Journal of Renal Transplantation Science
JRTS, 3(1): 140-151
www.scitcentral.com
ISSN: 2640-0847
Original Research Article: Open Access

Cost Analysis of The Peritoneal Dialysis and Hemodialysis in Prevalent Patients in Gerona Province: 2017-2018

Isabel García*, Cristina Noboa, Marcela Castillo, Xoana Barros, Nadia Martin, Jordi Calabia and Pere Torguet

Nephrology Department, University Hospital Josep Trueta, Girona, Spain

Received March 12, 2020; Revised March 23, 2020; Accepted March 25, 2020

ABSTRACT

Purpose: To assess and compare the main direct health costs of dialysis provision, either peritoneal dialysis (PD) or hemodialysis (HD) in a Third-level-University-Hospital (TLUH) during the years 2017 and 2018.

Methods: Retrospective analysis of a prospective database. The study sample included all the patients on dialysis treatment, either PD or HD, including incident and prevalent. All the PD patients were treated in the TLHU. However, the HD patients could be treated either in the TLUH (HDH) or in a contracted out-patient HD-center (CHDC). Cost analysis was carried out from the perspective of the Catalonian Institute of Health (CIH). Healthcare system costs were obtained via CIH. Other costs, such as transport services, food services, etc. were obtained via different sources that will be detailed.

Results: The overall number of prevalent patients on PD and HD were 68 and 156, respectively, in 2017 and 72 and 159, respectively, in 2018. The total costs of dialysis per prevalent patient/year for PD, HDH and CHDC in 2017 were 20,458.5 €, 49,079.0 €, and 52,837,2 €, respectively, and in 2018 were 21,752.6 €, 39,104.8 €, and 53,937.3 €, respectively. The cost-per-session for PD, HDH and CHDC in 2017 were 54.86€, 332.7€ and 228.5€, respectively; and in 2018 were 67.14€, 474.7€, and 228.5€, respectively.

Conclusions: This study suggested that total costs were lower on PD compared to HD, either HDH or CHDC, and regarding HD, CHDC was more expensive than HDH. Additionally, it should be highlighted the relatively high rate of patients on PD.

Keywords: Cost-analysis, Renal replacement therapy, Peritoneal dialysis, Hemodialysis, End-stage renal disease, Health-economic costs

Abbreviations: APD: Automated peritoneal dialysis; CAPD: Continuous ambulatory peritoneal dialysis; CHDC: Contracted out-patient Hemodialysis-center; CI: Confidence interval; CIH: Catalonian Institute of Health; CKD: Chronic kidney disease; ERA-EDTA: European Renal Association–European Dialysis and Transplant Association; ESRD: End-stage renal disease; HD: Hemodialysis; HDH: Hemodialysis at the Hospital; HRQoL: Health related quality of life; KT: kidney transplantation; NHS: National Health Service; OLHDF: Online Hemodiafiltration; PD: Peritoneal dialysis; RRT: Renal replacement therapy; SNHS: Spanish National Health System; TLUH: Third-level-University-Hospital

INTRODUCTION

End-stage renal disease (ESRD) is a prevalent condition worldwide [1]. Patients with ESRD require renal replacement therapy for replacing the functionality of their kidneys. Peritoneal dialysis (PD), hemodialysis (HD) and kidney transplantation (KT) are well established options for treating ESRD. Although KT is considered as the gold standard for renal replacement therapy (RRT), mainly due to its better patient survival and health related quality of life (HRQoL), as well as its cost effectiveness [2-5], the limited number of kidney donors has restricted the possibility of transplant, therefore dialysis, either PD or HD, is essential for patient survival while waiting for KT as well as for those

Corresponding author: Isabel García, University Hospital Josep Trueta, Nephrology Department, Avenida França, S/N.17007 Girona, Girona, Spain, Tel: +34 972 94 02 00; E-mail: isabel0408@yahoo.es

Citation: García I, Noboa C, Castillo M, Barros X, Martin N, et al,. (2020) Cost Analysis of The Peritoneal Dialysis and Hemodialysis in Prevalent Patients in Gerona Province: 2017-2018. J Renal Transplant Sci, 3(1): 140-151.

who are not candidates for KT.

