0001
Nothing (eating allowed, n=1059)	2.44 (1.83; 3.25)	<0.0001
Nothing (eating not allowed/examination, n=1782)	1.35 (0.96; 1.91)	0.0864
Missing (n=1195)	1.47 (1.04; 2.07)	0.0278
Number of snacks eaten during the NutritionDay		
Number of snacks	0.87 (0.80; 0.95)	0.0011
Missing (n=3942)	1.07 (0.88; 1.31)	0.4964

5.5 Supplements use in hospitals and their impact on outcome

The aim of this study was the evaluation of the influence of supplements on hospital mortality. The nutritionDay data presented in this section consists of three one–day cross–sectional audits (2006, 2007, and 2008) of food intake by hospitalized patients in 26 countries. All participating patients older or equal than 18 years, who have given consent were included in the study.

5.5.1 Statistical methods

For all patients, where an outcome (death in hospital within 30 days) was reported (n=23913), a propensity score for receiving supplements was calculated. After classifying the probability of receiving protein supplements (propensity score) in quintiles, the proportion of patients dying in hospital within 30 days is presented for patients in the according quintiles.

5.5.2 Results

A total of 29 518 patients treated in 1804 wards from 438 hospitals in 26 countries participated in the three audits of the nutritionDay study and were able to eat by themselves.

The factors influencing thy provision of protein/energy supplements is presented in section 4.2.2.

The mortality rate for patients receiving protein supplements was higher than for patients not receiving protein supplements in the three highest quintiles of propensity score. Therefore, in patients with a high need of protein supplements, the protective effect of providing protein supplements could not be shown in the observational cross-sectional nutritionDay study (table 5.6).

Table 5.6: Influence of supplements on mortality in hospital within 30 days, n=23913

	Receiving supplements		Not receiving supplements	
Quintile of propensity score for receiving supplements	N	Percentage died	N	Percentage died
1	26	0.00	4756	0.80
2	71	0.00	4712	0.93
3	139	3.60	4644	2.28
4	367	7.36	4416	3.87
5	1111	9.63	3671	7.25

5.5.3 Interpretation and discussion

The association between receiving supplements and death in hospital within 30 days stratified for the propensity score suggest that the fact if a patient received supplements was mixed up with the probability to die in hospital (table 5.6). It seems that the reasons for receiving supplements are not completely assessed. Unknown reasons for receiving supplements or for dying in hospital, which are probably mixed up with the disease state and lead to death in hospital, could have biased the results. In this type of observational study, only the increased risk for dying in hospital for patients receiving supplements can be shown. However, it is not possible to conclude a causal relationship. A randomized controlled study, which compares patients with similar degrees of disease severity, is the only possibility to find an unbiased effect of supplements on the probability to die in hospital.

5.6 Limitations

Results of a cross–sectional study may be affected by selection bias (see section 4.7). Structural data and ward specialty were considered in the multivariate analysis. In a cross–sectional survey patients with a longer length of stay are by nature more likely to be present in the survey population. This length bias was compensated in the analysis by giving more weight to patients with shorter length of stay. We considered the length of stay before NutritionDay as an additional covariable in the multivariate analyses because of the possibility that length of stay before sampling may be associated with higher disease severity. Disease severity was also considered by including several proxies for severity in the multivariate model. Cumulative incidence functions were chosen instead of Kaplan Meier curves in order to take into account the competing risk setting.

Systematically missing values in one or several parameters may bias estimates of hazard ratios. We therefore included a "missing data" category for all indicators evaluated, in order to reduce any possible hidden impact due to missing data. In fact, we found the missing category to be very informative and probably associated with a category of patients that cannot communicate well, due either to the impact of disease, concomitant neurological or psychological conditions. However, we cannot exclude that other factors have contributed to the missing category (e.g. refusal to answer after inclusion, discharge from the ward before lunch, etc).

We accepted a further limitation in the study design to facilitate participation: the direct data acquisition from the patients with simple questionnaires did not allow to precisely quantify total food intake over the whole day. Therefore, we separately analyzed the effect of food intake per meal. Only the fraction of the served meal eaten was recorded. Whether the meal served is in accordance with the patient needs could also not be assessed. Our data do not allow assessing the effect of reduced food intake for a longer period than one day.

6 Scoring system for nutrition in hospital and outcome

6.1 Defining malnutrition

The term "malnutrition" means over– as well as undernutrition together with inflammatory activity on the body. In research about malnutrition in hospital, the focus lies on undernutrition. Undernutrition is defined as a negative nutrient balance. Despite research in this field, no accepted measures for malnutrition or for assessing nutritional status exists.

A Delphi study was performed to define "malnutrition" associated with undernutrition (Meijers et al. (2010)). In a literature review and semi–quantitative interviews with six experts, elements for defining malnutrition and for operationalism of the definition of malnutrition were extracted. These elements were sent to 30 experts in the field of malnutrition and the experts were asked to rank the elements in their importance. The three elements selected for the definition of malnutrition were deficiency of energy, deficiency of protein and decreased fat-free mass. For the operationalism of malnutrition the following eight elements were chosen: involuntary weight loss, body mass index, no nutritional intake, acute disease effect, less nutritional intake than normal, normal intake but increased demands, normal intake but increased losses, and age. Of the 30 experts in the field of malnutrition, 22 experts ranked the elements for the definition of malnutrition. The classification of the elements of the malnutrition definition in the categories "least important", "moderately important" and "most important" did not show a clear picture which elements are more important. Contrary, 11 of the 22 experts, listed 11 individual elements missing in the definition of malnutrition. The missing elements included the importance of other nutritions than protein, function (muscle cognitive, immune), inflammatory activity and body composition (Meijers et al. (2010)).

Additionally, experts were asked to define relevant cutoff points for the elements involuntary weight loss, No nutritional intake time span and BMI. The suggested cutoff points varied greatly. For example, the suggested cutoff points for BMI were <18 (n=1), <18.5 (n=1), 20 (n=1), 21 (n=3), 23 (n=23) for elderly (different defined by experts). The suggested cutoff values for involuntary weight loss included $>10\%$ overall (n=2), $>10\%$ in 6 months (n=3), 5% in 1 month (n=2), 5% in 3 months (n=1), 10% loss over 3/12 months (n=1), 5kg or 10% in 4 weeks (n=1), 3kg in previous month or 6kg in 6 months

(n=3), any weight loss (n=4). Even more disgreement exists about the definition of acute disease effect. From 11 experts, 9 individual definitions were given. Of the eight elements for operationalism of malnutrition, three were evaluated as most important by nearly 60% of the experts or more (involuntary weight loss, body mass index, no nutritional intake). About 20% classified acute disease effect, less nutritional intake than normal as most important. Less than 10% of the experts found normal intake but increased demands, normal intake but increased losses, and age as most important for operationalism of malnutrition. Again, 11 missing elements on operationalism of the definition of malnutrition were given by the experts (Meijers et al. (2010)).

Despite uncertainties concerning the definition of malnutrition, several tools exist to screen for malnutrition.

6.2 Existing malnutrition scores

In the hospital setting, well known screening tools for identifying malnourished patients or patients at nutritional risk include Nutritional Risk Screening (NRS–2002)(Kondrup et al. (2003b)), Malnutrition Universal Screening Tool (MUST)(Elia (2003)), Mini Nutritional Assessment (MNA)(Vellas et al. (2006)), Short Nutritional Assessment Questionnaire (SNAQ)(Kruizenga et al. (2005a)) and Subjective Global Assessment (SGA)(Detsky et al. (1987)). Not often used is the Malnutrition Screening Tool (MST). In figure 6.5 (Ferguson et al. (1999)), the MST is given. Most screening tools were developed to identify subjects at nutritional risk or malnourished people. According to ESPEN, 2002, the purpose of nutritional screening is to predict the probability of a better or worse clinical outcome. A screening tool should assess subjects who show associations between nutritional factors and outcome and who would profit from nutritional treatment. The outcomes that may be improved by nutritional care are prevention of deterioration in mental and physical function, reduced number or severity of complications, accelerated recovery, and reduced consumption of resources such as length of hospital stay. In hospital, more attention should be put to disease–associated undernutrition, where in the community the mental and physical function should be of primary interest. In hospital, nutritional factors as well as disease associated factors should be considered in nutritional screening. Screening

tools should be evaluated by the health benefit of the patient arising from nutritional intervention after screening. Additionally, validity, reliability and practical implementation of the screening tool should be high. In the end, a screening tool should lead to defined nutritional intervention. A screening tool should be simple and rapid and distinguish between patients being at nutritional risk or being not at risk. In contrast, an assessment tool is a detailed examination of metabolic, nutritional and functional variables by expert clinician, dietician or nutrition nurse (ESPEN, 2002).

The SGA (Detsky et al. (1987))has been recommended as the tool to assess nutritional status. The SGA was published in 1987 and had the first attempt to assess nutrition status by a screening tool. It includes weight change, dietary intake change, gastrointestinal symptoms, functional capacity, and disease and its relation to nutrition requirements. Additionally, physical examination of fat and muscle strength at five locations is performed. The results are added and subjectively classified in well–nourished, moderately malnourished and severely malnourished patients without numerical scoring system. Despite the subjective classification, SGA is often considered as gold standard for nutrition screening.

The NRS–2002 (Kondrup et al. (2003b)) tool was constructed to screen undernutrition and the risk of developing undernutrition in hospitalized patients. In figure 6.2 (Kondrup et al. (2003b)), the NRS-2002 is given. This method was based on a literature review about the results of randomized controlled trials (RCT) showing beneficial effect of nutritional support on hospital outcome. In RCT with patients fulfilling the risk criteria of NRS–2002, the patients had higher probability to profit from nutritional support assessed by their clinical outcome than RCT with patients not fulfilling the criteria of NRS–2002. The NRS–2002 was developed with the assumption that the indications for nutrition support are severity of undernutrition and increase in nutrition requirements resulting from disease. The criteria for the NRS–2002 are BMI, weight loss, food intake in previous week, severity of disease and old age. Severity of disease was defined as absent, mild, moderate or severe with giving examples of the degrees. However, no objective classification of severity of disease was applied. It grades severity of disease as a reflection of increased nutrition requirements. The NRS–2002 had been developed to identify those patients

who will benefit from nutrition intervention, and not to categorize patients according to the risk of malnutrition. The possible nutrition interventions include administration of food, oral supplements, enteral and parenteral nutrition. A prospective, controlled trial including 212 hospitalized patients was conducted in 2004. When applying the NRS–2002, nutrition intake increased, but clinical endpoints as length of stay or quality of life have not been different between the group with NRS–2002 screening and without screening (Johansen et al. (2004)). Validity with clinical outcome in hospitalized patients was shown for long length of stay and increased mortality with risk categories according to NRS–2002 (table 6.3).

In figure 6.3 (Elia (2003)), the MUST is given. The MUST (Elia (2003)) for adults is recommended as a tool to detect malnutrition in the community (ESPEN). In this context, it is aimed to relate impaired nutritional status to impaired function. The MUST was developed by the Malnutrition Advisory Group, a standing committee of the British Association for Parenteral and Enteral Nutrition (BAPEN) in 2003. It was found that MUST was as practicable and valid as other malnutrition screening tools (Stratton et al. (2004)). Validity with clinical outcome in hospitalized patients was shown for long length of stay and increased mortality with risk categories according to MUST (table 6.2). The MUST can be applied to a wide range of care settings including hospitals and home care. The criteria for the MUST are BMI, unintentional weight loss and acute disease effect.

