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Development of integrated support software for clinical nutrition

Desarrollo de una aplicación informática de ayuda al soporte nutricional especializado integrado en la historia clínica electrónica

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Abstract

Objectives: to develop an integrated computer software application for specialized nutritional support, integrated in the electronic clinical record, which detects automatically and early those undernourished patients or at risk of developing undernourishment, determining points of opportunity for improvement and evaluation of the results.

Methods: the quality standards published by the Nutrition Work Group of the Spanish Society of Hospital Pharmacy (SEFH) and the recommendations by the Pharmacy Group of the Spanish Society of Parenteral and Enteral Nutrition (SENPE) have been taken into account. According to these quality standards, the nutritional support has to include the following healthcare stages or sub-processes: nutritional screening, nutritional assessment, plan for nutritional care, prescription, preparation and administration.

Results: this software allows to conduct, in an automated way, a specific nutritional assessment for those patients with nutritional risk, implementing, if necessary, a nutritional treatment plan, conducting follow-up and traceability of outcomes derived from the implementation of improvement actions, and quantifying to what extent our practice is close to the established standard.

Conclusions: this software allows to standardize the specialized nutritional support from a multidisciplinary point of view, introducing the concept of quality control per processes, and including patient as the main customer.

KEYWORDS
Computer system; Decision support; Nutritional assessment; Healthcare quality; Clinical nutrition

Resumen

Objetivos: desarrollar una aplicacion informática integral en el soporte nutricional especializado, e integrado en la historia clínica electrónica, que detecte de forma automatizada y precoz a los pacientes desnutridos o en riesgo de desarrollar desnutrición, determinando puntos de oportunidad de mejora y evaluación de resultados.

Métodos: se han tenido en cuenta los estándares de calidad publicados por el grupo de trabajo de nutrición de la Sociedad Española de Farmacia Hospitalaria (SEFH) y las recomendaciones del grupo de farmacia de la Sociedad Española de Nutrición Parenteral y Enteral (SENPE). De acuerdo con dichos estándares de calidad, las etapas o subprocesos asistenciales que debe contemplar el soporte nutricional son: cribado nutricional, valoración nutricional, plan de cuidados nutricionales, formulación, elaboración y administración.

Resultados: la aplicación permite, de forma automatizada, realizar una valoración nutricional específica a los pacientes con riesgo nutricional, instaurando, si fuese preciso, un plan de tratamiento nutricional y realizando el seguimiento y trazabilidad de los resultados derivados de la implantación de acciones de mejora y, cuantificando en qué medida nuestra práctica se aproxima a la establecida como estándar.

Conclusiones: la aplicación permite estandarizar el soporte nutricional especializado desde un punto multidisciplinar, introduciendo el concepto de control de calidad por procesos y al paciente como cliente principal.

PALABRAS CLAVE
Sistema informático; Soporte de decisión; Valoración nutricional; Calidad asistencial; Nutrición clínica

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Introduction

Malnutrition in the hospitalized patient is the result of the complex interaction between disease, diet and nutrition. It is important to understand the difference between malnutrition caused by undernourishment (uncomplicated starvation) or overnutrition (obesity), and malnutrition associated with a disease, because treatment success in the latter will require both nutritional and medical or surgical interventions, given that nutritional interventions alone cannot solve the metabolic anomalies associated with the disease or the injury[1].

Malnutrition is associated with multiple factors. On one hand, the disease itself might lead to an inadequate intake of nutrients due to anorexia, difficulty to swallow, chewing problems, dysphagia, mucositis, or lack of autonomy for eating. This can also make digestion and food absorption difficult, and can even increase nutritional requirements, either due to metabolic stress or due to a higher or lower level of loss of nutrients. On the other hand, certain diagnostic or therapeutic procedures can also contribute to the development of undernourishment, either because fasting is indicated in order to conduct some explorations, because the patient is in the post-surgical period , or because digestive rest has been indicated as part of the treatment for specific phsyiopathological situations (pancreatitis, etc.)[2–11].

A 23% of patients hospitalized in Spain are at risk of undernourishment; and this shows that undernourishment represents a safety problem for hospitalized patients, because it has impact on the complications of the disease which was the primary cause for hospitalization and those associated, it increases the risk of infections, it weakens the ability of responding to treatment, and reduces the level of immune response. All this will translate into an increase in costs and hospital stay. In Spain, this represents a mean 4-day increase in hospital stay, an increase of 1,409 € per patient, in those patients who were admitted with risk of suffering undernourishment, and of 6.000 € in those patients who suffered undernourishment during their hospital stay, compared with those who did not present undernourishment at any time[12].

Specialized nutritional support is a high-complexity process which offers multiple opportunities for medication errors within its different stages: prescription, formulation, preparation, administration, or treatment monitoring[13]. Previous studies have estimated the percentage of problems associated with clinical nutrition between 30% and 60%[14].

Parenteral Nutrition (PN) is included in the classification of high-risk medications, because it presents a high likelihood of causing severe damage to patients in case of inadequate use[15]. The United States Pharmacopeia (USP) has registered over 2,500 mistakes associated with PN within a 5-year period. More recently, 9 cases of deaths associated with the administration of PN contaminated by *Serratia marcescens* have been published[16]. Enteral Nutrition (EN) is not exempt from its own complications (mechanical, infectious, gastrointestinal and metabolic), and mistakes that affect patient safety. The USP and the ISMP have reported, within a 6-year period (from 2000 to 2006), 24 incidents associated with mistakes in the use of enteral nutrition; 33% of these were for sentinel events (permanent damage, potentially fatal situations, death)[17].

We must not forget the current lack of awareness about this problem by healthcare professionals, because there is not enough training on nutrition matters, due to the lack of knowledge of the importance of malnutrition in patients' evolution, as well as to the lack of resources in order to adopt nutritional support systems.