Due to the improvement of chronic kidney disease (CKD) care, as well as the technological and scientific advances in RRT modalities, there has been a slowing-down of ESRD progression, an improvement in life expectancy and a better HRQoL of the patients [6,7]. This improvement, therefore, has transformed ESRD from a terminal disease to a chronic condition with a long-life treatment [6,7]. Hemodialysis and PD are the two common forms of dialysis therapy for ESRD [8-10].

Although 30-40% of ESRD patients could be effectively treated with PD while they are waiting KT, such figures are far away from the current 11% who are undergoing PD [11]. The results of the Spanish Renal Registry reported that in 2017 only a 17.1% of patients who started an RRT did it on PD, while a 78.0% started in some modality of hemodialysis [12]. These results are in agreement with those reported by the European Renal Association-European Dialysis and Transplant Association (ERA-EDTA) [13]. According to this registry, among the patients who started a RRT in 2015, only the 11% did it on PD and the 85% on HD [13].

This actually means that many potential candidates to PD are actually being treated with HD, with the consequent increase in the burden of the disease (economical, personal and social). According to the Spanish Society of Nephrology Registry, the prevalence of RRT has been continuously increasing over the past ten years [12]. Because ESRD is a prevalent condition that requires a long-life treatment, which comprises a highly complex technology and high consumption of human and material resources, it represents a huge economic burden for health systems.

Different cost analyses have found lower costs associated with KT as compared with other RRT modalities [2,3,12,14]. Regarding dialysis, currently available scientific evidence suggest that HD therapy is more expensive than PD therapy in developed countries [5,14,15].

The Spanish National Health System (SNHS) is public, universal and mostly free of charge for the patients except for the share of out-of-pocket expenditure [16]. In 2002, health competences were transferred to the regional level, resulting in 17 regional health ministries with budget holding responsibility and primary jurisdiction over the organization and delivery of health services within their territory [17].

Because dialysis entails a significant impact on the Health System budget, it is extremely important to accurately know the cost of these techniques.

The purpose of this study is to describe and compare the main direct health costs (monetary value) of dialysis provision (PD and HD) in the Josep Trueta University Hospital and its region during years 2017 and 2018.

Methods

Design

Retrospective analysis of a prospective database.

Ethic Committee Approval

This study was approved by The Institutional Review Board of the Josept Trueta University Hospital, which waived the need for written informed consent of the participants.

Environment

Josept Trueta University Hospital is a level III University Hospital located in Gerona (Catalonia, Spain), which offers specialized assistance to a potential population of approximately 800,000 people. It is a reference Hospital of the Integrated Healthcare System under the authority of the Catalonian Institute of Health (CIH). The nephrology service consists of a HD Unit and a PD Unit. The HD has 12 beds (10 beds for chronic patients and 2 ones for acute treatments). There are 2 dialysis shifts: one in the morning from 8 to 14 and the other in the afternoon from 4 to 9 pm.

The PD Unit offers all the techniques and/or modalities of peritoneal dialysis: Continuous ambulatory peritoneal dialysis (CAPD) and Automated peritoneal dialysis (APD). APD is usually performed at night. Regarding CAPD, the treatment scheme is flexible and can be adjusted daily to the activities and schedules of each patient. Independently of the technique, the patient does not need to go to the hospital, except for regular visits (approximately every 1-2 months). Additionally, there is a contracted private out-patient center that provides HD treatments to the vast majority of patients doing HD. Our hospital does not currently offer “home hemodialysis”.

Sample

The study sample included all the patients receiving dialysis treatment, either PD or HD (including incident patients) independently of treatment duration at both the Nephrology Service of the Josep Trueta University Hospital and the out-patient dialysis clinic, during the years 2017 and 2018.

Direct costs

Cost analysis was carried out from the perspective of the regional health System CIH. Healthcare system costs were obtained via CIH. Other costs, such as transport services, food services, other non-medical materials, etc. were obtained via multiple sources. Besides the cost of the procedure, the different items considered in the model included cost of personnel, equipment, vascular (HD) and peritoneal (PD) access, consumables, drugs, laboratory tests, other medical supplies, structure, transport, and complications.

