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Cost analysis of adult parenteral nutrition systems; three-compartment bag *versus* customized

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Abstract

Background: **Parenteral nutrition (PN) is a costly technology used widely to provide nutrition to patients who have an inaccessible or non-functioning intestine. Two all-in-one systems currently being used are customized formulations and three-compartment bags.**

Objective: **To provide a systematic cost comparison of the two all-in-one PN systems: individualized (made from nutrient solutions) versus commercialized (made from three-compartment bag), both prepared in hospital pharmacies.**

Setting: **This study was conducted in three public Spanish hospitals.**

Method: **We conducted a cost-minimization study to analyze prospectively the total cost of PN bags, accounting for all of the processes involved in preparing and delivering PN bags (cost of manpower, nutrition solutions, medical supplies and quality controls) in three different healthcare settings. To compare therapeutic alternatives of equivalent nutritional value, the study was performed for the most frequently employed formulation and similar to commercial preparations. A univariate sensitivity analysis was performed to evaluate the impact of different rates of use of three-compartment PN bag.**

Results: **157 routine acts of PN bag preparation (65 customized and 92 three-compartment) were observed and timed over 9 days. Total costs of the 157 PN bags were included in the study. Mean costs of customized bags were higher than three-compartment bags, 51.16 ± 5.63 € versus 39.69 ± 3.00 € respectively (p < 0.01). Manpower costs were responsible for the majority of the differences found (70%). The time to complete an adult bag for the hospital compounded system was a mean of 25.9 minutes longer than the three-compartment system. In scenarios using a three-compartment system for 30%, 70% and 90% of PN provision, a cost savings of 4.3%, 10.1% and 12.9% respectively could be achieved. Greatest rates of changing from customized bags (70% and 90%), in a hospital with 1,800 PN bags/year, might reduce the annual budget by 9306 € and 11,964.8 €, respectively.**

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ANÁLISIS DE COSTES DE LOS SISTEMAS DE NUTRICIÓN PARENTAL; BOLSA TRICOMPARTIMENTAL *VERSUS* INDIVIDUALIZADA

Resumen

Antecedentes: **La nutrición parenteral (NP) es una tecnología costosa que se usa ampliamente para proporcionar nutrición a los pacientes que tienen un intestino inaccesible o no funcional. Los dos sistemas todo en uno que se utilizan en la actualidad son las formulaciones individualizadas y las bolsas tri-compartimentales.**

Objetivo: **Proporcionar una comparación de costes sistemática entre los dos sistemas todo en uno: los sistemas individualizados (preparados a partir de soluciones de nutrientes) frente a los comerciales (hechos a partir de una bolsa tri-compartimental).**

Contexto: **Este estudio se realizó en tres hospitales públicos españoles.**

Método: **Realizamos un estudio de minimización de costes para analizar prospectivamente el coste total de las bolsas de NP, considerando todos los procesos implicados en la preparación y suministro de las bolsas (coste de personal, soluciones de nutrición, material fungible y controles de calidad) en tres centros hospitalarios distintos. Para comparar alternativas terapéuticas de valor nutricional equivalente, el estudio se realizó con la formulación que se empleaba con mayor frecuencia y similar a los preparados comerciales. Se realizó un análisis de sensibilidad univariaante para evaluar el impacto de las diferentes tasas de uso de la bolsa de NP tri-compartimental.**

Resultados: **Se analizaron 157 elaboraciones de bolsas de NP (65 individualizada y 92 tri-compartimentales) programadas durante 9 días. Los costes totales de las 157 bolsas de NP se incluyeron en el estudio. Los costes medios de las bolsas individualizadas fueron superiores a los costes de las bolsas tri-compartimentales, 51,16 ± 5,63 € frente a 39,69 ± 3,00 €, respectivamente (p < 0,01). Los costes de personal fueron los responsables de la mayor parte de las diferencias encontradas (70%). El tiempo para completar una bolsa de formulación individualizada fue en promedio 25,9 minutos superior que para el sistema tri-compartimental. En los supuestos en que se utilizase el sistema tri-compartimental un 30%, 70% y 90% del total de NP, se producirían unos ahorros del 4,3%, 10,1% y 12,9%, respectivamente. Con mayores tasas de cambio (70% y 90%), en un hospital con 1.800 bolsas de NP/año, se podría obtener un ahorro en el presupuesto**

Meanwhile, in a large facility the savings for 8,000 TPN days would be 64,248 € and 82,605 €, respectively.