All this leads to the lack of application of adequate measures of detection and control in patients with nutritional problems, an inadequate use of the existing nutritional support resources, an increase in morbimortality, and in the cost of patient care[2–11].

Even though major methodological difficulties can appear in studies of nutritional intervention, there is evidence that nutritional intervention can improve the clinical evolution of the undernourished patient, and reduce those expenses associated with the disease[18–20]. The ruling by the Committee of Ministers of the European Council on diet and nutritional care in hospitals, approved on November, 12th, 2003, establishes the importance of malnutrition in hospitals, as well as the measures towards its prevention and treatment[21].

Accordingly, and with the aim to maximize those resources available, it would be advisable to use support software which would allow to conduct an initial assessment towards the early detection of undernourished patients or those at risk of developing undernourishment, and subsequently, to conduct a more specific nutritional assessment, and to implement, if necessary, a nutritional treatment plan. Even though there are various computer programs available in our setting, which are associated with nutritional support (Nutridata©, Kabisoft©, Nutriwin©, Multicomp©, Medical One©[22,23], none of these gathers together all the recommendations for a comprehensive control of hospital undernourishment. For example, they don't feature a system of nutritional screening for adult and/or paediatric patients, and most of them don't allow to obtain the information required in order to conduct an adequate quality control at the time of obtaining the indicators of the different processes involved.

Objectives

1. To describe the characteristics of a new computer program for assisted electronic prescription of parenteral and enteral nutrition.

2. To define the different prescription assistances involved in the nutritional support process, with the aim to standardize nutritional support and include it in protocols.
3. To describe any entries conducted with the electronic clinical record of the *Hospital Comarcal de Inca.*

Methods

For the development of the computer software, the characteristics which all new technologies applied to medication use should include were taken into account, according to the recommendations by the Group for Assessment of New Technologies (TECNO Group) of the Spanish Society of Hospital Pharmacy (SEFH)[24], as well as clinical practice standards published by the Work Group on Nutrition by the SEFH. According with said quality standards, the healthcare stages or processes that must be covered by the nutritional support system are: nutritional screening, nutritional assessment, nutritional care plan, prescription, preparation, administration, monitoring, and end of treatment[13,25]. The characteristics of each sub-process are described below, together with the different prescription assistances implemented.

The map of the healthcare process of the nutritional support in said software is initiated with the inclusion of patients through computer entry in the admission department. All patients will be screened within the first 48 hours since admission.

The nutritional screening selected for adult patients was NRS-2002 (26)or who are severely undernourished, or who have certain degrees of severity of disease in combination with certain degrees of undernutrition. Degrees of severity of disease and undernutrition were defined as absent, mild, moderate or severe from data sets in a selected number of randomized controlled trials (RCTs (Table 1) and FILNUT as computer screener[27] (Table 2). For paediatric patients, the PYMS Nutritional Screening System was selected[28] (Table 3). This section also includes an alternative method developed by the British Association for Parenteral and Enteral Nutrition (BAPEN), to determine patient size based on distance between olecranon and ulnar styloid process, and the age and gender of patients[29].

If the adult patient has no nutritional risk, the application won't request the screening until after one week, as long as there is no FILNUT score of risk; and in paediatric patients, this will depend on the PYMS score (Table 3).

Table 1. *NRS-2002 (Nutritional Risk Screening)*

1. BMI < 20.5?		Yes	No
2. Any weight loss within the last 6 months?		Yes	No
3. Any reduction in intake during the past week?		Yes	No
4. Severe disease?		Yes	No
If any question is answered Yes, continue with the assessment. If the answer is NO for all questions, re-assess after one week.			
NUTRITIONAL STATUS		DISEASE SEVERITY	
Absent 0 scores	Normal nutritional status	No disease 0 scores	Normal nutritional requirements
Mild 1 score	Weight loss > 5% in 3 months or 50-75% intake of requirement during the past week	Mild 1 score	Hip fracture, chronic patients (cirrhosis, COPD, hemodialysis, diabetics, in the past week oncological)
Moderate 2 scores	Weight loss > 5% in 2 months or BMI 18.5-20.5 + deterioration in overall status or 25-60% intake of requirement during the past week	Moderate 2 scores	Major abdominal surgery, stroke, severe pneumonia, haematological neoplasias.
Severe 3 scores	Weight loss > 5% in 1 month (> 15% in 3 months) or BMI < 18.5 3 scores + deterioration in overall status or 0-25% Intake of requirement during the past week	Severe 3 scores	CET, BMT, critical patients
Two scores are obtained: one to show the nutritional status, and another to assess disease severity. These scores must be summed up in order to obtain the final score; 1 score must be added to the total sum if the patient is ≥70 year-old.			
Overall score:	< 3: weekly re-assessment		
	≥3: patient at nutritional risk, initiate plan of nutritional care.		
COPD: Chronic Obstructive Pulmonary Disease; BMI: Body Mass Index; CET: Cranioencephalic Trauma; BMT: Bone Marrow Transplant.			

Tabla 2. *Computer Screening for Adult Patients*

FILNUT				
Parameter	Normal	Mild	Moderate	Severe
Albumin g/dl or total proteins g/dl or prealbumin mg/dl	>3.5 >6.4 >18 (0)	3-3.49 5-6.3 15-17.9 (2)	2.50-2.99 4-4.9 10-14.9 (4)	<2.5 < 4 < 10 (6)
Cholesterol mg/dl	> 180 (0)	140-179 (1)	100-139 (2)	< 100 (3)
Lymphocytes (%)	> 17 (0)	12-16.9 (1)	8-11.9 (2)	<8 (3)
Total range	0-1	2-4	5-8	9-12
Malnutrition ALERT	No or low alert		Moderate	High
Nutritional Risk (NR) PHASE 2	Low		Moderate	High risk
(NRI) For patients who will undergo **digestive surgery**				
Equation	NRI (%) = 150 – (16.6 * Alb) – (0.78*TCF) – (0.2*Tf)			
Range	< 40%		40-49 %	≥ 50%
Nutritional Risk	Low risk		Moderate risk	High risk
Variables	Alb: Albumin in g/dL. TCF: Tricipital Cutaneous Fold in mm. Tf: Transferrin in mg/100 ml.			