Peritoneal dialysis: Weighted average costs (CAPD and APD) were calculated. Prices of PD treatment per session were extracted from the awarding prices of the regional public procurement contracts CS/CC00/11

00425650/13/MAR [18], including the specific tariffs of icodextrin and bicarbonate-based PD solutions (both of them with premium prices).

Staff cost (doctors, nurses and nurse assistants) were extracted from the book of incomes of the CIH [19]. The cost of patient training was included in the salary of the nursing staff.

Costs associated with the peritoneal catheter placement and the number of interventions were calculated from unpublished data of the calculation of the costs of PD in Catalonia in 2015 year performed by the Catalonian Group of PD.

Cost of days of admission and cost per day of admission were calculated according to the information supplied by the Josep Trueta University Hospital.

The cost of other complications was calculated according to Arrieta [20]. The cost of peritonitis, including laboratory examinations, staff, medical supplies, and drugs was 266.4€ and 278.9€ for CAPD and APD, respectively [20]. All costs were updated to the year of analysis with the overall Consumer Price Index (CPI).

The costs associated with the structure were calculated from unpublished data of the calculation of the costs of PD in Catalonia in 2015 year.

Hemodialysis in contracted out-patient HD center (CHDC):

Prices of CHDC treatment per session were extracted from the Command SLT/244/2016 [21] including the tariff for conventional HD and the premium one for Online Hemodiafiltration (OLHDF).

The cost for the administration has been broken down into different items: Days of admission and cost per day of admission contributed by the hospital; vascular access; and patients transportation. For calculating total costs; the cost of structure; staff; equipment maintenance and amortization; and water consumption were prorated from the HD sessions performed in the Josep Trueta Hospital to those patients treated in contracted out-patient HD clinics.

Hemodialysis in Josep Trueta Hospital (HDH): Prices of HDH treatment per session and number of sessions were extracted from hospital data including the specific prices for conventional HD medical products and the premium tariff corresponding to OLHDF treatments.

Staff cost (doctors, nurses and nurse assistants) were extracted from the book of incomes of the CIH [19].

Cost per hospital day and, therefore, total costs for hospitalization were calculated according to the information supplied by the Josep Trueta University Hospital. The cost of other complications was calculated according to Arrieta [20]. The term other complications included the vascular access complications, such as surgical thrombectomy and fistulography: 2,243.9 €; mechanical or endovascular thrombolysis: 2,711.3 €; or pharmacological thrombolysis: 2249.2 €. All costs were updated to the year of analysis with the overall Consumer Price Index (CPI). Pharmacy and laboratory costs were calculated from data extracted from Hospital accounting system. Structure costs have been prorated 3:1 as compared with PD. Transportation associated costs have been calculated by averaging the lowest of each modality (individual and collective) according to the Command SLT/244/2016 [21]. Water consumption per monitor was calculated from the data provided the manufacturer and the price was averaged from "The price of water in Catalonia, 2016. Annual water price report" [22]. Reimbursement to Hospital for each dialysis session was extracted from the Command SLT/244/2016 [21]. All costs were updated to the year of analysis with the overall Consumer Price Index (CPI).

Statistics

A standard statistical analysis was performed using MedCalc Statistical Software version 19.1.5 (MedCalc Software bv, Ostend, Belgium; https://www.medcalc.org; 2020). Descriptive analysis included mean (standard deviation), 95% confidence interval (CI) and percentages as appropriate. We examined the distribution of continuous variables with a D'Agostino-Pearson test. For comparing quantitative variables, a two-tailed unpaired-samples Student's t test or the Mann-Whitney U test were used as appropriate. Categorical variables were compared using a Chi-square test and a Fisher`s exact test, as needed.

RESULTS

The number of prevalent patients on PD and HD (including those treated in the Josep Trueta Hospital and those in contracted out-patient HD center) were 68 and 156, respectively, in 2017 and 72 and 159, respectively, in 2018 (**Table 1**). At the time of starting RRT, there was not significant differences in mean age between patients underwent PD [62.2 (15.3) years)] and those underwent HD [60.1 (16.19) years], p=0.4618. Among the 53 patients who started dialysis in 2017 in Hospital Trueta, 27 patients did it on PD and 26 ones on HD. Regarding 2018 year, 30 patients started on PD and 15 on HD. From the administration perspective, the total costs of dialysis per prevalent patient/year in 2017 were 20,458.5 €, 49,079.0 € and 52,837,2 € for the PD, HDH, and CHDC, respectively (**Table 2**). On the other hand, the total costs of dialysis per prevalent patient/year in 2018 were 21,752.6 €, 39,104.8 €, and 53,937.3 € for the PD, HDH, and CHDC, respectively (**Table 3**). As compared with PD, in 2018, CHDC resulted 32.184,7 € more expensive than PD, while HDH was 17.352,2 € more expensive than PD. In other words, CHDC was 2.48 and 1.38 times more expensive than PD and HDH, respectively.