Conclusions: **Since seeking cost-reduction of effective treatments is needed, the use of three-compartment bags for standard adult PN could lead to cost savings. Our data should be helpful for health care providers to calculate their own cost of administer.**

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anual de 9.306 € y 11.964.8 €, respectivamente. A su vez, en un centro hospitalario mayor, el ahorro para 8.000 bolsas de NP sería de 64.248 € y 82.605 €, respectivamente.

Conclusiones: **Dada la necesidad de buscar una reducción de costes de tratamientos efectivos, el uso de las bolsas tri-compartimentales para la NP estándar del adulto podría conllevar una reducción de costes. Nuestros datos pueden ayudar a los gestores sanitarios a calcular su propio coste de administración de la NPT.**

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Palabras clave: *Análisis de costes. Nutrición parenteral. Métodos de nutrición parenteral. Economía de la nutrición parenteral.*

Abrevations

PN: parenteral nutrition.

Introduction

Parenteral nutrition (PN) was developed to provide intravenous nutrition to patients unable to tolerate gastrointestinal feeding, and is indicated in patients with a non-functioning digestive tract to correct or maintain their nutritional status. PN regimens contain different components, including macronutrients (amino acids, carbohydrates and lipids), and micronutrients (electrolytes, trace elements and vitamins). The most common way to administer PN to adult patients used in health care institutions in Spain is the all-in-one system (all nutrients are mixed in one bag and infused simultaneously).

Actually, two all-in-one systems are using in ours hospitals: customized formulations, prepared by hospital pharmacies or subcontracting laboratories, and industrial three-compartment bags. Thanks to their easy application, three-compartment system should save preparation and handling time on the ward, thus resulting in decreased manpower cost[1]. Since the pressure to reduce health care costs is increasing, attention is focused on cost- effectiveness as well as affordability of treatments.

The purpose of this cost-minimization study was to provide a systematic and comprehensive cost comparison of the two PN systems: hospital-compounded bag and the three-compartment bag system; on the basis that the efficacy and safety are the same, and the use of the three-compartment system might lead to an overall lowest costs and optimizing resources.

Methods

We conducted a prospective and descriptive study to analyze the total cost of PN bags, accounting for all of the processes involved in preparing and delivering PN bags in different healthcare settings. Three Spanish public hospitals participated in the study: Hospital Gregorio Marañón –Madrid– (Hospital 1), Hospital Arnau de Vilanova –Lleida– (Hospital 2), and Hospital Vall Hebrón –Barcelona– (Hospital 3); serving as data collection sites. The centre's costs were calculated using a cost accounting system, which included the same items and allocation criteria for all centres.

Costs were calculated from the perspective of health care institution. The costs per bag of each system included: cost of manpower, nutrition solutions and medical supplies needed. A cost-conscious approach relying on knowing the cost of all aspects of preparing different types of PN was made. The variable, direct cost of the provision of PN includes: PN solutions; nursing, pharmacist and other staff supervision of PN preparation and management; and additional ancillary services required (eg, microbiology tests).

A cost-accounting study of PN preparation and a study of ancillary service utilization were made to estimate the direct cost of PN delivery. Pharmacy, nursing and other staff at each hospital were interviewed to identify hospital-specific methods and work-flow patterns. In this way, a general flow chart documenting the array of steps in the delivery of PN was made. Besides, a structured form was developed and pretested so that the cost data from each hospital could be uniformly filled. Consumption of personnel time and supplies for each work-step were recorded. Pharmacists', nurses' and other staff's PN activities related to PN delivery and preparation were systematically timed. Pharmacy staff activities to handle the orders and to store and manage stock were not timed for each bag but were measured for each one item and extrapolated for one PN bag. Cost of nutrient solutions, additives and medical material needed was calculated using average manufacturers' selling prices to each hospital. Different parameters were taken into account to determine the cost of preparing and delivering PN bags. Variable costs depended on the type of formulation and included the cost of the raw material and the container.

Price of PN bags includes: cost of basic nutrient solutions entering the composition of PN formulas, cost of each category of personnel to produce the PN bag (reception of the prescriptions, preparation and control of the production charts, production process, bacteriology controls, preparation of the delivery boxes, and overhead cost). Overhead cost includes all costs related to cleaning and disinfection, production material (caps, filling devices, needles, syringes, swabs, etc), garments (sterile gloves, headwear, masks, and overshoes), equipment utilization, bacteriology controls, wrappings and PN order handling. As the commercial admixtures used do not contain vitamins, trace elements, or electrolytes, their costs was calculated after supplementation, in the same way as hospital-compounded bags. All time measurements were carried out by one pharmacist and recorded on data collection forms. The data was systematically cross checked by a second pharmacist. The cost of quality control for the bags was calculated from the billing prices provided by the bacteriology laboratory of each hospital. The personnel costs were calculated according to collective agreements for Spanish public service employees[2].