Table 3. *PYMS Nutritional Screening System*

1. BMI VALUE IS LOWER THAN STANDARD?	**NO**	0	**SCORE**
	YES	2	
2. ANY RECENT WEIGHT LOSS?	**NO**	0	
	YES	1	
	UNINTENTIONAL WEIGHT LOSS		
	LOOSE CLOTHES		
	LOW WEIGHT GAIN (IF < 2 YEARS)		
3. ANY REDUCTION IN INTAKE AT LEAST DURING THE LAST WEEK?	**NO**	0	
	ORDINARY INTAKE		
	YES	1	
	REDUCTION IN ORDINARY INTAKE AT LEAST DURING THE PAST WEEK		
	YES	2	
	NO INTAKE (OR SMALL SIPS OR FOOD BITES) AT LEAST DURING THE PAST WEEK		
4. WILL FOOD INTAKE BE AFFECTED AT LEAST DURING THE FOLLOWING WEEK DUE TO THE CAUSE FOR HOSPITAL ADMISSION?	**NO**	0	
	YES	1	
	AT LEAST DURING THE FOLLOWING WEEK		
	INTAKE REDUCTION AND/OR		
	INCREASE IN REQUIREMENTS AND/OR		
	INCREASE IN LOSS		
	YES	2	
	NO INTAKE (OR LITTLE SIPS OR FOOD BITES) AT LEAST DURING THE FOLLOWING WEEK		
OVERALL SCORE:	0: REPEAT PYMS ASSESSMENT IN ONE WEEK.		
	1: REPEAT PYMS WITHIN 3 DAYS.		
	≥2: NUTRITIONAL ASSESSMENT + REPEAT PYMS IN ONE WEEK.		

Table 4. *Record of Nutritional Assessment for Adult Patients*

CLINICAL RECORD	Primary condition	Secondary conditions		
NUTRITIONAL BACKGROUND	Inadequate intake Inadequate absorption	Risk factors: Increase in requirements Increase in losses Changes in intake	FOOD ALLERGIES Egg allergy Soy allergy Others:	
PREVIOUS PHARMACOLOGICAL HISTORY (Please include medicinal herbs and healthcare products)		PHARMACOLOGICAL ALLERGIES Latex Heparin Others:		
PHYSICAL EXAMINATION	Physical examination Vitamin deficiencies Functional abilities:	Limited work	Ambulatory	Bed-ridden
ANTHROPOMETRIC PARAMETERS	Weight loss rate relative to time Risk of severe undernourishment: • ≥ 15% within 7-12 months • 10% within 6 months • 7.5-10% within 3 months • 5-7.5% within one month • 2.5-5% within 2 weeks	Body Mass Index (BMI) BMI < 16: Severe Undernourishment BMI 16-16,9: Moderate Undernourishment BMI 17-18.5: Mild Undernourishment BMI 18.6-25: Normality BMI 25.1-29.9: Overweight BMI 30-34.9: Obesity Class I BMI 35-39.9: Obesity Class II BMI ≥ 40: Obesity Class III		
BIOCHEMICAL PARAMETERS		Mild	Moderate	Severe
Albumin (g/dl)		3.5-2.8	2.7-2.1	< 2.1
Lymphocytes (No. /mm^3)		2.000-1.200	1.200-800	< 800
Cholesterol (mg/dl)		179-140	139-100	< 100
MEDICATION-NUTRIENT INTERACTIONS				
OUTCOME	Well nourished patient (diagnostic code) Patient at nutritional risk Caloric undernourishment. Marasmus (263.9) Proteic undernourishment. Kwashiorkor (260) Severe protein-energy undernourishment (262) Moderate protein-energy undernourishment (263.8) Mild protein-energy undernourishment (263.8)			

Adult patients with nutritional risk are assessed according with the Nutritional Assessment Registry (Table 4), and paediatric patients are assessed according to the recommendations by the Spanish Society of Paediatrics (AEPED) (Table 5)[25,30].

If the patient is not undernourished, the program will classify him/her as a patient without nutritional risk.

The plan for nutritional care is defined for those patients who present undernourishment; said plan features an alarm system, which will inform if the limits of intake of different nutrients are exceeded (Table 6 and 7), and if the way of administration chosen is adequate, according with the estimated duration of the specialized nutritional support (Table 8). If during the estimation of requirements, the planned osmolarity for parenteral nutrition is superior to 800 mOsm/L, the software will indicate that the parenteral nutrition must be administered through a central line. In central lines, except for the umbilical for paediatric patients, the left or right side can be selected.

After determining the plan of care, the pharmacist must validate the prescription.

In the specific case of parenteral nutrition, according to the formulations for three-chamber, two-chamber and saline bags included in the program database, together with the stability conditions that any preparation must present (Table 9)[31–33], the program will generate automatically the preparation which better adjusts to said conditions. If it was decided to modify said preparation due to clinical criteria, this can be confirmed again with the aim to determine its physical-chemical stability. If there is any physical-chemical incompatibility, the program will issue an alert through the relevant warning signals.