Table 1. Number of prevalent patients, sessions, and main characteristics of the study sample.

	2017	2018
Patients PD, n (%)	68 (30.4)	72 (31.2)
Patients HD, n (%)	156 (69.6)	159 (68.8)
HDH[1]	31 (19.9)	34 (21.4)
CHDC[1]	125 (80.1)	125 (78.6)
Number of sessions		
PD	20,193	19,053
Icodextrin[2]	4,445 (22.0)	4,445 (23.3)
Bicarbonate[2]	14,570 (72.2)	17,246 (90.5)
HD	31,415	29,643
HDH[1]	4,573 (14.6)	2,801 (9.4)
CHDC[1]	26,842 (85.4)	26,842 (90.6)
Number of sessions pp/y[3]		
PD	297	265
HD	201	186
HDH	148	82
CHDC	215	215

1. Percentages of HDH and HDAC were calculated according to the HD population.
2. Percentages of PD sessions.
3. Number of sessions/numbers of prevalent patients per year.
PD= Peritoneal dialysis; HDH= Hemodialysis performed in Josep Trueta Hospital; CHDC= hemodialysis in contracted out-patient-center; HD= Hemodialysis

Table 2. Overview of the total and itemized costs (in euros) of peritoneal dialysis (PD), hemodialysis (HD) in Josep Trueta Hospital (HDH) and HD in contracted out-patient hemodialysis center (CHDC) in 2017 and 2018.

	2017 year					
	PD	**HDH**	**Acute CHDC patients**	**Chronic CHDC patients**	**CHDC total**	**CHDC[a]**
Dialysis sessions	1,107,856.7	259,050.4	70,071.3	5,511,949.3	5,582,020.6	
Staff	90,461.1	487,450.7	131,855.8		131,855.8	
Access	36,319.3	138,075.3				
Complications (hospitalization included)	17,029.6	319,629.8	266,400.0		266,400.0	
Pharmacy (erythropoietic agents)	35,320.0	42,677.7				
Laboratory	53,757.4	39,287.0				
Equipment and maintenance		11,966.0	471.2		471.2	
Structure	50,435.6	68,978.1	2,716.1		2,716.1	

Water		299.6	81.0		81.0	
Transport		154,033.3		621,101.8	621,101.8	
Total cost	**1,391,179.7**	**1,521,447.7**	**471,595.4**	**6,133,051.1**	**6,604,646.5**	**1,993,043.1**
Total cost[1]	**1,338,830.1**	**1,005,107.0**	**205,195.4**	**5,511,949.3**	**5,717,144.7**	**1,210,302.3**
Annual cost per prevalent patient	**20,458.5**	**49,079.0**	**3,772.8**	**49,064.4**	**52,837.2**	**52.851.7**
Difference versus PD	**N.A.**	**28,620.4**			**32,378.7**	**32,393.2**
	2018 year					
	PD	**HDH**	**Acute CHDC patients**	**Chronic CHDC patients**	**CHDC total**	**CHDC[a]**
Dialysis sessions	1,279,214.8	169,607.1	70,071.3	5,511,949.3	5,582,020.6	
Staff	115,610.6	436,198.7	192,637.5		192,637.5	
Access	28,957.1	180,212.1				
Complications (hospitalization included)	25,866.6	199,615.0	342,650.0		342,650.0	
Pharmacy (erythropoietic agents)	35,320.0	46,807.8				
Laboratory	27,813.6	39,287.0				
Equipment and maintenance		13,124.0	547.7		547.7	
Structure	53,402.4	75,653.4	3,157.0		3,157.0	
Water		119.1	52.6		52.6	
Transport		168,939.7		621,101.8	621,101.8	
Total cost	**1,566,185.1**	**1,329,563.8**	**609,116.1**	**6,133,051.1**	**6,742,167.2**	**1,938,679.9**
Total cost[1]	**1,504,998.5**	**914,201.3**	**266,466.1**	**5,511,949.3**	**5,778,415.4**	**1,180,667.4**
Annual cost per prevalent patient	**21,752.6**	**39,104.8**	**4,872.9**	**49,064.4**	**53,937.3**	**43,977.8**
Difference versus PD	**N.A.**	**17,352.2**			**32,184.7**	**22,225.2**