Because the study aimed to determine cost differences, activities of items which applied to and were identical for all two systems were not included in the cost calculation (i.e. central venous catheters, three-way taps, transport services between pharmacy and wards). The start-up costs of developing the PN preparing team are not included here, because we assume these teams are already in existence. Similarly, the overhead costs of operating the hospital (i.e. administrators' salaries, utilities, and building depreciation) are assumed to be fixed and were excluded.

To compare therapeutic alternatives of equivalent nutritional value, the study was performed for the most frequently employed formulation and similar commercial preparations in adult patients. Thereby, PN formulations compared in the study, hospital-compounded and three-compartment bag, had the same amount of nutrients and volume. Characteristics of these PN formulas are listed in table I. All raw materials and all equipment used to prepare all PN in each hospital during three different days were included in the cost analysis. Time spent by each category of personnel related to preparation and delivery of PN, was also recorded daily during these three days. All costs were expressed in euro. Student's *t* test was used to compare the means (non-parametric test, when necessary).

A univariate sensitivity analysis was performed to evaluate the impact of different rates of use of three-compartment PN bag in a Hospital Pharmacy Service. To test the cost accounting model with respect to each centre characteristics, patient requirements, and different PN protocols, different rates of switching from hospital compounding to three-compartment system were developed (30%, 70% and 90%). The analysis was run over a year time horizon and assumed to be placed in two different hospital sizes, a medium size and another larger with a mean of 1,800 and 8,000 PN bags per year, respectively. Based on these assumptions, the model calculates the present value of the savings on costs, as well as on staff time, generated by different rate of switching to the three-compartment system.

Results

A total of 157 routine acts of performing the procedures of preparation of PN bags were observed and timed by stopwatch in 9 different days in the three hospitals included. The total costs of one hundred and fifty-seven PN bags (65 hospital compounded and 92 three-compartment) were included in the study. The time intervals as well as the materials used were recorded on data transcription forms. As Hospital "1" did not use three-compartment PN bags during the study period, data used from this hospital were only for hospital-compounded PN bags

Overall, mean costs of hospital compounded bags were higher than three-compartment bags, 51.16 ± 5.63 € versus 39.69 ± 3.00€ respectively (Table II). Manpower costs were responsible for a major part of the difference between the two ways of preparation studied (70%).

Table III presents the mean time required for each of the subcategories of procedures, the expenditure on hourly wages (depending on category of staff

Table I
Composition of parenteral admixtures studied (Hospital compounded and 3-compartment bag)

	Hospital compounded & 3-Compartment		
Bag content	*(Smofkabiven®/ Oliclinomel® N7)*	*(Smofkabiven®)*	*(Smofkabiven®/ Oliclinomel N8)*
Nitrogen (g)	8 / 6.6	12	16 / 16.5
Carbohydrates (g)	125 / 160	187	250 / 250
Lipids (g)	38 / 40	56	75 / 60
Volum (mL)	1,000	1,500	2,000

Table II
Overall costs, absolute in euro and relative (%), per PN bag

Item	*€/NPT Hospital compounded*	*€/NPT 3-Compartment*	*Difference*
Manpower			
Purchase & Stock Management	2,62	0,40	
Orders & Formula Management	6,19	3,22	
Preparation	6,11	2,61	
Visual & Microbiological Controls	0,34	0,19	
Total	**15,26 ± 2.44** (29.8%)	**6,43 ± 1.80** (16.2%)	**8,83 €**
Materials			
Solutions	29,51	32,92	
Material	6,39	0,33	
Total	**35,90 ± 7.47** (70.2%)	**33,26±3.09** (83.8%)	**2,64 €**
TOTAL	**51,16 ± 5.63**	**39,69 ± 3.00**	**11,47 €***

Total cost expressed as mean ± SD. *p < 0.01 (total cost difference between hospital compounded and commercial PN).