The SNAQ (Kruizenga et al. (2005a)) is a 4–item screening tool developed by Dutch dieticians in response to the ESPEN screening guidelines. In figure 6.4 (Kruizenga et al. (2005a)), the SNAQ is given. A "objective standard of malnutrition" was defined as a BMI of < 18.5, unintentional weight loss of more than 5% in the last month or more than 10% in the last 6 months. If one or several conditions were present, the patients were considered as severely malnourished. A questionnaire with questions from previous published scores and quality of life questionnaires were given to the patients and the questions were validated against the objective definition of malnutrition. The questions which predicted best the nutrition status were selected for the score. The items were unintentional weight loss in last month and in last 6 months, decreased appetite over the last month

and special nutritional care such as supplements or artificial nutrition. In a validation study, new mixed patients were asked the SNAQ and the results were validated against the objective definition of malnutrition (n=297). The resulting AUC of the ROC was 0.85 (95% CI 0.79–0.90) for moderate or severely malnourished patients. However, the SNAQ was not validated for clinical outcome. In a controlled, not randomized trial, a group with screening with SNAQ and controls were compared concerning clinical outcome. In the group of patients that have been screened with SNAQ, LOS was not significantly different to the patients that have not been screened with SNAQ.

Guy's and St Thomas' Hospital NHS
NHS Trust

HOSPITAL NUTRITION SCREENING TOOL

Patient ..... **Admission date** .....

COMPLETE THIS FORM FOR ALL PATIENTS WITHIN 72 HOURS OF HOSPITAL ADMISSION

Date of assessment						
Has the patient unintentionally lost weight in the last 6 months or since the last assessment?						
NO		0	0	0	0	0
YES		2	2	2	2	2
Has the patient unintentionally been eating less in the last 6 months or since the last assessment?						
NO		0	0	0	0	0
YES		2	2	2	2	2
NBM/unable to eat for ≥ 5 days		3	3	3	3	3
TOTAL SCORE						
Usual weight (kg): Recalled height (m):	Actual weight (kg)					
Arm: R / L Mid-point (cm):	Mid-arm circumference (cm)					
Is the Body Mass Index (BMI) in the pale green category? Please circle appropriate response.		YES/NO	YES/NO	YES/NO	YES/NO	YES/NO
NURSE'S SIGNATURE						
Date patient referred to dietitian						

ACTION PLAN

Score 0 Re-assess patient weekly throughout hospital stay

Score 2 – 3 Re-assess weekly, encourage eating and drinking and complete food record chart for 3 days. Refer to dietitan if no improvement.

Score 4 - 5
or BMI in pale green category
or MAC < 23.2 cm (females); MAC < 26.4 cm (males)
or patient on tube feed or parenteral nutrition
or patient has Grade 3 – 4 pressure sore

Discuss with multi-disciplinary team & refer to dietitian for assessment within 24 hours

Figure 6.1: BAPEN Score

Table 1 Screening for nutritional risk

Impaired nutritional status		Severity of disease (≈ stress metabolism)	
Absent Score 0	Normal nutritional status	Absent Score 0	Normal nutritional requirements
Mild Score 1	Wt loss >5% in 3 months Or Food intake below 50–75% of normal requirement in preceding week	Mild Score 1	Hip fracture Chronic patients, in particular with acute complications: cirrhosis (11), COPD (12) *Chronic hemodialysis, diabetes, oncology*
Moderate Score 2	Wt loss >5% in 2 months Or BMI 18.5 – 20.5 + impaired general condition Or Food intake 25–50% of normal requirement in preceding week	Moderate Score 2	Major abdominal surgery (13–15). Stroke (16) *Severe pneumonia, hematologic malignancy*
Severe Score 3	Wt loss >5% in 1 month (≈ >15% in 3 months (17)) Or BMI <18.5 + impaired general condition (17) Or Food intake 0–25% of normal requirement in preceding week in preceding week.	Severe Score 3	Head injury (18, 19) Bone marrow transplantation (20) *Intensive care patients (APACHE 10*
Score:			
Total score:			

Calculate the total score:
1. Find score (0–3) for Impaired nutritional status (only one: choose the variable with highest score) and Severity of disease (≈ stress metabolism, i.e. increase in nutritional requirements).
2. Add the two scores (→ total score)
3. If age ≥ 70 years: add 1 to the total score to correct for frailty of elderly
4. If age-corrected total ≥ 3: start nutritional support

Figure 6.2: NRS–2002 Score

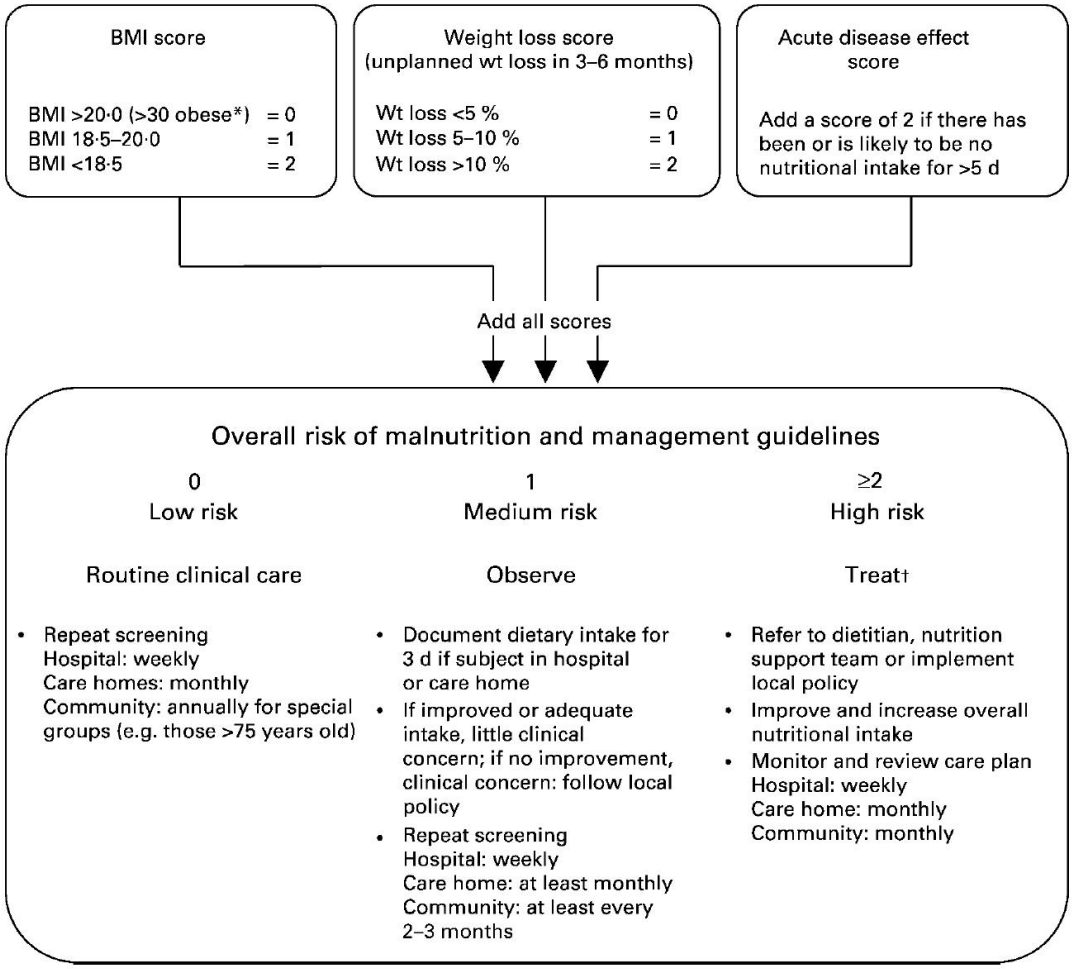

Figure 6.3: MUST Score

Table 3 Final selection of the questions for the SNAQ©.

	Regression coefficient	Regression coefficient x 4/7	Score[a]	OR (95% CI)
Constant	−4.07			
Did you lose weight unintentionally?				
More than 6 kg in the last 6 months	5.59	3.19	3	267.0 (30.0–2376.2)
More than 3 kg in the last month	3.63	2.07	2	37.7 (12.5–113.6)
Did you experience a decreased appetite over the last month?	1.42	0.81	1	4.2 (1.5–11.4)
Did you use supplemental drinks or tube feeding over the last month?	1.47	0.84	1	4.3 (1.4–13.9)

[a]To get round numbers for the SNAQ-scores, the B-coeficients of the logistic regression analyses are multiplied with 4/7 and rounded of to the nearest integer.

Figure 6.4: SNAQ Score

TABLE IV.

MALNUTRITION SCREENING TOOL (MST)

Have you lost weight recently without trying?	
No	0
Unsure	2
If yes, how much weight (kilograms) have you lost?	
1–5	1
6–10	2
11–15	3
>15	4
Unsure	2
Have you been eating poorly because of a decreased appetite?	
No	0
Yes	1
Total	

Score of 2 or more = patient at risk of malnutrition.

Figure 6.5: MST Score

Table 6.1: **Comparison of the items used in published malnutrition scores and in the SNOOS**

	NRS 2002	MUST	BAPEN	SNAQ	SNOOS
	Kondrup et al. (2003b)	Elia (2003)	Weekes et al. (2004)	Kruizenga et al. (2005a)	submitted
When to do the screening			Within 72 hours of admission	At admission	Any time of hospital stay
Age	> 70 years				in 10 years intervalls
BMI	<18.5, 18.5-20.5, >20.5	<18.5, 18.5-20.0, >20.0	<18.5, 18.5-20.0, >20.0		<18.5, 18.5-25, 25-30, 30-35, 35-50,>40
Weight loss	> 5% in 3, 2, 1 months	<5, 5 -10, > 10% in 3-6 months	Yes or no in 6 months	> 6 kg in 6 months or > 3 kg in 1 month	0-4, 5-10, >10 kg in 3 months
Previous time intake	75-100%, 50-75%, 25-50%, 0-25% in previous week		Less in the last 6 month (yes/no)		normal, less than normal, half, quarter to nothing in previous week
Actual intake					Eaten all, half, quarter, nothing of dinner and snacks
Appetite				Decreased appetite over last month	
Oral supplement or enteral tube			Yes/No	Yes/No (over the last month)	Yes/No
Expected oral intake		No oral intake has been or is expected for >5 days			
Mobility					ability to walk and how far
Severity of illness	Mild, moderate severe				
Additional information			Unable to eat for more than 5 days , Mid-arm-circumference, Pressure score		Days since admission, Affected organs (IDC-10 code), type of ward, fluid status

6.3 Validation of existing malnutrition scores with clinical outcome

As malnutrition is not clearly defined (section 6.1), but several tools for screening for malnutrition exist (section 6.2), it is important to look at the association between malnutrition assessed by scores with hard clinical outcomes like morbidity and mortality. A literature review was done to assess the effect of existing malnutrition scores with clinical outcome. The results for the MUST are presented in table 6.2 and for NRS–2002 in table 6.3. No studies about the effect of malnutrition scores on hard clinical outcomes in observational studies for the remaining existing scores were found.

Table 6.2: Validation of MUST with clinical outcome

reference	Study population	Type of study	% at risk	Outcome	Result
Amaral et al. (2008)	Consecutively, N=130, mean age 57, cancer patients	Observational, prospective study	44% medium/ high risk	LOS**	OR=3.24 (1.50 to 7.00) for long LOS (> 7 days)
Henderson et al. (2008)	consecutive patients, who were admitted to the male and female assessment wards, N=126, mean age 82	Observational, prospective study	14% medium risk, 35% high risk	Mortality, LOS	Mortality at 1000 days of follow up (registry) were 62,85,78%, HR=1.91 (0.95 to 3.83) for medium risk; HR=1.98 (1.15 to 3.42) for high risk, no association with LOS
Kyle et al. (2006)	Every 10^{th} consecutive admitted patient, N=995, mean age about 55	Observational, prospective study	10% medium risk, 27% high risk	LOS	OR=1.1 (0.4 to 3.2), p=0.889 for long LOS (>11 days) for medium risk; OR=3.1 (2.1 to 4.7), p<0.001 for high risk
Stratton et al. (2006)	150 consecutive emergency admissions to elderly care wards, mean age 85	Observational, prospective study	17% medium risk, 41% high risk	In hospital mortality, 3 and 6 months mortality, LOS	In hospital-Mortality (9,13,33%), 3 and 6 months mortality were all three significantly different between the three risk groups; LOS was significantly higher for risk groups[a]
Stratton and Elia (2006)	One thousand patients consecutively, mixed patients, mean age 71	Observational, prospective study	14% medium risk, 28% high risk	Hospital mortality,	OR=2.03 (1.22 to 3.39) for medium/high vs. low risk, increased LOS for risk patients
Raslan et al. (2009)	one of five consecutive admitted patient from Feb. to Aug. 2007, N=705, only patients who were able to communicate, mean age 57	Observational, prospective study	40% medium/ high risk	LOS of survivors, mortality in hospital, complications	AUC for death in hospital (n=24 died): 0.636; for long LOS (>= 16) of survivors: 0.611 and for complications: 0.604

[a] The length of stay of patients who died did not differ significantly according to 'MUST' category. But the proportion of patients dying in hospital was higher in the risk groups.