Once the preparation has been selected, the relevant preparation forms and labels are generated, with

Table 5. *Record of Nutritional Assessment for Paediatric Patients*

CLINICAL RECORD	Primary condition	Secondary conditions		
NUTRITIONAL BACKGROUND	Inadequate intake Inadequate absorption	Risk factors: Increase in requirements Increase in losses Changes in intake	FOOD ALLERGIES Egg allergy Soy allergy Others:	
PREVIOUS PHARMACOLOGICAL HISTORY (Please include medicinal herbs and healthcare products)		PHARMACOLOGICAL ALLERGIES Latex Heparin Others:		
PHYSICAL EXAMINATION	Physical examination Vitamin deficiencies Functional abilities:	Limited work	Ambulatory	Bed-ridden
ANTHROPOMETRIC PARAMETERS	Weight loss rate relative to time Risk of severe undernourishment: • ≥ 15% within 7-12 months • 10% within 6 months • 7.5-10% within 3 months • 5-7.5% within one month • 2.5-5% within 2 weeks	Body Mass Index Severe Undernourishment: BMI percentile < 2 Moderate Undernourishment: BMI percentile =3 Mild Undernourishment: BMI percentile = 10-15. Brachial perimeter and tricipital fold: Undernourishment: percentile < 15. Cranial perimeter (<3 years): Undernourishment <P15		
PAEDIATRIC PATIENT PARAMETERS (5-16 YEARS) Lama Mor and col.		Mild	Moderate	Severe
Albumin (g/dl)		3.5-2.8	2.7-2.1	< 2.1
Transferrin (mg/dL)		200-150	150-100	< 100
Prealbumin (mg/dL)		17-11.5	11-5.5	< 5.5
MEDICATION-NUTRIENT INTERACTIONS				
OUTCOME	Well nourished patient (diagnostic code) Patient at nutritional risk Caloric undernourishment. Marasmus (263.9) Proteic undernourishment. Kwashiorkor (260) Severe protein-energy undernourishment (262) Moderate protein-energy undernourishment (263.8) Mild protein-energy undernourishment (263.8)			

the "*modus operandi*" including: patient identification data, patient location (bed, hospital unit), date of preparation, volume of the different solutions that will allow to determine the order of addition into the bag, identification of products by lots, datamatrix codes to guarantee product identification and traceability, signature of the pharmacist in charge, signature of the staff in charge of preparation, preparation lot, and reference number.

Finally, the nursing staff will validate the administration by identifying patient and preparation through reading the bar codes (patient wristband) and datamatrix codes (nutrition) respectively; this will allow to determine that they are the right patient and the right preparation.

Besides, any complications that may arise during administration can be reported, by documenting their causes and any actions taken (Table 10).

For treatment monitoring, there is a section for collection of Vital Constants (systolic pressure, diastolic pressure, temperature, heart rate, partial oxygen saturation), fluid balance, and record of test results.

Regarding the end of treatment, the following options were determined as possible causes: hospital discharge, death, oral or enteral transition, loss of line, indisposition, worsening of the condition, or others. In this last case, there is a Notes section for specifying the cause that was the reason for ending treatment.

To obtain Quality Indicators, a module was selected for searching into the software database, in order to generate those indicators considered relevant, because it allows to relate all variables collected in sub-processes, as well as any prescription assistance implemented.

Table 6. *Plan for nutritional care in adult patients*

Energy requirements BEE: Basal Energy Expenditure EER: Energy Expenditure at Rest	TEE (kcal) = BEE or EER x AF x DF

In order to determine energy requirements in adult patients, all calculations are conducted with the current weight of the patient, with the following exceptions:

— Obese patients (current weight > 20% of the ideal weight or BMI ≥30 kg/m^2): Adjusted Body Weight will be used (ABW = (ideal weight + 0.25 [current weight – ideal weight]).), except in those equations where it is specifically indicated to use real weight. In order to determine ideal weight, Lorentz Equation will be used:

- Male: ideal weight (kg) = height (cm) – 100 – (height [cm] – 150)/4
- Female: ideal weight (kg) = height (cm) – 100 – (height [cm] – 150)/2

— Undernourished patients with BMI < 18 kg/m^2: Real weight will be used until the risk of Refeeding Syndrome is considered minimal; from then on, ideal weight will be used.

Predictive Formula	Equation
Harris and Benedict (HB)[39] To estimate the total energy expenditure, it must be multiplied by a correction factor (1.3-1.5) It can be used in elderly patients	• Male: BEE = 66.47 + (4.8 × height [cm]) + (13.75 × weight [kg]) – (6.75 × age [years]) • Female: BEE = 655 + (1.85 × height [cm]) + 9.56 × weight[kg]) – (4.67 × age [years])
Mifflin-St. Peor[40] Adults with normal weight or non-critical obese (real weight) Estimation of EER (energy expenditure at rest = 1.1-1.3 × BEE)	• Male: BEE = 9.99 × weight + 6.25 × height – 4.92 × age + 5 • Female: BEE = 9.99 × weight + 6.25 × height – 4.92 × age – 161
Penn State[41] Critical patients on mechanical ventilation	• HB × 0.85 + ventilation minute (l) × 33 + maximum body temperature (degree Celsius) × 175 – 6,433
Arligton[42] Cerebral palsy	EER = 15.8 *MLG + 460 • Male: %MLG = 0.735 + (sum of PCT + PCP (mm)) + 1 • Female: %MLG = 0.610 + (sum of PCT + PCP (mm)) + 5.1
Butte[43] Pregnant	• BMI < 20 pre-pregnancy EER = BEE + (8.8 × week of pregnancy) • BMI 20-26 pre-pregnancy EER = BEE + (9.5 × week of pregnancy) • BMI > 26 pre-pregnancy EER = BEE + (16.3 × week of pregnancy)
Roza and Shizgal[44] Low weight (BMI < 18 kg/m^2)	• Male: 13.397 × weight (kg) + 4.799 ×height (cm) – 5.677 ×age (years) +88.362 • Female: 3.098 ×height (cm) + 9.247 ×weight (kg) – 4.330 ×age (years) + 447.593
Activity Factor (AF)	At rest in bed: 1.0 Movement in bed: 1.2. Perambulation: 1.3
Disease Factor (DF)	Complex (Major) Surgery:,25-1.40. Scheduled (Minor) Surgery: 1.20. Overall undernourished patients: 1.00. Liver disease: 1.00-1.17. Intestinal Inflammatory Disease: 1.05 in outpatients and 1.10 in hospitalized patients. Transplant: 1.20. Trauma: 1.35. Major burns: 2.10. Infections: 1.25-1.45. Leukemia: 1.34. Lymphomas: 1-25. Pancreatitis: 1.10 (chronic) and 1.12 (acute). 1.20 if there are abscesses. Burns: 1.60. Sepsis: 1.35-1.60. Solid tumours: 1.20 in hospitalized patients and 1.00 in stable outpatients. In all cases, we must also add on a 1.1 DF for each degree over 37°C.