Table III
Times required for earch procedure in minutes

	Hosp. 1		*Hosp. 2*		*Hosp. 3*		*Total*	
	min/PN	*€/PN*	*min/PN*	*€/PN*	*min/PN*	*€/PN*	*min/PN*	*€/PN*
Purchase & Stock Management	**12,6**	**3,77**	**1,6**	**0,48**	**8,9**	**2,64**	**8,8**	**2,62**
Pharmacist	0,3	0,13	0,2	0,06	1,17	0,45	0,3	0,15
Technician*	12,3	3,64	1,5	0,42	7,78	2,19	8,4	2,47
Orders & Formula Management	**10,5**	**4,03**	**31,9**	**12,28**	**2,5**	**0,96**	**16,1**	**6,19**
Pharmacist	10,5	4,03	31,9	12,28	2,5	0,96	16,1	6,19
Technician*	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00
Preparation	**23,0**	**7,62**	**12,1**	**3,75**	**16,4**	**5,02**	**18,8**	**6,11**
Pharmacist	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00
Technician*	23,0	7,62	12,11	3,75	16,4	5,02	18,8	6,11
Visual & Microbiological Controls	**0,3**	**0,11**	**2,3**	**0,72**	**1,5**	**0,46**	**1,1**	**0,34**
Pharmacist	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00
Technician*	0,3	0,11	2,3	0,72	1,5	0,46	1,1	0,34
TOTAL Hospital Compounded PN	**46,3 ± 3.0**	**15,5**	**47,9 ± 5.1**	**17,2**	**29,3 ± 4.4**	**9,1**	**44,7 ± 7.0***	**15,3**
Pharmacist	10,8	4,2	32,0	12,3	3,7	1,4	16,5	6,3
Technician*	35,5	11,4	15,8	4,9	25,7	7,7	28,3	8,9
COMMERCIAL 3-COMPARTMENT PN								
Purchase & Management	**–**	**–**	**0,6**	**0,2**	**1,67**	**0,5**	**1,3**	**0,4**
Pharmacist	–	–	0,1	0,0	0,63	0,2	0,43	0,2
Technician*	–	–	0,5	0,1	1,0	0,3	0,85	0,2
Orders & Formula Management	**–**	**–**	**18,3**	**7,1**	**2,5**	**1,0**	**8,4**	**3,2**
Pharmacist	–	–	18,3	7,1	2,5	1,0	8,4	3,2
Technician*	–	–	0,0	0,0	0,0	0,0	0,0	0,0
Preparation	**–**	**–**	**3,6**	**1,1**	**11,4**	**3,5**	**8,5**	**2,6**
Pharmacist	–	–	0,0	0,0	0,0	0,0	0,0	0,0
Technician*	–	–	3,6	1,1	11,4	3,5	8,5	2,6
Visual & Microbiological Controls	**–**	**–**	**1,4**	**0,4**	**0,2**	**0,1**	**0,6**	**0,2**
Pharmacist	–	–	0,0	0,0	0,0	0,0	0,0	0,0
Technician*	–	–	1,4	0,4	0,2	0,1	0,6	0,2
TOTAL 3-Compartment PN	**–**	**–**	**23,9 ± 1.9**	**8,8**	**15,8 ± 0.2**	**5,1**	**18,8 ± 4.1***	**6,4**
Pharmacist	–	–	18,4	7,1	3,2	1,2	8,8	3,4
Technician*	–	–	5,5	1,7	12,6	3,8	10,0	3,0

Total time expressed as mean ± SD. *p < 0.01 (total time difference between hospital compounded and commercial PN).

involved), and the resulting total personnel costs per procedure for hospital compounded and three-compartment PN bags. The time to complete an adult bag including all activities and personnel categories for the hospital compounded system was a mean of 25.9 minutes longer than the three-compartment system. Besides, hospital compounded system required more time on the ward than three-compartment bag system for all activities. Hospital compounded system required more material and solution items than three-compartment bags; being the mean cost of solutions and material required for preparation 35.90 euro and 33.26 euro, respectively. Mean cost of items (nutrient solutions, additives and material) used per PN bag are detailed in table IV.

We ran the cost model under 3 progressive scenarios depending on the percentage of PN converted to three-compartment system. As for scenario of 30% of use of three compartment system, a 4.3% cost saving was expected. Meanwhile, scenarios of 70% and 90% utilisation could lead to a cost savings of 10.1% and 12.9%, respectively. These results revealed that greatest rates of changing (70% and 90%), in a hospital with 1,800 PN bags/year, might reduce the annual budget in 9306 € and 11,964.8 €, respectively. Meanwhile, in a large facility the savings for 8,000 TPN days would be 64,248 € and 82,605 €, respectively.