Table 6.3: Validation of NRS–2002 with clinical outcome

reference	Study population	Type of study	% at risk	Outcome	Result
Amaral et al. (2008)	Consecutively, N=130, mean age 57, cancer patients	Observational, prospective study	29% at risk	LOS[a]	OR=2.47 (1.05 to 5.80) for long LOS (> 7 days)
Kyle et al. (2006)	very 10^{th} consecutive admitted patient, N=995, mean age about 55	Observational, prospective study	19% medium , risk 9% high risk	LOS	OR=2.2 (1.4 to 3.5), p<0.001 for long LOS (>11 days) for medium risk; 2.9 (1.7 to 4.9), p<0.001 for high risk
Martins et al. (2005)	N=207, elderly at orthopaedic–trauma departments, mean age 74	Cross–sectional study	31% at risk	LOS[a]	2.25 (1.03 to 4.88) for long LOS (> 8 days)
Ozkalkanli et al. (2009)	Consecutively, N=223, patients with orthopedic surgery	Observational, prospective study	23% at risk	Complications after surgery, LOS, mortality in hospital	LOS: 7±8 in patients not at risk; 11±17 in at risk group, p=0.013; Complications: OR=4.1 (2.0-8.5), p<0.001; Mortality: n=1(0.5%) vs n=8 (15%)
Raslan et al. (2009)	one of five consecutive admitted patient from Feb. to Aug. 2007, N=705, only patients who were able to communicate, mean age 57	Observational, prospective study	28% at risk	LOS of survivors, mortality in , hospital, complications	AUC for death in hospital (n=24 died): 0.795; for long LOS (>= 16) of survivors: 0.651 and for complications: 0.653)
Sorensen et al. (2008)	Consecutively, N= 5051, multicenter, mixed patients, mean age 60 mean age 60	Observational, prospective study study	33% at risk	Hospital mortality (1.12%) LOS	Higher mortality (1% vs. 12%) and LOS (β=0.93 for each increase in score points, p<0.001, N=4670) for at risk patients, censored patients were excluded

[a] Mortality rate not shown

Associations between high risk groups according to the MUST and hospital mortality as well as long LOS were found (table 6.2). Similar effects were found for NRS–2002 (table 6.3).

In a study of consecutive admitted patients in 7 months of general hospital wards, the area under the receiver operating characteristic (aROC) curve for death in hospital was calculated. The aROC was 0.636 according to the MUST and 0.795 for NRS–2002.

6.4 A simple score relating nutrition to hospital outcome

The most problematic project, calculating a score for the prediction of hospital outcome, was added at last. Hence, for this project data from all nutritionDay surveys (2006, 2007, 2008, 2009) have been available. The nutritionDay data of the survey in 2010 have been intentionally excluded for the calculation of the risk score, because the nutritionDay 2010 data were used for external validation.

In the cross-sectional nutritionDay study, disease related and nutrition oriented data were assessed from patients lying in hospital on a typical day in hospitals in Europe, Israel, Japan and Australia. The following results refer to the four nutritionDay surveys from 19. 01. 2006, 25. 01. 2007, 31.01.2008 and on 29.01.2009. In total, more than 40 000 patients participated in these surveys. For about 80%, the outcome was documented as the type and date of outcome within 30 days after nutritionDay.

N=45132 patients who did give consent and received the nD sheets

↓ missing information on outcome, N=8797

N=36335

↓ not allowed to eat by themselves on any meal, N=2206

N=34129

From the participants in the score building study, 3.53% (1204 of 34129) patients died

in the hospital within 30 days. The aim of this study was to develop a simple score relating nutrition to hospital mortality within 30 days of follow up in general hospital wards, excluding intensive care units. The score should be easy to use and not needing any specialists or teaching. Therefore, we developed the Simple Nutrition-oriented Outcome Score (SNOOS). Adults 18 years old and older from several clinical wards in general hospitals (no intensive care units) were included for the developing of the SNOOS. The SNOOS score was constructed for patients who are able to eat by themselves at least on one time per day. Therefore, the score is not suitable for patients who are fed with artificial nutrition exclusively. The patient characteristics concerning the score elements are given in table 6.4.
The SNOOS score consist of the simple arithmetic sum of two boxes or subscores:
Box I: Disease related box with points for specialty of the ward, age, days since hospital admission, diseased organs according to ICD-10 top categories (multiple answers possible) and mobility.
Box II: Nutrition related box with points for unintended weight loss in the previous three months, quantity eaten in the previous week, quantity eaten at dinner (or if not available replace through lunch), eating snacks, additional nutrition support, fluid status.

6.4.1 Methods and statistical analysis

The following variables have been available from the nutritionDay survey:
Metric variables:
Age in years, days since unit admission, number of drugs per day, BMI, weight 5 years ago in kg, current weight in kg, unintended weight loss in the previous 3 months in kg, number of drinks per day
Categorical variables:
Affected organs (brain, nerves; eye, ear; nose, throat; heart, circulation; lung; liver; gastrointestinal tract; kidney/ urinary tract; endocrine system; skeleton/ bone/ muscle; blood/ bone marrow; skin; ischaemia; cancer; infection; pregnancy - each yes or no, multiple affected organs possible), previous ICU stay (yes/no), visits (daily, every other day, once a week, rarely or never), mobility (ability to walk – yes, with assistance, bedridden;

Table 6.4: Patient characteristics In percentages, if not other stated

Parameter			N
gender	for female gender	50.1	34005
age	mean ± std	63.3 ± 17.6	34129
BMI	mean ± std	26.2 ± 7.3	34129
	internal	40.3	34129
	surgery	31.1	34129
specialty of ward	geriatrics	9.4	34129
	neurology	4.0	34129
	other	15.2	34129
days since hospital admission	> 2 weeks	26.0	33601
	lung	13.1	33365
	liver	7.2	33365
diseased organ	sleketon/bone/muscle	17.6	33365
	blood/ bone marrow	4.3	33365
	cancer	17.6	33365
Can you walk without assistance?			
	yes	67.6	32892
	no, only with assistance	21.1	32892
	no, I stay in bed	11.3	32892
If YES, how far do you walk?			
	in the room	14.6	17231
	in the corridor	36.7	17231
	to the hospital admission area/shops	48.7	17231
Patient is receiving additional nutritional support			
	includes enteral nutrition or parenteral nutrition or both or protein/energy supplements	19.6	33382
	dehydrated	8.8	31340
fluid status	normal	79.8	31340
	overloaded	11.4	31340
Have you lost weight unintentionally within the last 3 months?			
If YES, how many kg did your weight decrease?			
	5–10	11.5	33192
	>10	13.2	33192
How well have you eaten during the last week?			
	normal	50.1	32877
	a bit less than normal	24.3	32877
	less than half of normal	14.9	32877
	less than a quarter to nearly nothing	10.7	32877
Please tick a circle for lunch to indicate how much you ate today			
	all	49.9	30625
	50%	27.5	30625
	25%	13.1	30625
	nothing	9.5	30625
Have you eaten snacks today?	yes	65.6	27270

how far - in the room, in the corridor, to the hospital admission area/shops), waiting for operation (yes/no), being after operation (yes/no), type of clinical ward (surgery, internal, neurology, geriatrics, other), weight loss in the previous 3 months (yes/no), quantity eaten last week, reasons for eating less in the previous week, quantity eaten at each meal (morning, lunch, dinner) at nutritionDay, reasons for eating less at each meal at nutritionDay, having the usual appetite on nutritionDay (yes/no), reasons for eating not typical at nutritionDay, eating snacks on nutritionDay (yes/no), type of snacks brought in, fluid status, types of drinks consumed, additional nutrition support (supplements or artificial nutrition).
Multiple imputation of missing data was done by use of the option "closest" in the aregImpute algorithm in R (Frank and Harrell (2008)). The algorithm generates values for missing data based on the remaining available data, where the outcome variable was excluded. First, the univariate association between metric variables and death in hospital within 30 days was studied with smoothed lowess curves (Cleveland (1981)). To achieve a simple coding system in the final score, in all the following calculations, metric variables have been categorized (e.g. age in categories of 10 years, duration since hospital admission in categories of weeks, BMI according to WHO).

Variable selection

Bootstrap samples with replacement from the total sample (n=34129) were drawn 1000 times. For computational convenience, a standard logistic regression with backward selection procedure for "death in hospital within 30 days" was performed for each bootstrap sample. A local significance level of 0.01 was applied as a selection criterion to keep overfitting low ("p-value thresholding"). Variables which were included more than 75% of the samples were selected ("majority voting").
The categorical variables "food intake" were highly correlated between breakfast, lunch and dinner. To keep the score simple, the intention was that food intake should be assessed only at one occasion a day. Therefore, the bootstrapping for quantity eaten at morning, lunch and dinner (each: all, half, quarter, nothing) with the according reasons for eating less was done separately. We also evaluated if interactions among the predictors (especially current food intake and disease related factors) would influence results.

Interactions, however, did not make any valuable contribution for the prediction.

Construction and internal cross-validation of the score

To account for the clustering of patients in wards, a generalized estimation equation with clinical wards as repeated factors and exchangeable covariance matrix was performed with the dependent variable death in hospital within 30 day of follow up and the variables selected as independent variables in the previous step. The parameter estimates were multiplied by 10 and rounded towards the origin for each bootstrap sample (n=1000) ("shrinking"). Shrinkage to the origin of the estimated coefficients generally is used to improve prediction (Hastie et al. (2001)).

Predicting death in hospital within 30 days

The quality of prediction of the score in the bootstrap development sets and validation samples (the patients not containing in the respective bootstrap sample) and the total sample was assessed by Max-rescaled R–Square, aROC and the Brier score ("bagging"). Observed-to-expected (O/E) mortality ratios were calculated by dividing the number of observed deaths per group by the number of expected deaths per group (as predicted by the score) together with their 95% confidence intervals (CI) according to the method described by Hosmer and Lemeshow (Hosmer and Lemeshow (1995)). The Hosmer–Lemeshow goodness-of-fit H-statistic and C-statistic were used to evaluate the calibration of the SNOOS score (Hosmer and Lemeshow (1982)).
The statistical analyses were done with the software programs SAS 9.1 (SAS statistical software, SAS Institute, Cary, NC) and R 2.8.1.

6.4.2 Results

To avoid patient selection, we decided to base the score on the imputed data set because hospital mortality in patients with missing values was noticeably higher than in the complete cases (4.7% vs. 3.3%). However, later we will report sensitivity analyses using complete cases only.

In total, 5.0% data were missing of all variables in the score building process and were therefore imputed. Finally, in the variables selected for the score, there were only 3.9% imputed missing values.

Variable selection

The highest explained variation and aROC was achieved by looking at the quantity eaten at dinner. Hence, the quantity eaten at dinner was chosen for the construction of the score. Surprisingly, exactly the same variables were selected when looking at the quantity eaten at lunch, instead of dinner. It is worth to be noted, that when looking at the joint measures of the minimum eaten from all meals or the maximum eaten from all meals prediction did not improve. The correlation between quantity eaten at lunch and at dinner was r=0.59 as assessed by Kendall correlation coefficient.
Based on the methodology, 34 item classes (representing 12 variables) were selected for the SNOOS score.
Disease related:
Specialty of the ward, age, BMI, days since hospital admission, diseased organs according to ICD–10 top categories (multiple answers possible), mobility
Nutrition related:
Unintended weight loss in the previous three months, quantity eaten in the previous week, quantity eaten at dinner (or if not available replace through lunch), eating snacks, additional nutrition support, fluid status
By looking at the selected variables, BMI is the only variable that had to be calculated. As the attempt was to make the score as simple as possible, BMI was omitted from the score. To check how prediction can be improved by including BMI, a second score was constructed including BMI variables.
For the simple score without BMI, 29 item classes (representing 11 variables) were selected for the SNOOS score (see the second column of table 6.5).
The correlation between the score items was low, a Kendall correlation coefficient of greater than r=0.25 was found only between the variables "Can you walk without assistance" and age groups (r=0.28) and between the quantity eaten at dinner and quantity eaten in previous week (r=0.32).