Protein requirements (protein g/kg/day): These will be calculated based on the primary disease and patient situation, because in order to make the best use of nitrogen in protein synthesis processes, the non-protein calories / protein gram ratio must be adequate. That is why in stress periods, the non-protein kcal / nitrogen g ratio will be of 90-100, 160-200 in patients with renal impairment, and 120-160 in the rest of situations.

Basal protein requirements:	0.8-1 g/kg/day
Catabolic patients	1-2 g/kg/day
Renal impairment	0.6-1 g/kg/day
Renal impairment + dialysis	1-1.5 g/kg/day
Renal impairment + continuous hemodiafiltration	1.5-2.5 g/kg/day
Liver conditions	0.6-1.5 g/kg/day

Table 6 *(cont.)*. *Plan for nutritional care in adult patients*

Protein requirements (protein g/kg/day):		
Obese (BMI 30-40 kg/m^2)	2 g/kg Ideal W/day	
Obese (BMI > 40 kg/m^2)	2,5 g/kg Ideal W/day	
Lipid requirements:		
Intake of 1-2.5 g/kg/day. The recommended proportion of lipids is of 30-40% of non-protein calories.		
Carbohydrate requirements (glucose):		
Glucose intake of 4-7 g/kg/day. Don't exceed the 5 mg/kg/min infusion rate. The recommended proportion of glucose is of 60-70% of non-protein calories.		
ELECTROLYTE	REQUIREMENT/ weight kg	DOSE
SODIUM	1-2 mEq/kg	80-150 mEq
POTASSIUM	0.5-1 mEq/kg	40-100 mEq
CHLORIDE	1.5-2 mEq/kg	50-150 mEq
CALCIUM	0.15-0,3 mEq/kg	10-15 mEq
MAGNESIUM	0.25-0.35 mEq/kg	8-20 mEq
PHOSPHATE	0.14 mmol/kg+adjustments according to energy and nitrogen intakes; renal function.	20-40 mmol
ACETATE	Amount required to maintain the acid-base balance.	
Trace Element Requirements		
	AMA/NAG	
Chromium	10-15 µg	
Copper	0.5-1,5 mg 0.3-0,5 mg*	
Manganese	60-100 µg*	
Selenium	20-60 µg*	
Zinc	2.5-5 mg	
*ASPEN Recommendations		
Vitamin Requirements		
Liposoluble vitamins		
	AMA/NAG	FDA
A (retinol)	3.300 UI	3.300 UI
D (ergocalciferol)	200 UI	200 UI
E (alpha tocopherol)	10 mg	10 mg
K (phylloquinone)	100 µg	150 µg
Water-soluble vitamins		
Thiamine (B_1)	3 mg	6 mg
Riboflavin (B_2)	3,6 mg	3,6 mg
Pyridoxine (B_6)	4 mg	6 mg
Cyanocobalamin (B_{12})	5 µg	5 µg
C (ascorbic acid)	100 mg	200 mg
Folic acid	400 µg	600 µg
Nicotinamide	40 mg	40 mg
Pantothenic acid	15 mg	15 mg
Biotin	60 µg	60 µg
Liquid Requirements: Holliday and Segar. In case of hyperthermia, the application will add to these calculations the replacement of those losses caused, estimated in 360 ml/24 h per each degree Celsius over 37 ºC.	Age < 50 years Volume = 1,500 ml + 20 ml × (body weight (kg)– 20) Age> 50 years Volume = 1,500 ml + 15 ml × (body weight (kg)– 20)	

Table 7. *Plan for nutritional care in paediatric patients*

Predictive equations for calculating energy requirements (kcal/day) Total energy requirements (kcal/day): EER x factor (1.1-1.2)				
EER Calculation		With weight	With weight and height	WHO
Boys	0-3 years***	59.48 x W – 30.33	0.167 x W + 1517.4 x H– 617.6	60.9 x W - 54
	3-10 years	22.7 x W + 505	19,6 x W + 130.3 x H + 414.9	22.7 x W + 495
	10-18 years	13.4 x W + 693	16.25 x W+ 137.2 x H + 515.5	17.5 x W + 651
Girls	0-3 years***	58.29 x W – 31.05	16.25 x W + 1023.2 x H -413,5	61 x W - 51
	3-10 years	20.3 x W + 486	16,97 x W + 161.8 x H + 371.2	22.4 x W + 499
	10-18 years	17.7 x W + 659	8,365 x W + 465 x H + 200	12,2 x W + 746
W = weight (kg); H = height (m)				

Energy Requirements in special situations:			
		With weight:	With weight and height
***Infants < 9 kg of weight	TEE (kcal/day)	[98.07 x W (kg)] – 121.73	[10.66 x H (cm)] + [73.32 x W (kg)] – 635.08
	EER (kcal)	[84.5 x W (kg)] – 117.33	[10.12 x H (cm)] + [61.02 x W (kg)] – 605.08
Crítical	TEE=[(17 x age in months) + (48 x W en kg) + (292 x Body temperature in °C) – 9677] x 0.239.		
Obese Adolescents	Male	[16.6 x Real W (Kg)] + [77 x T (metres)] + 572	
	Female	[7,4 x Real W (Kg)] + [482 x T (metres)] + 217	