PD= Peritoneal dialysis; HDH= Hemodialysis performed in Josep Trueta Hospital; CHDC= hemodialysis in contracted out-patient-center; NA= Not available.
[a] total cost attributed to the hospital
[1] Total cost excluding pharmacy, hospitalization and transport

Table 3. Overview of the cost (in euros) associated with peritoneal dialysis in years 2017 and 2018.

	2017		**2018**	
Sessions	**Price**	**Total cost**	**Price**	**Total cost**
CAPD	40.9	171,772.0	40.9	414,829.4
APD	71.0	735,899,8	71.0	632,291.9
Icodextrin	6.0	26,452,2	6.0	26,452,2
Bicarbonate	11.9	173,732,7	11.9	205,641,3
CPS	**54.9**	**1,107,856.7**	**67.1**	**1,279,214.8**

Staff	N	Payment	CPPP		N	Payment	CPPP	
Doctors	0.75	44,611.3	492.0		1.00	44,611.3	619.6	
Nurses	1.50	27,993.3	617.5		2.00	27,993.3	777.6	
Nursing assistants	0.00	19,059.5	0.0		0.00	19,059.5	0.0	
Head of Department	0.10	58,890.2	86.6		0.10	58,890.2	81.8	
Head of nurses	0.20	35,092.8	103.2		0.20	35,092.8	97.5	
Secretary	0.10	21,051.8	31.0		0.10	21,051.8	29.2	
Total			**1,330.3**				**1,605.7**	
Catheter	**N**	**CpU**	**Total**		**N**	**CpU**	**Total**	
Ultrasound	33	998.6	32,951.2		29	998.5	28,957.1	
Laparoscopic	2	1,684.1	3,368.1		0	1,684.1	0.0	
Complications	**N(D)**	**CpU**	**Total**	**Average**	**N(D)**	**CpU**	**Total**	**Average**
Admissions	3(15)	555.0	8,325.0	122.4	5(30)	555.00	16,650.0	231.3
Other		128.0	8,704.6			128.01	9,216.6	
Total			**17,029.6**	**250.4**			**25,866.6**	**359.3**
Pharmacy	**CPPP**		**Total**		**CPPP**		**Total**	
	519.4		35,320.0		490.6		35,320.0	
Laboratory	**N**	**CpU**	**Total**	**PPP**	**N**	**CpU**	**Total**	**PPP**
Blood test	5	134.8	663.8		2	134.8	269.5	
Microbiology	4	29.2	116.8		4	29.2	116.8	
Total			**53,757.4**	**790.6**			**27,813.6**	**386.3**
Structure	**CPS**	**CPPP**	**Total**		**CPS**	**CPPP**	**Total**	
Blood test	2.0	741.7	50,435.6		2.03	741.7	53,402.4	

CAPD=Continuous ambulatory peritoneal dialysis; APD=Automated peritoneal dialysis; CPS=Cost per session; CPPP=Cost per prevalent patient year; CpU=Cost per unit; N0 Number; D=Days

For PD, the cost per session (cps) was 54.86 € and 67.14 € in years 2017 and 2018, respectively. This means an increase of 12.28 (22.4%) € (table 3). Interestingly, the rate of icodextrin usage was the really very similar in 2017 (22 %) and in 2018 (23%), p=0.8344. However, the rate of bicarbonate usage was significantly higher in 2018 (90.5%) than in 2017 (72%), P=0.0410. The total cps of the CHDC in 2017 and 2018 was 228.5 € each, respectively. The cost is itemized in **Table 4**.