Construction and cross-validation of the score

Rounding the mean of the shrinked estimates leads to the same score as averaging the original bootstrap estimates and rounding the mean to the origin afterwards. For each bootstrap sample, those patients not included, have been used as a validation sample, respectively. The bootstrap estimates were very similar to that of the total sample, with few exceptions where the points were one point higher in the total sample. This reflects the reduction of overfitting by bootstrapping. Repeating the construction process with 1000 new bootstrap samples, there was hardly any change in the score and its performance. The items together with the additive points in the score are presented in table 6.5. The variability of the coefficients in the bootstrap samples is given in table 6.9.

Performance of the score

The score has a theoretical minimum of 0 and a theoretical maximum of 85. The distribution of the SNOOS score is given in figure 6.6. The minimum observed value was 0 and the maximum observed value was 72 with a mean of 25.7 $\pm$ 11.1 and a median of 25 (17–33) (figure 6.6).

The relationship between the SNOOS score and hospital mortality within 30 days is given by the equation:

$$\text{Logit} = -7.0126 + 0.1134 \times \text{SNOOS}$$

and the probability of mortality by the equation:

$$\text{Probability of death} = \exp^{\text{logit}}/(1 + \exp^{\text{logit}})$$

The predicted probability of hospital death varied from 0.09% to 76.04% with a mean of 3.53% $\pm$ 5.95%. The Hosmer-Lemeshow test for predicted mortality classes of 0–0.1, 0.1–0.2, 0.2–0.3, 0.3–0.4, 0.4–0.5, 0.5–0.6, >0.6 (H-statistic, chi-square=2.656, df=5, p=0.7528) and according to deciles of expected risk (C-statistic, chi-square=0.404, df=8,

p=0.9999) demonstrated proper fit in the population of complete cases not affected by the imputation procedure (figure 6.7). The fit in the high risk patients (> 0.5 predicted mortality) was not as perfect for the imputed cases.

Another criterion to judge the appropriateness of the model was the fit in certain subsamples, such as age-groups, BMI groups, specialty of the wards and European regions (figure 6.8). We have a rather poor fit for the youngest group of patients, in which a small number of death (10 of 1813) has been observed.

The discriminatory capability of the model, as measured by aROC curve, was 0.838 in the total sample. The performance of the score in the development data, validation data and in the total sample is given in table 6.6. The performance in the validation samples on average is remarkably good. In the sensitivity analyses, where only patients with complete data were included, the aROC was slightly increased (0.839). When replacing the answers to the questions "Please tick a circle for dinner to indicate how much you ate today" by the answers given at lunch instead of dinner for each patient, the performance of the score was slightly decreased (0.837, table 6.8). The explanatory power was slightly higher for box I than for box II (table 6.7). The parts filled out by the patient and the part filled out by physicians or nurses contributed equally to the score (table 6.7).

When not accounting for overfitting and only performing a logistic regression with all variables available, the aROC was 0.851. It is surprising that our method of construction produced a score with only a marginally poorer performance.

In a further sensitivity analysis, the score was constructed for complete cases only. The points for the individual items of this score were remarkably similar, deviating from those in table 6.5 if at all by one point.

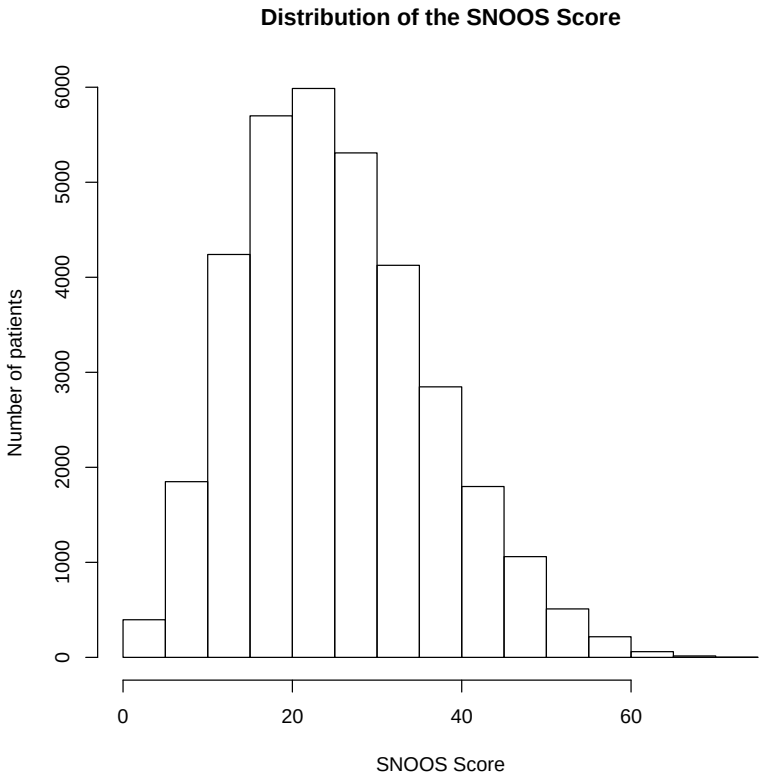

Figure 6.6: Distribution of the SNOOS Score, N=34129

Table 6.5: Score sheet for score without BMI, Minimum=0, Maximum=85

	question / variable	answer category	points
			14[1]
	Specialty of Ward	surgery or neurology	-4
		other	0
		<30	0
		[30-40)	0
		[40-50)	1
	Age[2]	[50-60)	2
		[60-70)	3
BOX I		[70-80)	5
To be filled		[80-90)	8
out by		≥90	12
physician/nurses	Days since hospital admission	>14 days	2
		lung	3
		liver	5
	Diseased organ	Isolated skeleton/bone/muscle	-5
	(multiple answers possible)	Blood/ bone marrow	3
		Cancer	8
	Patient is receiving enteral nutrition or		
BOX II	parenteral nutrition or both	yes	3
To be filled	or protein/energy supplements		
out by		dehydrated	6
physician/nurses	fluid status	normal	0
		overloaded	8
		Yes	0
BOX I	Can you walk without assistance?	No, only with assistance	5
To be filled		No, I stay in bed	10
out by		in the room	5
the patient	If YES, how far do you walk?	in the corridor	3
		to the hospital admission area/shops	0
	Have you lost weight unintentionally	0–4	0
	within the last three months?	5–10	1
BOX II	If yes, how many kg did your weight decrease?	>10	2
To be filled		normal	0
out by	How well have you eaten	less than normal	2
the patient	during the last week?	less than half of normal	4
		less than a quarter to nearly nothing	5
		all	0
	Please tick a circle for dinner	half	4
	to indicate how much you ate today	quarter	6
	to indicate how much you ate today	nothing	10
	Have you eaten snacks today?	yes	-2

[1] Every patient gets an offset of 14 points (to avoid negative SNOOS).
[2] For age below 50 years a linear trend was enforced.

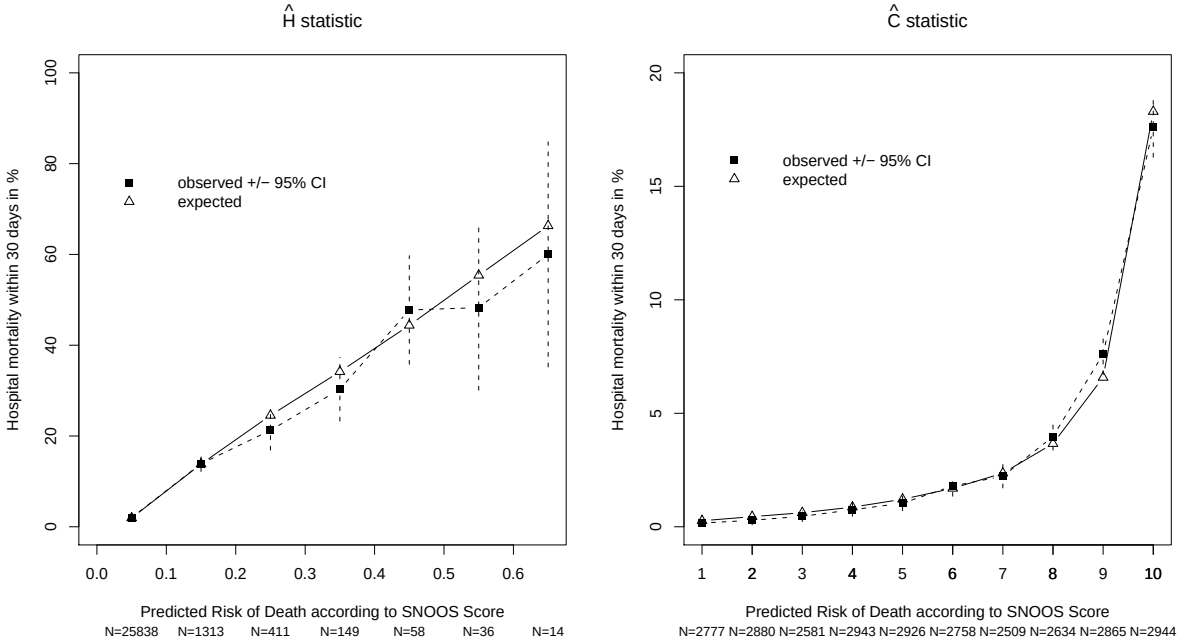

Figure 6.7: Observed and expected hospital mortality according to predicted risk, N=27817 (full cases)

Table 6.6: Performance of the model

	Development set (patients in bootstrap sample), N=1000 samples containing n= 21728 patients on average	Validation set (patients not in bootstrap sample), N=1000 samples containing n=12401 patients on average	Total sample, N=1 sample containing n=34129 patients	Sensitivity analyses, Complete cases, N=1 sample containing n=27817 patients
Max–rescaled R–Square, mean ± std	0.218 ± 0.007	0.218 ± 0.012	0.218	0.218
aROC, mean ± std	0.838 ± 0.004	0.838 ± 0.008	0.838	0.839
Brier score, mean ± std	0.031 ± 0.001	0.031 ± 0.001	0.029	0.029

Table 6.7: Performance of the model in the total sample, N=1 sample containing n=34129 patients

	Box I	Box II	Box Patient	Box Physician /Nurse	Total sample
Max–rescaled R–Square	0.156	0.134	0.143	0.136	0.218
aROC	0.797	0.770	0.777	0.779	0.838
Brier score	0.032	0.032	0.032	0.032	0.029

Table 6.8: Performance of the model, when replacing dinner with lunch

	Development set (patients in bootstrap sample), N=1000 samples containing n= 21728 patients on average	Validation set (patients not in bootstrap sample), N=1000 samples containing n=12401 patients on average	Total sample, N=1 sample containing n=34129 patients	Sensitivity analyses, Complete cases, N=1 sample containing n=29108 patients
Max–rescaled R–Square, mean ± std	0.216 ± 0.007	0.216 ± 0.012	0.216	0.216
aROC, mean ± std	0.837 ± 0.005	0.837 ± 0.008	0.837	0.837
Brier score, mean ± std	0.031 ± 0.001	0.031 ± 0.001	0.029	0.029

Table 6.9: Variability of coefficients for score without BMI,
N=1000 bootstrap samples