Increasing the use of three-compartment system also reduces the time required on the ward in 546 h and 702 h in a medium hospital for utilisation rates of three-compartment system of 70% and 90%, respectively. In large facilities, the mean reduction of time would be 2,426 h and 3,120 h, respectively.

Discussion

This analysis finds that there are important differences in PN costs between hospital-compounded and 3-compartment PN. Savings resulting from lower direct costs (PN components and personnel cost) were considered in this cost analysis. Results from the sensitivity analysis indicate that use of 3-compartment PN may lead to cost savings. The results of the study veri-

Table IV
Mean cost of items used per PN

	Hosp. 1 €/PN	*Hosp. 2* €/PN	*Hosp. 3* €/PN	*Total* €/PN
HOSPITAL COMPOUNDED PN				
Solutions	**26.61 ± 0.13**	**35.83 ± 8.28**	**27.14 ± 4.40**	**29.51 ± 6.37**
Macronutrients (Lipids, Glucose & Amino acids)	18.55	26.46	22.99	
Electrolytes	2.55	7.23	0.75	
Trace elements & Vitamin	5.51	2.14	3.40	
Materials	**6.29 ± 0.27**	**6.17 ± 0.34**	**7.42 ± 0.26**	**6.39 ± 0.49**
Production material (caps, filling devices, needles, syringes, filters, bags, etc)	5.63	5.54	4.48	
Garments (masks, gloves, headwear, etc), Cleaning & Microbiological media	0.46	0.57	1.79	
Water for injection	0.20	0.06	1.15	
TOTAL Hospital Compounded PN	**32.89 ± 0.37**	**42.01 ± 8.60**	**34.56 ± 4.36**	**35.90 ± 6.42***
COMMERCIAL 3-COMPARTMENT PN				
Solutions	**–**	**34.57 ± 0.74**	**31.96 ± 0.84**	**32.92 ± 1.50**
Macronutrients (Lipids, Glucose & Amino acids)	–	31.92	27.96	
Electrolytes	–	0.43	0.60	
Trace elements & Vitamin	–	2.22	3.60	
Materials	**–**	**0.24 ± 0.04**	**0.39 ± 0.42**	**0.33 ± 0.08**
Production material (caps, filling devices, needles, syringes, filters, bags, etc)	–	0.04	0.09	
Garments (masks, gloves, headwear, etc), Cleaning & Microbiological media	–	0.20	0.9	
Water for injection	–	–	–	
TOTAL 3-Compartment PN	**–**	**34.81 ± 0.77**	**32.35 ± 0.82**	**33.26 ± 1.44***

Total cost of materials and solutions expressed as mean ± SD. *$p < 0.01$ (total cost difference between hospital compounded and commercial PN).

fied the hypothesis of cost advantage: compared to hospital compounded PN bags, 3-compartment bags were least expensive.

Our results on compounding cost for adult PN are in agreement with data from the literature, finding a cost savings of 22.4% per bag of the global PN costs[1]. The three-compartment bags were related to lower costs than hospital compounded bags, and also compared to multibottles system. In the same way, a recent study in Germany with ICU adult patients related a reduction of costs of 18% with three-compartment compared to multibottles system[3]. However, results from a similar study costs in France comparing adult PN bag costs with the three systems, showed disadvantage of the three-compartment system versus the other two systems[4]. These differences may be explained by the differences in cost of the solutions and raw materials found between these studies. As reported in a recent cost analysis study of paediatric PN, differences in nutrients and/or supply costs are also between countries and hospitals[5]. Thus, personnel and non nutrition material costs in our study represented a 42.3% of the hospital compounding costs, similar to the 40% reported in the Swiss study[1]. Meanwhile, these costs only represented a 22% in the French study[4].

In our study there was also cost reduction for materials (solutions and material) of € 2.64 per TPN bag; this means a reduction of 7.4% for the 3-compartment bag. Our results are also comparable to the data from the Swiss study of Pichard et al., although it showed a bigger decrease in the costs of material and solutions for the 3-compartment bag[1]. This difference is mainly due to the overhead costs calculated for hospital compounded bags in the Swiss study.