The cps of HDH was 332.7 € and 474.7 € in 2017 and 2018, respectively. Such increase was mainly due to the greater number of OLHDF sessions in 2018 (1,142 that represented a 41% of the HD sessions) than in 2017 (915 that represented only the 20% of the HD sessions). Nevertheless, for HDH, it can be observed a reduction in 9,974.14 € in 2018 as compared with 2017 per prevalent patient. The costs were broken down in **Table 5**.

Regarding complications, independently of the technique, the highest cost was associated with hospital admissions. The cost attributable to complications was much lower with PD (average cost per prevalent patient/year 250.4 and 359.3 in 2017 and 2018, respectively) than with CHDC (average cost per prevalent patient/year 2,131.2 and 2,486.4 in 2017 and 2018, respectively) or with HDH (average cost per prevalent patient/year 1,844.0 and 3,770.7 in 2017 and 2018, respectively).

DISCUSSION

This study collected and analyzed costs relating to materials; pharmacy; personnel (doctors, nurses and nurse assistants); administrative and hospitalization fees; hospitalizations due

to complications; patient transportation; as well as other incidentals, to establish economic parameters.

Table 4. Overview of the cost (in euros) associated with hemodialysis in arranged centers (HDAC) in years 2017 and 2018.

	2017				2018			
Price	**PPS**		**Total**		**PPS**		**Total**	
Conventional	200.2		4,369,983.7		200.2		4,369,983.7	
OLHDF	227.7		1,141,965.65		227.7		1,141,965.7	
Complications	N	CpU	Total[a]	CPP[b]	N	CpU	Total[a]	CPP[b]
Admissions[c]	480	555.0	266,400.0	2,131.2	560	555.0	310,800.0	2,486.4
Access thromboses								
Angioplasty	0	0	0	0	2	2,500.0	5,000.0	
Other	0	0	0	0	19	1,550.0	25,650.0	
CPS	0	0	0	0	2	600.0	1,200.0	
Total			**58.3**				**122.33**	
			266.400.0				**342,650.0**	
Access[d]	**N**	**CpU**	**Total**		**N**	**CpU**	**Total**	
IAVF								
Placement	0	957.0	0		0	957.0	0	
Reparation	0	957.0	0		0	957.0	0	
CVC	0	470.3	0		0	470.3	0	
PC	0	4,736.0	0		24	4,736.0	113,664.0	
Transport	N	CPS	CPP/Y	Total	N	CPS	CPP/Y	Total
Hospital transportation	39,000.0	31.9	4,968.8	621,101.8	39,000.0	31.9	4,968.8	621,101.8

aCost per request
bAveraged
cNumber of days
dVascular Access
PPS=Price per session; N=Number of patients; CpU=Cost per unit; CPS=Cost per session; IAVF=Internal arteriovenous fistula; CVC=Central venous catheter; PC=Permanent catheter

Table 5. Overview of the cost (in euros) associated with hemodialysis in Josep Trueta Hospital (HDH) in years 2017 and 2018.

	2017				2018			
Cost	**CPS**		**Total**		**CPS**		**Total**	
Conventional	52.9		193,453.3		52.9		87,736.2	
OLHDF	71.6		65,597.0		71.6		81,870.8	
Equipment	**N**	**CPS**	**CPP/Y**	**CPE**	**N**	**CPS**	**CPP/Y**	**CPE**
HD monitors		2.5	386.0			2.5	386.0	