Question/Variable	Answer categories	Bootstrap estimates (times 10)	Std of bootstrap estimates (times 10)	Rounded Shrinked coef– ficients	Std of shrinked coef– ficients
Specialty of Ward	surgery or neurology	-4.7	0.8	-4	0.8
	[50–60)	2.8	1.3	2	1.3
	[60–70)	3.1	1.2	3	1.3
Age	[70–80)	5.0	1.2	5	1.3
	[80–90)	8.0	1.3	8	1.3
	≥90	12.3	1.6	12	1.7
Days since hospital admission	>14 days	2.3	0.7	2	0.8
	Lung	3.9	0.8	3	0.9
	Liver	5.3	1.0	5	1.0
Diseased organ	sleketon/bone/muscle	-5.8	1.7	-5	1.7
(multiple answers possible)	Blood/bone marrow	3.5	1.3	3	1.2
	Cancer	8.9	0.8	8	0.8
Can you walk without assistance?	No, only with assistance	5.2	0.9	5	0.9
	No, I stay in bed	10.6	0.9	10	1.0
If YES, how far do you walk?	in the room	2.7	1.0	2	1.1
	to the hospital admission area/shops	-3.9	1.1	-3	1.2
Patient is receiving enteral nutrition or parenteral nutrition or both or protein/energy supplements	Yes	3.5	0.7	3	0.8
fluid status	dehydrated	6.2	0.8	6	0.9
	overloaded	8.8	0.8	8	0.8
Have you lost weight unintentionally within the last three months?					
If yes, how many kg did	5-10	1.4	0.9	1	0.9
your weight decrease?	>10	2.8	0.8	2	0.9
	less than normal	2.6	0.9	2	0.9
How well have you eaten	less than half of normal	4.4	0.9	4	1.0
during the last week?	less than a quarter to nearly nothing	5.4	1.0	5	1.1
	half	4.6	0.9	4	0.9
Please tick a circle for dinner	quarter	6.9	1.0	6	1.0
to indicate how much you ate today	nothing	10.3	1.0	10	1.1
Have you eaten snacks today?	Yes	-2.1	0.6	-2	0.7

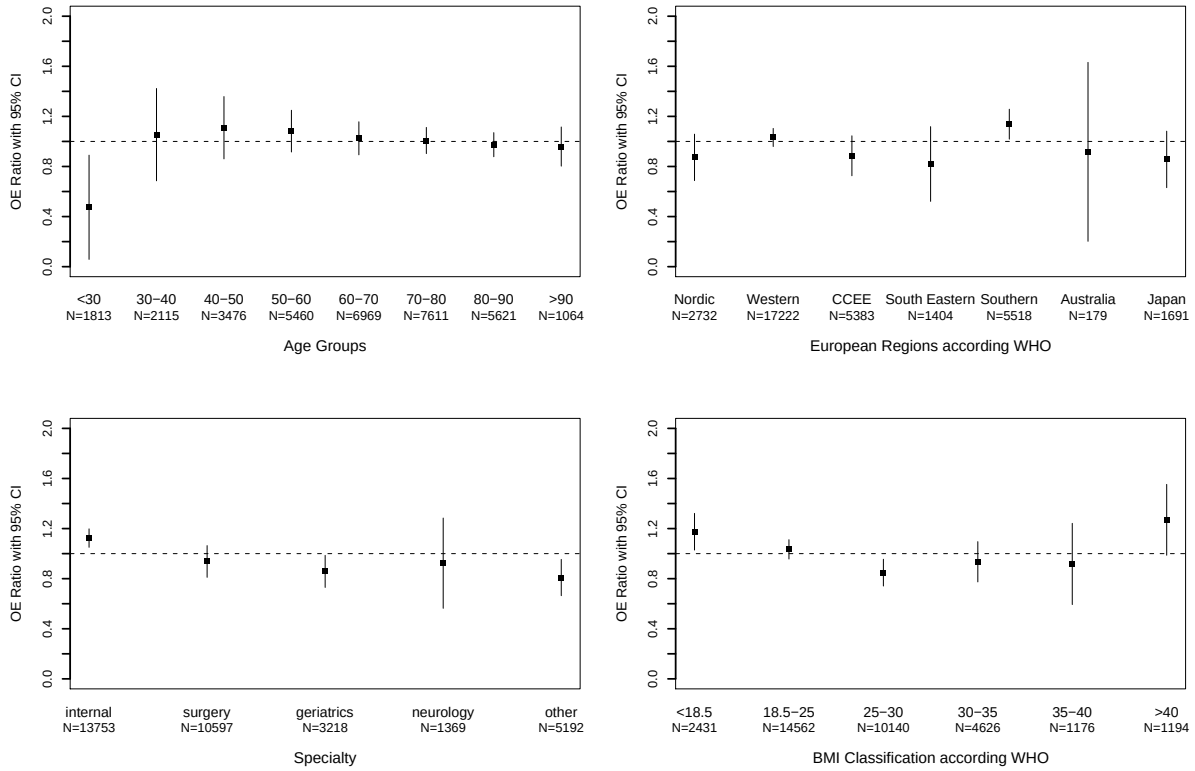

Figure 6.8: Observed-expected ratios for several sub-samples (score without BMI)

Due to the cross-sectional sampling including all patients being in hospital at one particular day, patients with different length of hospital stay prior to the survey participated. The mean score and 95% confidence interval stratified for intervals according to the length of stay in hospital prior to the survey and the according OE ratios are given in figure 6.9. The SNOOS score was higher in patients already longer in hospital. Interestingly, the performance of the score as assessed by OE ratios was not affected by the duration in hospital prior to the nutritionDay survey. The higher SNOOS score in patients with longer length of stay prior to the survey reflects the association of length of stay with severity of disease. The performance of the score was not affected by the time the patient is already in hospital at the time of survey (table 6.10).

In table 6.11, the performance of the model is given, when restricted to patients who underwent an outcome within the follow–up time. As expected, the performance of the model increased, when patients who were still at hospital at the end of the follow–up time

were excluded. The aROC increased to 0.851. The individual prediction of the model as indicated by max–rescaled R–square, aROC and brier score was best in patients with outcome in the following three days and decreased as the time to outcome increased. The ratio of observed to expected events was below 1 in patients with outcome within the next three days, which means that more patients were expected to die than observed. The OE ratio and its confidence interval covered the OE ratio 1 for the patients with outcome within the next 4 to 12 days. For patients with outcome in more than 13 days, more observed deaths than expected have occurred (figure 6.10).

Table 6.10: Performance of the model stratified duration since hospital admission, n=34129

	patients who are in hospital since								
	[0-3] days n=10585	[4-6] days n=5741	[7-9] days n=4909	[10-12] days n=2892	[13-15] days n=2025	[16-20] days n=2112	[21-30] days n=2582	[31-50] days n=1639	>50 days n=1644
Max–rescaled R–Square	0.205	0.233	0.214	0.181	0.185	0.245	0.171	0.207	0.226
aROC	0.847	0.856	0.831	0.809	0.815	0.845	0.795	0.812	0.815
Brier score	0.021	0.024	0.033	0.030	0.036	0.044	0.045	0.052	0.044

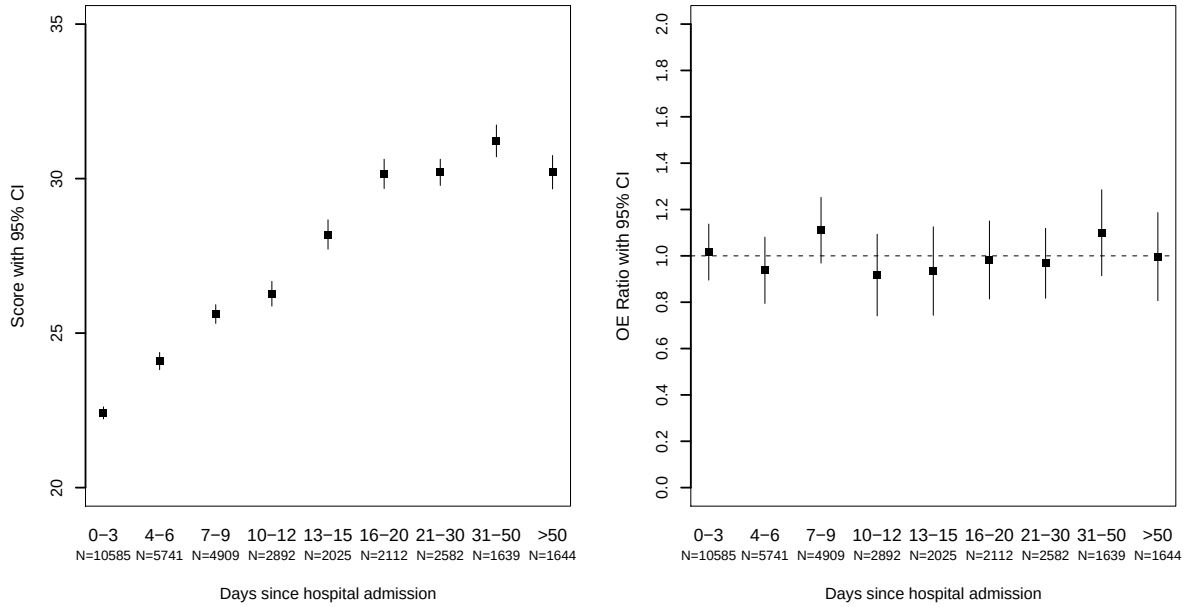

Figure 6.9: Score and observed-expected ratio stratified for duration since hospital admission

Table 6.11: Performance of the model stratified for time to discharge, patients who were still in hospital at end of follow-up period were excluded, n=28942

	n=28942	patients who have outcome				
		within [1-3] days n=8781	within [4-7] days n=7482	within [8-12] days n=4985	within [13-20] days n=4205	in >20 days n=3374
Max–rescaled R–Square	0.241	0.330	0.278	0.265	0.141	0.159
aROC	0.851	0.910	0.878	0.856	0.773	0.766
Brier score	0.032	0.014	0.027	0.035	0.046	0.067

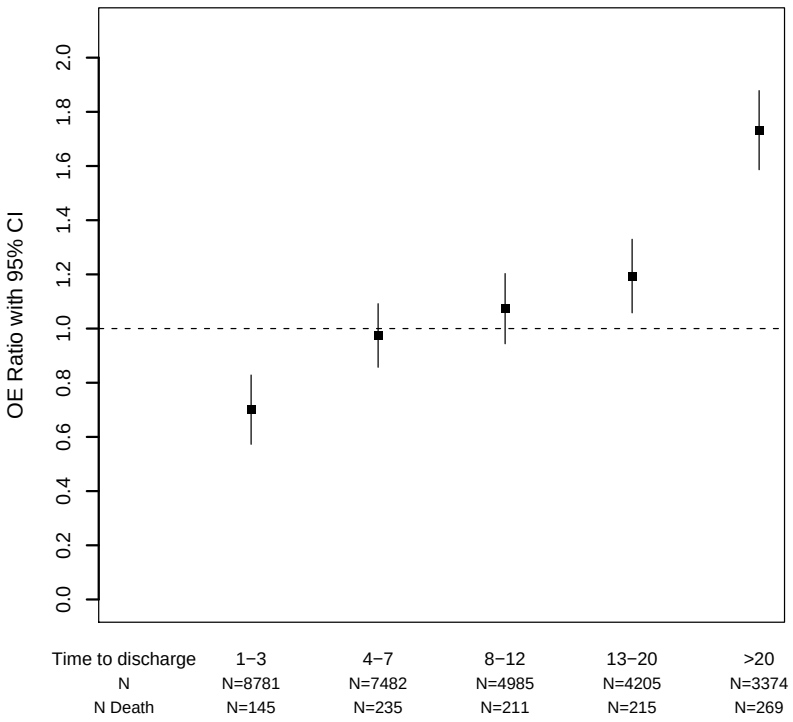

Figure 6.10: Observed-expected ratio stratified for time to discharge, the time is calculated as the days between day of survey and discharge from hospital

The points for the score including BMI are presented in table 6.12. There are few changes in the points compared to those of table 6.5. The items being fluid overloaded got one point more and being dehydrated got one point less. Note that the lowest BMI category (< 18.5) contributed two points in the modified score.