Protein Requirements: Protein Gram/Weight Kg/day (stable patient)		
AGE	LIMITS	RECOMMENDATIONS
Pre-term newborn	1,5-4	2.5-3.5
Full-term newborn	1.5-3	2.3-2.7
2nd month – 3 years	1-2.5	2-2.5
3-5 years	1-2*	1.5-2
6-12 years	1-2*	1-1.5
Adolescents	1-2	1-1.5
*In critical patients this can be increased up to 3 g/kg/day		

Lipid Requirements:		
AGE	MAX INTAKE g/kg/d	INFUSION RATE g/kg/hour
INFANTS (INCLUDING PTNs)	3-4	0.13-0.17
CHILDREN	2-3	0.08-0.13

Carbohydrate Requirements (glucose):		
AGE	INITIAL DOSE g/kg/d	MAXIMUM DOSE g/kg/d
PTNs	6-12	16-18
INFANTS < 2 YEARS	7-10	16-18
REST OF AGES	4-7	10-14

ELECTROLYTE		TS	IS	GS
SODIUM (mEq/kg/day)	FTNs	0-3 (5)**	2-5	2-3
	PTNs >1.5 kg	0-3 (5)**	3-5	3-5 (7)**
	PTNs <1.5 kg	0-3 (5)**	2-3 (5)**	3-5 (7)**
	>1st month		2-3	
POTASSIUM (mEq/kg/day)	FTNs	0-2	1-3	1,5-3
	PTNs	0-2	1-3	2-5
	< PTNs 1.5 kg	0-2	1-2	2-5
	>1st month		1-3	
**Polyuric stage (values between parentheses)				

	PTNs (/kg/día)	NBs (/kg/day)	<1 YEAR (/kg/day)	1-11 YEARS (/kg/day)	12-15 YEARS (/kg/day)
CALCIUM (mEq)	2-4.5	**2-3**	**1-.12**	**0.5-1**	**0.2-0.4**
PHOSPHATE (mmol)	1.3-2.25	1-1.5	0.3-1	0.25-0.7	0.16-0.3
MAGNESIUM (mEq)	0.25-0.6	**0.25-0.5**	**0.25-0.5**	**0.25-0.5**	**0.2-0.4**

In order to achieve better phosphate-calcium retention, a molar CALCIUM:PHOSPHATE ratio of 1.1-1.3/1 is recommended, or a weight ratio of 1.3-1.7/1.
CALCIUM: 1 mM=40 mg=2 mEq (gluconate 10%: 100 mg=9 mg Ca)
PHOSPHATE: 1 mM=31 mg=2 mEq (CALCIUM/PHOSPHATE ratio = 1.1-1.3/1)
MAGNESIUM: 1 mM=24 mg=2 mEq

Table 7 ***(cont.)***. *Plan for nutritional care in paediatric patients*

Trace Element Requirements			
	PTNs (µg/kg/day)	FTNs-1 year (µg/kg/day)	Rest of ages (µg/kg/day)
CHROMIUM	0.2	0.2	0,2 (max. 5 µg/day)
IRON	100	100	1 mg/day
COPPER[a]	20	20	20 (max. 300 µg/day)
MANGANESE[a]	1	1	1 (max. 50 µg/day)
SELENIUM	2	2	2 (max. 30 µg/day)
ZINC[b]	400	250 < 3months 100 > 3months	50 (max. 5000 µg/day)
MOLYBDENUM	0.25	0.25	0.25 (max. 5 µg /d)
IODINE	1	1	1 (max. 50 µg /d)

[a] In patients with cholestasis, there is a risk of copper and manganese build-up, and therefore it is recommended to reduce their intake.

[b] Besides basal requirements, additional intakes of zinc are required in situations of intestinal loss, at a l 2 mg/kg of loss rate, until a máximum of 6-12 mg/day.

In patients with renal conditions, the intake of selenium, molybdenum and chromium must be reduced.

Vitamin Requirements		
Liposuble Vitamins		
	PTNs (DOSE/KG/DAY)	Infants - Children (DAILY DOSE)
A (retinol)	700-1.500 IU	1.500-2.300 IU
D (ergocalciferol)	40-160 IU	400 IU
E (alpha tocopherol)	3.5 mg	7-10 mg
K (phylloquinone)	8-10 µg	50-200 µg
Water-soluble vitamins		
Thiamine (B_1)	0.35-0.5 mg	1.2 mg
Riboflavin (B_2)	0.15-0.2 mg	1.4 mg
Pyridoxine (B_6)	0.15-0.2 mg	1 mg
Cyanocobalamin (B12)	0.3 µg	1 µg
C (ascorbic acid)	15-25 mg	80-100 mg
Folic acid	56 µg	140 µg
Niacin	4-6.8 mg	17 mg
Pantothenic acid	1-2 mg	5 mg
Biotin	5-8 µg	20 µg

WATER REQUIREMENTS: For paediatric patients, the program will take into account if the patient has been born on full-term (FTN) or pre-term (FTN), in order to adjust water intake to their stage of post-natal adaptation. Three special stages are considered (see requirements in the annex table):

1) Transition Stage (TS): immediately after birth (first 3-6 days).
2) Intermediate Stage (IS): with a duration of 5-15 days.
3) Growth Stage (GS) > 15 days.