Nevertheless, the main savings identified were related to personnel costs, because of the less manpower time needed for one TPN preparation (44.7 min vs 15.3 min). This personnel workload reduction using the 3-compartment bag was also reported in past studies, even when final results were against the 3-compartment bag[4,6]. Therefore, compared to the hospital compounded system, the increase in 3-compartment system use might represent a reduction of manpower work of 600 h approximately in a medium hospital or for 1,800 PN bags, as the sensitivity analysis found. Since staff costs represent the large part of the overall budget of a hospital, the use of the 3-compartment system might be a cost-savings strategy by reducing personnel time needed.

Moreover, apart from the reduction in the cost of personnel, there is a cost advantage for material and solutions. On average, we found a cost advantage using the 3-compartment bag of 11.47 € per bag compared with the hospital compounded system. These lower costs of the 3-compartment system might represent a saving of the global TPN costs up to 11,900 € for 1,800 PN bags, with a scenario of 90% of use of 3-compartment system.

Apart from the analysis of costs, other aspects of the use of three-compartment bags should be considered. The customized formulas must be prepared almost daily because of limited stability, and their compounding requires special, expensive equipment and infrastructures. Three-compartment bags are pre-mixed products and its sterility is guaranteed by the manufacturing process. Three-compartment bags contain macronutrients and electrolytes in three separate compartments; nutrients are mixed just prior to infusion, by breaking the plastic connectors between the compartments, then vitamins and trace elements are added extemporaneously to the bag. The nutrients are mixed immediately before use by breaking the non-permanent seals between the compartments and require fewer additives. Thereby the likelihood of contamination during PN preparation is minimized, since fewer manipulations are needed and far less time consuming for preparations[6,7]. Besides the less risk of contamination, the simplicity of the three-compartment system also offers additional potential benefits: less risk of production, prescribing or administration errors. The utilization of three-compartment system could be used for the standardization of PN formulations, including prescribing and compounding methods, and therefore could lead to enhance patient safety and reduce both ordering and compounding errors[9-11]. Moreover, the use of three-compartment bags might help to manage workload and lack of manpower, especially during peak periods, week-end and holidays.

Cost analyses are increasingly important to support and justify medical procedures. To our knowledge, this is the first cost accounting analysis of the two main systems of PN bags in Spain. Few studies were made in the past in Europe; however, they reported data from one single hospital. Other limitation of this study is that personnel costs are calculated using Spanish official sources as it was not possible to obtain personnel cost data from the recruited hospitals[2]. Cost analyses should regard overall costs and not only partial results. Therefore, cost analyses regarding PN cannot be restricted to the cost of nutrition solutions alone but should include all the procedures associated with the preparation of PN. We reported data from three teaching hospitals in Spain, performing a detailed study on cost accounting for the PN preparation. We considered the cost not only of solutions but of all materials necessary for the PN preparation. In addition, we timed the duration of manpower work needed for PN preparation using the hospital-compounded and the three-compartment bag system; and the manpower time obtained was similar to those reported in similar studies[1,3,4].

Provided that both types of PN –the hospital-compounded and the 3-compartment system– lead to identical patient outcomes, the type resulting in the overall lowest per-bag costs should be preferred. However, it should be noted that the nutritional support systems considered in this study were only three different PN formulations, and the costs compared were as mean of all PN bags for each system. Therefore, it might affect the hypothetical impact in the hospital budget. Besides, the limited range of 3-compartment

PN formula available, particularly in some countries, might be a potential disadvantage of this system. Nevertheless, a wide variety of standard solutions for PN are available today for adult patients, and they are currently used for various patient populations[11-13].

However, our findings should be verified in each facility, as there might be differences in personnel and materials costs, even in the same country, since wide differences between the hospitals studied have been found. Therefore, some of the differences found in materials and nutrients costs might be minimized with the skills of negotiation of their hospital pharmacy. However, reduction in purchasing prices may depend on the size of the hospital. In this way, strategies as hospital purchasing group alliances, establishment of price ceilings, and nationwide contracts might lead to reducing costs[14]. Several potential benefits of the use of standard solutions have been pointed, and their use is recommended by clinical organizations[3,11]. The manufacturing cost of the three-compartment system compared to the hospital compounding found in this study is lower; mainly due to less time consuming by staff. In this way, our results show data that could help to make decisions when redistribution of workload is needed.

Conclusion

In conclusion, this study showed a cost advantage of 22.4% for the three-compartment system within the framework of three public hospitals in Spain. The use of this system is less expensive than hospital-compounded bag system; mainly due to a reduction in manpower needed. Our data should be helpful for health care providers to calculate their own cost of administering TPN, helping to compare the costs of preparation with alternative methods for each facility.

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