There was a slight increase in the performance of the score when including BMI (aROC 0.840, table 6.13). There is a univariat u–shaped association between BMI and death in hospital within follow–up period, which could not be removed completely when applying the SNOOS score (figure 6.8). However, when BMI was added to the score, the u-shaped association was not found anymore (figure 6.11). The u–shaped association between BMI and death in hospital within 30 days was discovered also in multivariate adjusted models (table 5.4 in the data of the survey in 2006. The association between BMI and death in hospital within 30 days adjusted for age in the data of the surveys 2006 - 2009 is given in figure 6.12. The u–shaped association was found for the current BMI at time of survey, but not for the BMI five years ago. Additionally, the u–shaped association was found beteen change of BMI in previous five years ago with death in hospital (figure 6.12). Only patients with information on current BMI, previous BMI and outcome have been taken for this analysis in figure 6.12.

Overall, considering the rigid inclusion criteria for items, the high performance of the score in the bootstrap validation samples, in the overall population and in various sub–populations, we are confident that the simple nutrition oriented outcome score in future samples will work out as an easily accessible and valid measure for the association between nutritional factors and hospital outcome.

Table 6.12: Score sheet for score with BMI, Minimum=0, Maximum=90

	question / variable	answer category	points
			16[1]
	Specialty of Ward	surgery or neurology	-4
		other	0
		<30	0
		[30–40)	0
		[40–50)	1
	Age[2]	[50–60)	2
		[60–70)	3
BOX I		[70–80)	5
To be filled		[80–90)	8
out by		≥90	12
physician/nurses	Days since hospital admission	>14 days	2
		lung	3
		liver	5
	Diseased organ	Isolated skeleton/bone/muscle	-5
	(multiple answers possible)	Blood/ bone marrow	3
		Cancer	8
		<18.5	2
		[18.5–25)	0
	BMI	[25–30)	-2
		[30–35)	-2
		[35–40)	-1
		≥40	1
BOX II	Patient is receiving enteral nutrition or		
To be filled	parenteral nutrition or both	yes	3
out by	or protein/energy supplements		
physician/nurses		dehydrated	5
	fluid status	normal	0
		overloaded	9
		Yes	0
BOX I	Can you walk without assistance?	No, only with assistance	5
To be filled		No, I stay in bed	10
out by		in the room	5
the patient	If YES, how far do you walk?	in the corridor	3
		to the hospital	
		admission area/shops	0
	Have you lost weight unintentionally	0–4	0
	within the last three months?	5–10	1
BOX II	If yes, how many kg did your weight decrease?	>10	2
To be filled		normal	0
out by	How well have you eaten	less than normal	2
the patient	during the last week?	less than half of normal	4
		less than a quarter	
		to nearly nothing	5
		all	0
	Please tick a circle for dinner	half	4
	to indicate how much you ate today	quarter	6
	to indicate how much you ate today	nothing	10
	Have you eaten snacks today?	yes	-2

[1] Every patient gets an offset of 16 points (to avoid negative SNOOS).
[2] For age below 50 years a linear trend was enforced.

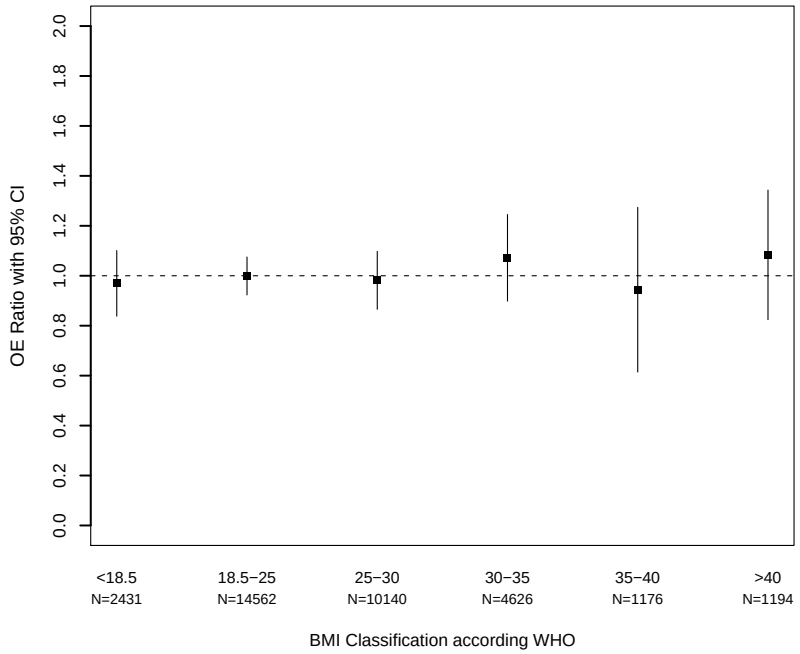

Figure 6.11: Observed-expected ratios for BMI (score with BMI)

Table 6.13: Performance of the model, score with BMI

	Development set (patients in bootstrap sample), N=1000 samples containing n= 21728 patients on average	Validation set (patients not in bootstrap sample), N=1000 samples containing n=12401 patients on average	Total sample, N=1 sample containing n=34129 patients	Sensitivity analyses, Complete cases, N=1 sample containing n=27817 patients
Max–rescaled R–Square, mean ± std	0.219 ± 0.007	0.220 ± 0.012	0.219	0.219
aROC, mean ± std	0.840 ± 0.004	0.840 ± 0.007	0.840	0.840
Brier score, mean ± std	0.031 ± 0.001	0.031 ± 0.001	0.029	0.029

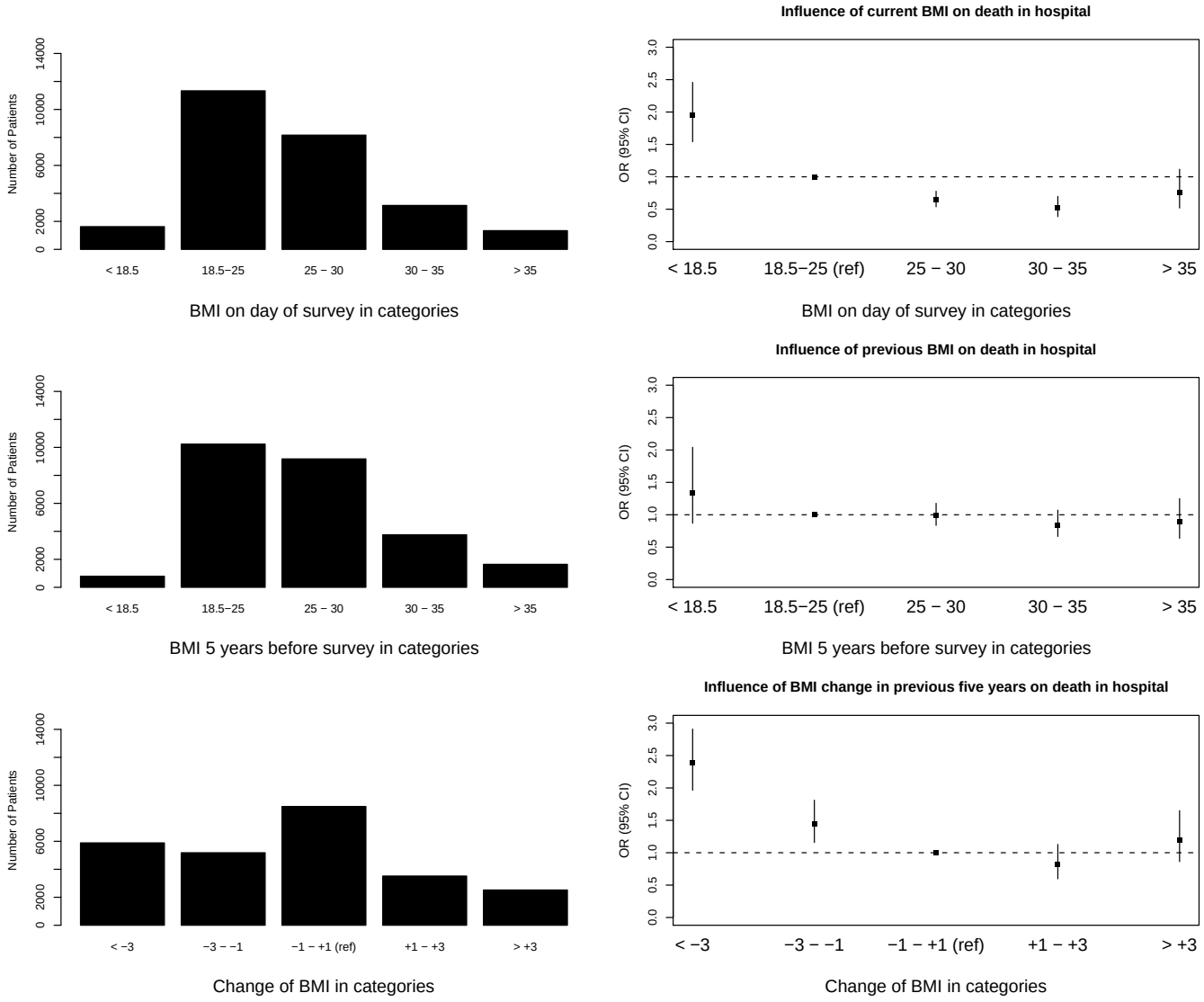

Figure 6.12: Association between BMI and risk for death in hospital within 30 days, N=25602.

Odds ratios and 95% confidence intervals for death in hospital are adjusted for age

Current and BMI five years age was divided into classification of WHO

Change in BMI was calculated as actual BMI minus BMI five years age; for example category "< -3" means that the patients have lost weight and their BMI reduced for more than 3 units in the previous 5 years

6.5 External validation of the simple score relating nutrition to hospital outcome

A validation of SNOOS with an external sample, data nutritionDay survey 2010, was performed. The data of the nutritionDay survey 2010 were not used for the development of the score and thus, are a proper external validation sample. Unfortunately, two parameters were not assessed in the nutritionDay survey 2010: fluid status and the question additionally to the ability to walk: If YES, how far do you walk?

The validation was done in a sample of 4874 patients.

N=9431 patients who did give consent and received the nD sheets

↓ missing information on outcome

N=6838

↓ missing information on score items

N=5298

↓ not allowed to eat by themselves on any meal

N=4874

Patients characteristics of the validation sample are given in table 6.14.

The minimum observed SNOOS value was 3 and the maximum observed value was 61 with a mean of 25.8 ± 9.6 and a median of 25 (19–32), n=4874 in the validation sample. The predicted probability of hospital death varied from 0.05% to 63.65% with a mean of 2.95 ± 5.23%. The Hosmer–Lemeshow test for predicted mortality classes of 0–0.1, 0.1–0.2, 0.2–0.3, 0.3–0.4, >0.4 (H–statistic, Chi-Square=4.68, df=3, p=0. 1965) and according to deciles of expected risk (C–statistic, Chi-Square=1.54, df=8, p=0.9920) demonstrated proper fit in the validation sample (figure 6.13). The OE–ratio for subgroups showed poor fit only for groups where the observed number of deaths is lower than 10 (figure 6.14). The discriminatory capability of the model, as measured by aROC curve, was 0.836 in the validation sample (table 6.15).