		TS	IS	FGS
FTNs (ml/kg/day)		60-120	140	140-170
PTNs (ml/kg/day) > 1500 g		60-80	140-160	140-160
PTNs (ml/kg/day) < 1500 g		80-90	140-180	140-180
FROM THE FIRST MONTH OF AGE				
1ST MONTH-YEAR /kg/day (plus losses)		100 mL		
1st YEAR-12 YEARS/kg/day (plus losses)	< 10 kg	100 ml/kg		
	10-20 kg	1000 ml (first 10 kg) + 50 ml/kg over 10 kg		
	> 20 kg	1500 ml (first 20 kg) + 20 ml/kg over 20 kg (max 2000-2500 mL/24h)		

PTNs: Pre-term newborns
FTNs: Full-term newborns

Table 8. *Ways of Administration*

WAY	TYPE	EXPECTED DURATION	PAEDIATRIC	ADULT
PARENTERAL	CENTRAL	7-28 DAYS	INTERNAL JUGULAR EXTERNAL JUGULAR SUBCLAVIAN HUMERAL UMBILICAL FEMORAL SAPHENOUS	INTERNAL JUGULAR SUBCLAVIAN FEMORAL
	PERIPHERAL < 800 mOsm/L	< 7 DAYS		BASILIC CEPHALIC
ENTERAL	CATHETERS	< 28 DAYS	OROGASTRIC CATHETER NASOGASTRIC CATHETER NASODUODENAL CATHETER NASOYEYUNAL CATHETER	
	OSTOMIES	>28 DAYS	GASTROSTOMY YEYUNOSTOMY GASTROYEYUNOSTOMY	

Table 9. *Physical-chemical stability of preparations*

MACRONUTRIENTS					
AMINOACIDS (%)		GLUCOSE (%)		LIPIDS (%)	
2-5		5-34		1.5-5	
ELECTROLYTES (ternary mixtures)					
POTASSIUM	100 mEq/l	SODIUM	180 mEq/l	MAGNESIUM	15 mEq/l
CALCIUM (mEq/l) + PHOSPHATE (mmol/l)		≤30 mEq/l			
ACETATE		85 mEq/l (not including acateta in aminoacid solutions).			
CALCIUM/PHOSPHATE COMPATIBILITY Base don the volumen to which calcium is added on, and chemical nature of elements.					
INORGANIC CALCIUM/PHOSPHATE CHEMICAL NATURE					
		LIMITS			
AMINOACIDS (%)		> 1.5	1-1.5		< 1
CALCIUM (mEq/l) + PHOSPHATE (mmol/l)		≤30	≤20		Only CALCIUM or only PHOSPHATE
ORGANIC CALCIUM/PHOSPHATE CHEMICAL NATURE (Sodium Glycerophosphate)					
AMINOACIDS (%)		< 0.5	0.5-1.25	1.25-2.5	≥2.5
CALCIUM (mmol/l)		Only CALCIUM or	20	35	56
PHOSPHATE (mmol/l)		only PHOSPHATE	25	30	48

Outcomes

The computer program developed presents the following characteristics:

– It allows the nutritional screening of all patients, from hospital admission to discharge, with 24-hour monitoring 365 days of the year, with a series of screenings until hospital discharge.
– It incorporates automatic nutritional screening systems (FILNUT) (Table 2), and for interviews (NRS 2002 and PYMS) (Table 1,3), that will increase the process efficiency.

Table 10. *Administration*

COMPLICATIONS	CAUSES	ACTIONS
	MECHANICAL	
Erosions	Inadequate location of catheter Inadequate catheter gauge	Check / Modify the catheter location Use lower gauge catheters
Aspiration	Inadequate location of catheter Inadequate catheter gauge Inadequate patient position	Check / Modify the catheter location Use lower gauge catheters Elevate over 30' the bed headboard or half-sit the patient.
Obstructions	Inadequate maintenance Non-adequate product texture	Clean the catheter adequately Prevent lumps in food.
Skin irritation in ostomies	Loss of food or digestive fluid	Hygienic measures
	GASTROINTESTINAL	
Abdominal discomfort	Excessive infusion rate Inadequate temperature of formula Poor absorption issues	Reduce the bolus rate or continuous administration Administer diet at room temperature Eliminate from diet the poorly absorbed component
Nausea and vomiting	Excessive infusion rate Excessive fat content Gastric retention	Reduce the bolus rate or continuous administration Reduce fat intake to <30-40% of the total calories. Administer isotonic formula. Consider use of Antiemetics.
Diarrhea	Preparation contamination Concomitant medication (e.g. Antibiotics, antiacids with Mg) Severe Hypoalbuminemia Excessive fibre in diet Inadequate infusión rate Hyperosmolarity of formula Poor absorption or lack of tolerability to some of the diet components Inadequate temperature of the formula Catheter placed over the pylorus level	MediHygienic measures and adequate diet storage Modify medication, if possible. Otherwise, antidiarrheal drugs Administer isotonic formula Reduce the fibre intake in diet, or modify the type of fibre. Reduce the rate of bolus or continuous administration Reduce formula osmolarity. Consider antidiarrheal drugs Eliminate from diet the poorly absorbed or non-tolerated component (.e.g. lactose-free formula) Administer diet at room temperature Check (Modify the catheter location
Constipation	Fecal impaction Low fibre intake Lack of physical activity Concomitant medication Lack of adequate hydration	Rectal palpation and extraction Administer a fibre-rich diet If possible, increase physical exercise (perambulation) Modify medication, if possible Increase liquid intake
	INFECTIOUS	
Pneumonia	Caused by aspiration	Check catheter location and gauge
Other infections	Insufficient hygienic measures of materials or diet Inadequate storage of diet	Adopt hygienic measures (personal and material cleaning) Control the adequate storage of diets
	METABOLIC	
Hyperglycemia	Associated conditions, e.g. diabetes "Rebound" for re-feeding	Adjust intake based on glycemia. Consider medication. Glycemic control until stabilization.
Hypoglycemia	Sudden withdrawal of nutrition	Gradual withdrawal of diet. Glucose intake.
Dehydration	Insufficient water intake Excessive loss of fluids Use of hypertonic diets	Water intake adjusted according to water balance, weight control, and osmolarity, urea and creatinine monitoring Adequate water intake and watching for abnormal losses. Adequate water intake and administration of isotonic formula.
Inadequate electrolyte levels	Inadequate diet composition Excessive losses (e.g. diarrhea) Concomitant medication (particularly insulin, diuretics)	Control blood levels and adapt diet composition. Trat To treat the cause for excessive losses. To re-consider treatment, if possible. Control serum levels.
	PSYCHOSOCIAL	
Difficulties in adapting to the situation	Change in body image Lack of ability to taste food	Information. Dialogue. Psychological support.