Table 6.14: Patient characteristics in validation sample, n=4874 In percentages, if not other stated

Parameter		
gender	for female gender	49.9
age	mean ± std	65.7 ± 17.3
BMI	mean ± std	25.4 ± 5.8
	internal	42.4
	surgery	29.0
specialty of ward	geriatrics	8.5
	neurology	6.0
	other	14.0
days since hospital admission	> 2 weeks	29.1
	lung	14.2
	liver	5.5
diseased organ	sleketon/bone/muscle	10.5
	blood/ bone marrow	4.1
	cancer	18.6
Can you walk without assistance?		
	yes	63.9
	no, only with assistance	25.3
	no, I stay in bed	10.8
If YES, how far do you walk?		
	in the room	not available
	in the corridor	not available
	to the hospital admission area/shops	not available
Patient is receiving additional nutritional support		
	includes enteral nutrition or parenteral nutrition or both or protein/energy supplements	19.4
	dehydrated	not available
fluid status	normal	not available
	overloaded	not available
Have you lost weight unintentionally within the last 3 months?		
If YES, how many kg did your weight decrease?		
	5–10	11.7
	>10	13.1
How well have you eaten during the last week?		
	normal	52.1
	a bit less than normal	24.1
	less than half of normal	13.8
	less than a quarter to nearly nothing	10.1
Please tick a circle for lunch to indicate how much you ate today		
	all	50.6
	50%	28.6
	25%	14.5
	nothing	6.3
Have you eaten snacks today?	yes	43.8

Table 6.15: Performance of the score without BMI in the validation sample, n=4874 (144 deaths, 2.95%)

Max–rescaled R–Square	0.219
aROC	0.836
Brier score	0.026

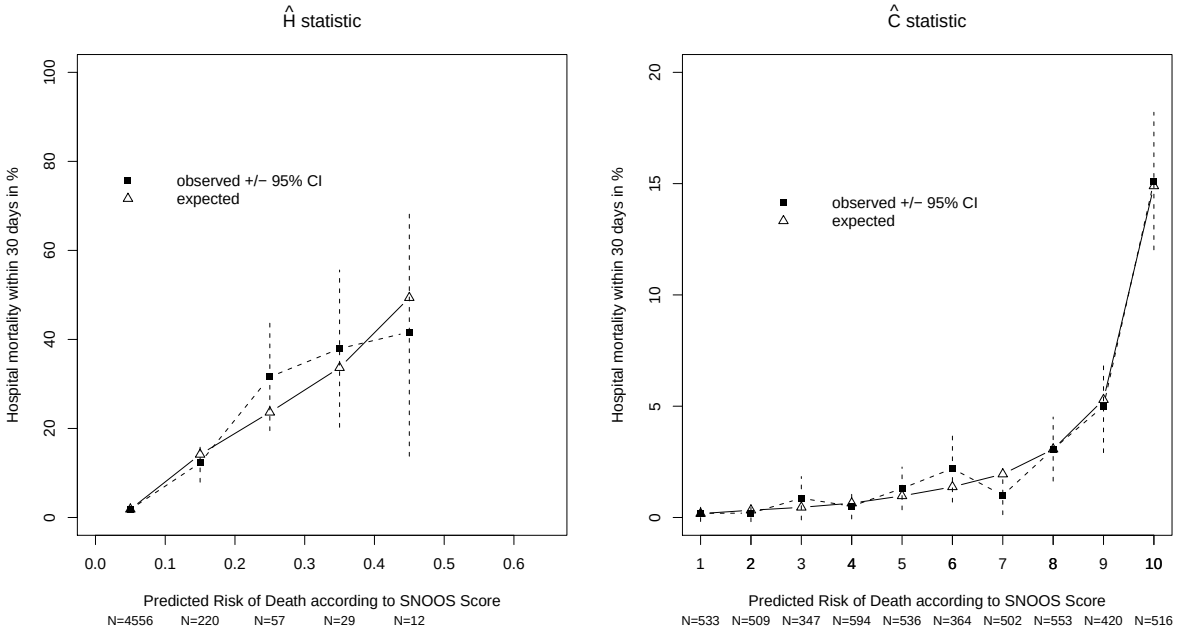

Figure 6.13: Observed and expected hospital mortality according to predicted risk, n=4874

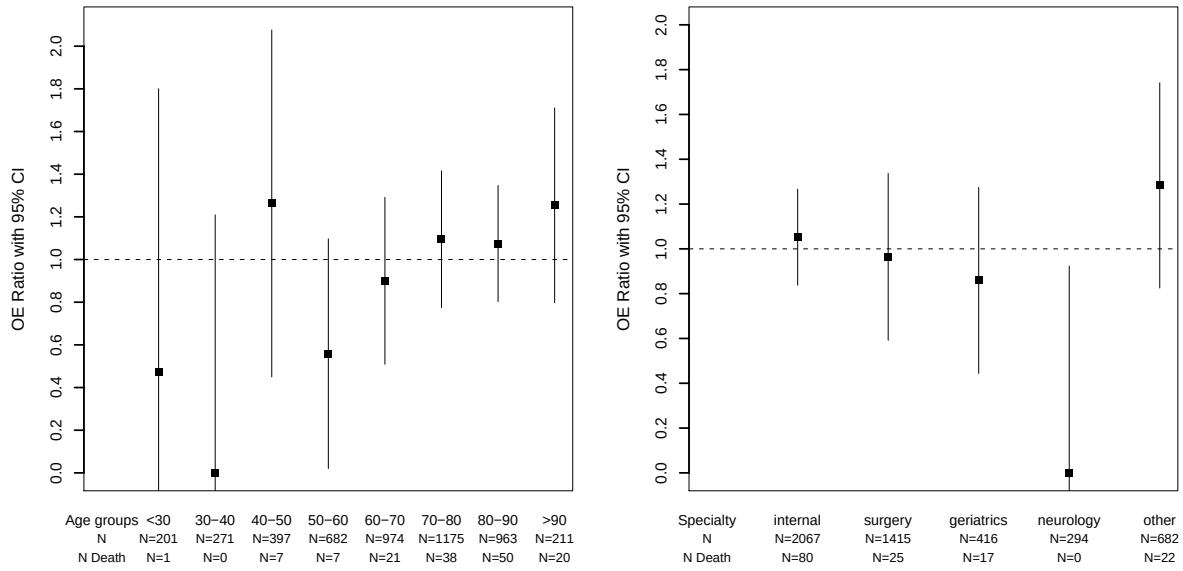

Figure 6.14: Observed-expected ratios for age and specialties

6.6 Interpretation and discussion

The association between nutrition in hospital and outcome in hospital in such a strong way was surprising. However, the interpretation of this association has to be done with care. Nobody would question that nutrition will in one way or other also be related to the later outcome of a patient. But it is also obvious that nutrition itself depends on the patient's condition. Any deterioration of the condition may lead to a change of the patient's nutrition behaviour. As the observational nutritionDay study is not a prospective, randomized intervention study, no causal interpretation is allowed. Furthermore, it is not possible to conclude that the outcome can be improved because of change of nutritional intake in hospital. It is probable that nutrition oriented factors are surrogates for unobserved patients' characteristics that directly cause death. The factors that cause patients to eat less might be complex and hard to gather. A scoring system based on simple nutrition related questions can help to identify patients at risk. Simplicity and practicability are major advantages of the SNOOS to allow wide use of the score. The calculation of the BMI by the stuff in practice might be too complicated, hence versions with and without BMI were constructed. Additionally, any experts are not required for

assessing the score items. The score is calculated simply by adding whole numbers of the single score items.

In the score with BMI, patients in the BMI range of 25–35 received minus 2 points, which means that they have lower risk for death in hospital than patients in normal BMI range (18.5–25). Higher BMI than in the normal range was protective. This observation was found in the score points of the SNOOS and was also found in the multivariate analysis in table 5.4 and in the age adjusted odds ratios for death in hospital in figure 6.12.

Given the risk factors available, it was not possible to verify any potential positive effect of supportive measures of nutrition. Supportive measures include supplementation and artificial nutrition, which are applied by the physician to improve the patients' condition, are applied in patients with worse disease state. The independent effect of supportive measures adjusted for available disease and patient–related factors, remained to be a risk factor for death in hospital. Only "eating snacks" in hospital had a positive impact. However, snack eaters were patients with already adequate food intake (table 4.4).

The results of the SNOOS score are satisfactory from a statistical point of view when compared to other scores, even to various specialized risk scores in intensive care medicine like SAPS II (Gall et al. (1983), Gall et al. (1993)), SAPS 3 (Moreno et al. (2005)), APACHE (Knaus et al. (1981), Knaus et al. (1991)) and SOFA (Amaral et al. (2005)) which use also physiological variables. Also these special scores face problems when used in the discussion of possible intervention to improve physiological conditions. It has to be differentiated between physiological values who have been artificially forced to be in the normal range and physiological values who are in the normal range without intervention. These problems with interventions motivated from non–interventional studies are also true for other physiological markers like blood glucose, blood pressure, BMI, etc. In the observational nutritionDay study, the u–shaped association of BMI with hospital outcome was found with lowest risk for patients with a BMI between 25 and 35. However, it is necessary to take into account which factors influenced the patient to achieve the current BMI. BMI five years before the survey did not show any impact on the risk for death in hospital, but the change of BMI in the previous five years showed again the u–shaped association (figure 6.12). Therefore, the u–shaped association seems to be restricted to measurements of BMI near to death because no such association was found between BMI

five years ago and death in hospital. Is is not clear, if the BMI near to death, the changes in BMI in previous five years or more probably, the reasons for the changes affect the risk for death in hospital. In observational studies, the reasons for changes in physiological markers and BMI are complex as they are not as easily explained as in experimental research. In randomized controlled trials, the intervention causes changes in physiological markers or body composition. In observational research, factors that causes changes in BMI might explain the association between BMI and risk for death. Therefore, it is not possible to conclude that patients that are forced to change their behaviour from not eating to eating the full provided meal (by using artificial nutrition, etc.) lower their risk for death in hospital to the same level as patients eating their full meal voluntarily. Also changing the BMI from lower values to higher values by intervention might not have the same effect on the risk for death as patients increasing their BMI by their lifestyle without any administered diet. For example, a cholesterol level of a patient without any intervention and an identical cholesterol level of a patient who is using cholesterol level reducing medication can not be regarded as similarly serious.

Because of the serious "hen and egg" problem between nutrition and health condition, the interpretation of scores using nutrition associated risk factors has to be done with uttermost care. However, the nutritional associated risk factors are easy to assess and show good performance on the predication of high risk patients. Therefore the nutritional factors can be used as indicators for patients in bad health condition. The score can be used for screening and monitoring or for stratification of risk patients in clinical studies. The time the patient is already in hospital did not play significant role. However, in patients where the outcome occurred later than 13 days after the calculation of the score, the performance of the score decreased.

6.7 Limitations

Planning of the study was originally not focused on the score problem. Some score items of published malnutrition scores were not assessed and therefore, these scores can not be validated in the nutritionDay sample. The questionnaires were not designed to develop a scoring system. Overall, the SNOOS showed good performance, but not unexpected, in

small subgroups with low mortality a rather poor fit may occur. In the external validation sample (nutritionDay survey 2010), the fit was poor, when lower than 10 deaths occurred in subgroups (figure 6.14). For example, in the age groups <30, 30-40, 40-50, 50-60, where less than 10 deaths occurred, the fit was not good. In the specialty neurology, where no death out of nearly 300 patients in the validation sample occurred, the 95% confidence interval of the O/E ratio did not even cover 1.0. However, in subgroups, where more than 10 deaths occurred, the fit was properly (figure 6.14) in the external validation sample.

7 Conclusions

7.1 Nutrition in hospital

The nutritionDay study has shown how nutrition is organized in daily routine through Europe. Only a small part of the patients of about 10% did not finish their meals because of too big portion sizes, but absence of hunger, problems with taste or smell of the meal and presence of nausea are the reasons for not completing the provided meal. This survey clearly demonstrates that, snacks are consumed by those patients who already eat their meals and that the potential of snacks to increase nutritional intake of patients with inadequate food is limited. To make snacks a successful concept will also have significant implications for structures of hospital catering services as well as the ward's staff. It is not enough simply to offer choice. The choices offered must not only be acceptable to the patient but the patient must also be motivated and closely monitored to ensure that what is offered is actually eaten.

Nutritional routines and nutritional care remain poor in Europe and Israel. The nutritionDay study shows huge differences between units in the process of nutritional screening, planning nutritional care and monitoring patients' food intake. The presence of dietitians and/or dietetic assistants and the use of screening tools positively promoted the provision of specialized nutrition to patients at risk of malnutrition. However, the development of universal training tools, without language barriers, which could facilitate these planning and monitoring processes is clearly needed. Enhancement of interprofessional collaboration and identification of the responsibilities for nutrition at both unit and hospital level is also required. This study shows that establishing proper nutritional risk screening is an important starting point for improving nutritional care in many hospitals in Europe.