– It incorporates the indirect method of height determination BAPEN, particularly interesting in bed-ridden patients.
– It allows the calculation of energy requirements based on metabolic stress and patient characteristics (cerebral palsy, pregnancy, low weight…) (Table 6,7).
– It provides different prescription assistances based on patient evolution.
– It includes a traceability system of raw materials and sterile preparations, through a datamatrix coding system, as well as for patients through printed identifying wristbands.
– It allows a control of preparation stability according to the information included in the program database (Table 9).
– It prevents mistakes in parenteral nutrition preparation, by generating the preparation sheet with the correct order of component addition, thus preventing its instability.
– It documents the complications of the administration process, directing the nursing staff towards their possible causes, and offering actions to follow in order to correct them (Table 10).
– It prevents administration mistakes by allowing to print patient wristbands that will control the process through reading the datamatrix code of the sample and the barcode of the patient wristband.
– It incorporates a statistical module that allows to extract all information required in order to prepare the scorecard for a Nutrition Unit, according to published standards.
– It considers the multidisciplinary quality of processes, defining different accesses according to the profile of the user: physician, pharmacist, dietician, ward nurse, and pharmacy nurse.
– It generates discharge reports with the summary of all complications presented and the respective actions taken, together with the outcome of the specialized nutritional support.
– It allows an integration with the electronic clinical record (fluid balance and vital constants), hospital census and clinical test lab.

Regarding entries, in the specific case of the *Hospital Comarcal de Inca,* the set of standards for electronic information exchange HL7 version 2.5 are used. This is integrated with the clinical record of the centre: vital constants (systolic pressure, diastolic pressure, temperature, heart rate, partial oxygen saturation), clinical test unit (blood test and biochemical tests), and admission (hospitalization, transfer, and hospital discharge).

Discussion

The Institute of Medicine (IOM) puts forward the following as quality objectives in healthcare: patient safety, efficacy, orientation to patient, opportunity, and equity. These objectives correspond or are related, respectively, with the specialized nutritional support processes that have been incorporated in the program: nutritional screening, formulation of preparations, assessment of nutritional status, and plan for nutritional care, management and dispensing[13].

There are different systems of automated nutritional screening systems for adult patients in scientific literature, CONUT and FILNUT, which allow the systematic detection and early identification of malnourished patients at hospital admission and during hospitalization. The FILNUT system has been implemented in the application developed, because by analyzing at patient admission the relationship between the nutritional risk detected by this screening method, mortality, hospital stay, and re-admission rate, it presented a 92.3% sensibility, a positive predictive value of 94.1%, a 91.2% specificity, and a 0.83 concordance (kappa index, estimated vs. a gold standard for nutritional assessment). Besides, it is worth highlighting that all those patients who meet the criteria for CONUT are included within FILNUT positives[27,34].

According to the outcomes of our article, we must take into account that, in those cases where the integration with the hospital clinical test lab cannot be conducted, the FILNUT screening system will lose its benefit, if the outcomes of biochemical parameters must be entered manually. Therefore, in these cases the NRS-2002 interview system becomes more efficient. In those cases in which integrations with the admission unit and the clinical test lab are possible, the steps in the Method Section will be followed.

There are no automated screeners based on biochemical parameters in paediatric patients, because these are better markers for inflammation or infection than for undernourishment; therefore, they won't show the nutritional status of the patient in case of disease[35]. For this reason, paediatric patient screening is conducted through the PYMS interview system, which considers as malnutrition predictors: the body mass index, recent weight loss, reduction in intake during the past week, and any other condition or situation which might modify the nutritional status of the patient in the following week; these criteria are requirements for screening systems by the ESPEN guidelines[28].

In order to determine the nutritional status of the patient, the *SENPE-SEDOM Document on Hospital Undernourishment Coding* has been adopted for adult patients. Said consensus has been adapted for paediatric patients in terms of biochemical and anthropometric parameters (36). Recently, the following classification for nutritional diagnosis in clinical practice has been proposed: undernourishment associated with starvation, when there is chronic starvation without inflammation; undernourishment associated with chronic disease, when there is chronic inflammation and with mild or moderate intensity, and undernourishment associated with acute disease or stress, when there is acute inflammation or

severe intensity. This classification has not been taken into account, because the first version of the software was already under development; therefore, it will be taken into account for subsequent versions[37].

According to the Institute for Safe Medicine Practices (ISMP), and as a key measure in order to reduce the risk of mistakes, the software will establish by protocol, through an alarm system, the range of maximum and minimal amounts of nutrients and additions for parenteral nutrition preparations, in order to guarantee their stability and compatibility; this will be the same as the majority of software programs currently marketed in our setting. This standardization will also affect clinical aspects, such as the limits in macronutrient contents or the calories/protein balance, which will facilitate treatment validation by the pharmacist, allowing them to confirm that the parenteral nutrition they are preparing is coherent and adapted to patient needs[38].

Finally, it is worth highlighting that a closed module with the quality indicators published so that was not implemented, because said software allows to meet some of them *per se,* such as an universal screening of all hospital population, and nutritional diagnostic coding of patients.

So that the application can be more versatile, all information contained can be used through the generation of dynamic tables combining all variables of different sub-processes; for example, it is possible to determine the relationship between patients at nutritional risk and the level of undernourishment, the prevalence of undernourishment, the number of days on nutritional support based on level of undernourishment, etc.

All these data can be exported in excel, csv and pdf format, so that they can be treated with other information systems for subsequent treatment, if required.

Summing up, this software introduces the concept of quality control by processes in specialized nutritional support, with the objective to determine any points of likely improvement, as well as the assessment of its outcomes.

Once the software has been developed, it is necessary to set it into production, in order to determine if the standardization of specialized nutritional support with said tool will translate into an improvement in quality standards, and in order to assess its limitations.

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