It also highlights need for well–designed intervention studies.

In this survey, supplementation played only a minor role in the practice of hospital nutritional care. However, the factors influencing the provision of protein supplementation indicated that protein supplementation is targeted in patients with nutritional needs. It appears that protein supplementation is given to highly malnourished patients only. The impact of different types of interventions has to be determined by future studies.

From the caregivers view, there were no sex-specific differences in the type of nutritional care given to the patients or in the subjective classification if a patient is at nutritional risk. However, when adjusting for BMI, quantity eaten at nutritionDay and other covariables, females were less likely to be regarded as at nutritional risk. Women were more sensitive to nutritional intake and showed reduced food intake in the week previously to the survey and on the day of the survey in hospital. It is possible that factors like the quantity previously or actually eaten is not taken into account to sufficient extent when evaluate a patients nutritional status. Females consumed less because they normally eat less or because of nausea or vomiting compared to the answers of men. Special attention has to be given to nutrient density in hospital food as females prefer to eat half portions compared to men. Male patients complain more often about the taste and smell of the food. Men are more often not allowed to eat. Further research is needed to explore reasons behind this finding.

7.2 Nutrition in hospital and outcome

The nutritionDay Study clearly showed that decreased food intake and altered nutritional status are still a major problem within European hospitals, and that little is being done about it. Patients who do not finish their meals should be considered to be at an increased risk of acquiring a significant protein–energy deficit within few days, and that they should immediately be considered for nutritional care. We believe that fractions of the meal eaten, at least for one meal, should be considered to be included in patient charts, very much like temperature or blood pressure, because this information is easily obtained, does not require personnel specialised in nutrition, is associated with outcome and may trigger early nutritional intervention, if recorded daily. Our data do not allow recommendations

how to react to decreased food intake but current evidence based guidelines from the National Institute for Clinical Excellence in the UK (National Institute for Health and Clinical Excellence (2006)) exist and recommend fortified food, additional snacks and/or sip feeds, enteral tube feeding or parenteral nutrition. Specific nutritional interventions were effective in specific clinical situations (Delmi et al. (1990),McWhirter and Pennington (1994)); this effect was confirmed in a metaanalysis (Stratton and Elia (2007)). Most importantly, although the study is not designed to establish cause-effect relationship, our results suggest that there is plenty of room for improvement and that a change of attitude about the importance of hospital nutrition is required in both patients and caregivers.

7.3 Scoring system for nutrition in hospital and outcome

There was a strong relationship between nutrition in hospital and outcome. To identify patients with high risk for dying in hospital within 30 days, a simple score was developed using nutrition related factors. Items as type of ward where they are lying, age, duration already in hospital and mobility were used to assess patients characteristics. Nutrition oriented factors like fluid status, nutrition support needed, weight loss, food intake in fractions in previous week and actually on the day of the survey were additionally used to identify high risk patients. In the end, a simple score with points for each item, was created and the sum of the score items predicted the risk for death in hospital within 30 days properly. The simplicity, practicability and good performance of this simple score is noteworthy. The score can be used for screening and monitoring or for stratification of risk patients in clinical studies. Compared with other existing severity scores, it can be concluded that the quantity eaten and mobility status of patients showed similar prognostic performance as physiological parameters.

However, the interpretation of the score has to be done with uttermost care. The nutrition oriented items are connected with the health condition of the patients. Is is not possible to solve the "hen and egg" problem even with such a huge number of participants. Interventions based on observational studies have to be interpreted with care.

7.4 Suggestions for improvement

The nutritionDay study gives insight about nutrition in hospitals on typical days. The large–scale study provides interesting findings in the contribution of meals, snacks and supplements to nutrition in hospitals, the assessment of nutritional risk as well as the association between nutrition and clinical outcome. Further analysis are planed (e.g. when do patients receive artificial nutrition, where and how are diabetic patients treated, nutritionDay in ICU wards). However, the nutritionDay study has several limitations (see sections 4.7 and 5.6).

My task was restricted to do the statistical analyses of all these presented results (and more) and preparing several manuscripts. Unfortunately, I was not involved in planning or modifying the design of the nutritionDay study. I have provided several suggestions for improvement and some of them have been considered. I want to point out ideas for further improvement or modification of the study design or the questionnaires:

It is not clear, if the consumed snacks on sheet 3b (figure 2.5) are brought in by relatives or are provided by the hospital. On sheet 3a (figure 2.5), the question for food consumed apart from hospital food generally (not on the specific survey day) is asked, which gives indication for the source of the snacks consumed at the nutritionDay (see section 4.4.2). Few questions are assessed in an unsatisfactory way. Is is asked for the duration since operation on sheet 2 (figure 2.3). However, is can not be differentiated between missing because of missing information on the days since operation or because the patient has not underwent an operation. It seems that the number of the staff (figure 2.2) is hard to specify. I suggest, that this variable is assessed in categories and that the type of staff is reduced in order to achieve higher quality in the data. The information of the health status of the patient is limited. Analyses have shown (see section 5.5.3), that the disease state in the participants was not completely assessed. It has to be noted that no assessment methods for disease severity in general hospital wards exist. Nevertheless, the interpretation of the results concerning nutrition and outcome has to be done with care due to the incomplete assessment of the disease severity. One disadvantage in the data of the nutritionDay study is the fact that no other existing tool for screening of malnutrition can be applied. Unfortunately, for each existing screening tool, some variables are not

assessed. It would be helpful to assess the effect of existing malnutrition scores, because based on the results, a new scores with better prediction of outcome or different focus could be developed. However, the most commonly used malnutrition scores (NRS 2002, MUST) include variables, which can be assessed only by specialists. The severity of illness in the categories mild, moderate, severe is part of the NRS 2002 and if the patient is expected to not eat for more than 5 days is part of the MUST. A basic principle of the nutritionDay study was that no specialists are needed and that the assessed items are objective assessable. The nutritionDay study has achieved large interest and huge participation rates. I think that for further research the design of the nutritionDay study should be modified in order to be able to answer new questions. Based on the results, further research questions can be deduced. I think, in future, the nutritionDay study should assess more detailed information in order to answer new hypothesis. My suggestions are to study: the effect of nutritional intake on several consecutive days; the assessment of the nutritional intake from admission day beginning; increasing focus on the type and quality of nutrition (information from kitchen, from menus description, from dietician, from patient); assessing the severity of disease in more detail (physiological measurements,..); assessment of body composition; recruiting consecutively admitted patients. Of course, the assessment of such information is not possible in several thousand patients.

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I wish to thank my parents, Gabriela and Anton Pernicka as well as my whole family and all my friends.

A Abstract

Recognition and treatment of undernutrition in hospitalized patients are not often a priority in clinical practice. The aim of the "nutritionDay" study was to increase awareness and knowledge about the importance of nutrition status and care. The data were collected with the help of questionnaires available in more than 30 languages assessing nutritional care in hospital from patients and caregiver's view. The nutritionDay was repeated five times so far and more than 50000 patients took part in the surveys.

More than half of the patients did not eat their full meal provided by the hospital. The food wastage in hospitals as seen by the percentage eaten less than the full provided meals was as high as 30 %. The nutritionDay study showed that snacks were consumed by those patients who already ate their meals. Supplementation played only a minor role in the practice of hospital nutritional care. However, the factors influencing the provision of protein supplementation indicated that protein supplementation is targeted in patients with high nutritional needs only. The use of energy sources additionally to hospital food like snacks, supplements and artificial nutrition were highly variable across European regions but stable between the sexes.

Decreased food intake on NutritionDay or during the previous week was associated with an increased risk of dying. Data of the survey 2006 resulted in a hazard ratio for dying when eating about a quarter of the meal on NutritionDay of 1.97 (1.42–2.71); when eating nothing 2.71 (1.88–3.91, adjusted for patient and disease related factors. The results demonstrated a strong association between nutrition related factors and mortality in hospital.

However, the data of the nutritionDay study do not allow causal interpretation or to

derive recommendations how to react to decreased food intake. It is probable that nutrition oriented factors are surrogates for unobserved patients' characteristics that directly cause death. The factors that cause patients to eat less might be complex and hard to gather. A scoring system based on simple nutrition related questions was developed and resulted in an area under the receiver operating characteristic of 0.84. Therefore, more attention should be put on nutrition in normal hospital wards as it is easy to access and patients at risk can be recognized.

Keywords: malnutrition, undernutrition, nutritional care in hospital, fractions of food eaten, screening, death in hospital, scoring system

B Kurzfassung

Der Erkennung und Behandlung von Unterernährung bei hospitalisierten Patienten wird oft zu wenig Priorität zugeordnet. Das Ziel der "nutritionDay" Studie war es das Bewusstsein und Wissen über Mangelernährung in Spitälern und dessen Wichtigkeit zu erhöhen. Die Daten wurden mit Hilfe von Fragebögen, die in über 30 Sprachen verfügbar waren, erhoben. Hauptaugenmerk lag auf der Ernährungsversorgung aus Sicht der Patienten und Behandler am Tag der Befragung. Die Befragung fand bis jetzt fünf mal statt und insgesamt nahmen über 50000 Patienten an der nutritionDay Studie teil.

Mehr als die Hälfte der Patienten haben das servierte Mahl nicht aufgegessen. Der Speiseabfall im Spital, erhoben durch den Anteil an gegessener Nahrung von der servierten Mahlzeit war mit 30% sehr hoch. Die nutritionDay Studie zeigte, dass Zwischenmahlzeiten / Jausen von Patienten, die ebenso die servierte Hauptmahlzeit großteils aufessen, bevorzugt werden. Supplemente spielten eine geringe Rolle in der klinischen Praxis. Die Faktoren, die eine Gabe von Supplementen beeinflussten, zeigten an, dass diese nur in Patienten mit starker Mangelernährung eingesetzt werden. Der Gebrauch von Energiequellen abgesehen von der Spitalskost wie Zwischenmahlzeiten / Jausen, Supplemente und künstliche Ernährung ist in den Europäischen Regionen sehr unterschiedlich. Kein Unterschied diesbezüglich wurde jedoch zwischen den Geschlechtern entdeckt.

Reduzierte Nahrungsaufnahme in der Vorwoche oder am Tag der Befragung hing mit dem Risiko im Spital zu versterben zusammen. In den Daten vom Jahr 2006, wurde ein "Hazard Ratio" (HR) von 1.97 (1.42–2.71) für PatientInnen, die ein Viertel des angebotenen Mittagessen zu sich nahmen und ein HR von 2.71 (1.88–3.91) für PatientInnen, die nichts von dem angebotenen Mittagessen zu sich nahmen, adjustiert für patienten- und krankheitsbezogene Faktoren, beobachtet. Die Ergebnisse zeigten einen starken Zusam-

menhang zwischen ernährungsbezogenen Faktoren und Tod im Spital.

Zu beachten ist jedoch, dass die Daten der nutritionDay Studie keine kausalen Schlüsse zulässt und ebenso keine Empfehlungen bei reduzierter Nahrungsaufnahme abgeleitet werden können. Wahrscheinlich sind die ernährungsbezogenen Faktoren Surrogate für unbeobachtete Merkmale der PatientInnen. Diese Merkmale sind vermutlich für den Tod im Spital verantwortlich, sind jedoch komplex und schwierig zu erfassen. Daher wurde ein Score System basierend auf einfachen ernährungsbezogene Fragen entwickelt. Dieser Score zeigte eine gute Prognose der Spitalsmortalität mit einer Fläche unter der "Receiver Operating Characteristic" von 0.84. Daher muss mehr Aufmerksamkeit auf die Nahrungsaufnahme von SpitalspatientInnen gelenkt werden, da diese leicht zu erfassen ist und RisikopatientInnen erkannt werden können.

Sichwörter: Mangelernährung, Unterernährung, Ernährungsversorgung im Spital, Aufnahme von Teilen der Nahrung, Screening, Tod im Spital, Score System

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- ESPEN congress, 29. August - 1. September 2009, Vienna, Austria
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Publications related to the thesis:

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