Other								
Infrastructure	**m^2**	**CPS**	**CPP/Y**	**CPm^2**	**m^2**	**CPS**	**CPP/Y**	**CPm^2**
Dialysis room								
Changing room								
Other		2,225.1	14.3			2,225.1	14.3	
Staff	**N**	**Income**	**CPS**	**Total**	**N**	**Income**	**CPS**	**Total**
Doctors	2.0	44,611.3	4.4	89,222.6	2.0	44,611.3	4.7	89,222.6
Nurses	16.0	27,993.3	22.2	447,892.2	16.0	27,993.3	23.5	447,892.2
Nursing assistants	1.0	19,059.5	0.94	19,059.5	1.5	19,059.5	1.5	28,589.2
Head of	0.5	58,890.2	1.5	29,445.1	0.5	58,890.2	1.6	29,445.1
Department	0.7	35,092.8	1.2	23,161.3	0.7	35,092.8	1.2	23,161.3
Head of nurses	0.5	21,051.8	0.52	10,525.9	0.5	21,051.8	0.55	10,525.9
Secretary			**30.7**				**33.0**	
Total				**19,977.6**				**18,495.2**
PPP								
Access[d]	**N**	**CpU**	**CPS**	**Total**	**N**	**CpU**	**CPS**	**Total**
IAVF								
Placement	18	957.0		17,226.0	26	957.0		22,011.0
Reparation	10	957.0		9,570.0	6	957.0		5,742.0
CVC	5	470.3		2,351.3	12	470.3		5,643.1
PC	23	4,736.0		108,928.0	31	4.736.0		146,816.0
Total			**30.2**	**138,075.3**			**63.3**	**180,212.1**
Laboratory	**N**	**CpU**	**Total**	**PPP**	**N**	**CpU**	**Total**	**PPP**
Blood test	10	134.8		1,347,5	10	134.8		1.347,5
Microbiology	1	29.3		29,2	1	29.3		29,2
Total			**42,677.7**				**46,807.8**	
CPS				**8.8**				**8.8**
Complications	**N**	**CpU**	**Total[a]**	**CPP[b]**	**N**	**CpU**	**Total[a]**	**CPP[b]**
Admissions[c]	103	555,0	57,165.0	1,854.0	231	555.0	128,205.0	3,770.7
Access thromboses	4	458,0	1,348.0		4	2,500.0	10,000.0	
Angioplasty		337,0			9	1,350.0	12,150.0	
Other		778,5			8	600.0	20,400.0	
Admissions[d]	427	555.0	236,985.0		52	555.0	28,860.0	
CPS			**18.1**				**61.0**	
Total			**294,150**				**199,615.0**	
Transport	**N**	**CPS**	**CPP/Y**	**Total**	**N**	**CPS**	**CPP/Y**	**Total**

Hospital transportation	9,146	31.9	4,968.8	154,033.3	5,602	31.9	4,968.1	168,939.7
Water	**C/S(l)**	**CPm^3**	**CPS**	**Total**	**C/S(l)**	**CPm^3**	**CPS**	**Total**
Consumption	150.0	3.0	0.45	2,057.9	150.0	3.0	0.45	1,260.5
Pharmacy	N	CPS	Total		N	CPS	Total	
	34	8.6	39,287.0		34	14.0	39,2897.0	

[a]*Cost per request*
[b]*Averaged*
[c]*Number of days*
[d]*Patients admitted in other hospitals*
CPE= Cost per equipment

The results of this study suggested that on average, the costs associated with HD are greater than those of PD. When comparing total costs (including those of dialysis sessions, complications-hospital admissions, and patient transportation) of PD versus HD (combining both CHDC and HDH) it can be observed that HD resulted in an extra charge per prevalent patient/year of 31,631.8 € in 2017 and 29,013.0 € in 2018.

It should be pointed out that, within hemodialyzed patients, the cost is greater among those treated in CHDC (52,837.2 € and 53,937.3 € in 2017 and 2018, respectively) than among those treated in the Josep Trueta Hospital (49,079.0€ and 39,104.8 € in 2017 and 2018, respectively).

Regarding those HDH patients there was a saving costs of 191,893.9 € between 2017 and 2018. This cost saving was due to the reduction in the incidence of complications, for being precise, the decrease in the number of days of hospitalization in a hospital different than Josep Trueta Hospital. When comparing our results with the current literature, it can be observed that with the exception of the Berger et al study [23] that reported a total cost significantly greater than ours for HD (232,934.9 €) and for PD (161,433.9 €) (values calculated according the current exchange rate), our results are in line with the published literature (**Table 6**).

Table 6. Overview of the total cost associated with peritoneal dialysis (PD) and hemodialysis (HD) in different studies.

Study	Country	Currency	HD	PD	Year of publication
Salonen et al. [14]	Finland	US $	54,140	45,262[a]	2003
Baboolal et al. [15]	UK	£	35,023[c, d]	15,570[a, b]	2008
Berger et al. [23]	USA	US $	263,001[e]	182,292[e]	2009
Villa et al. [5]	Spain	€	37,968[f]	25,826[f]	2011
de Abreu et al. [24]	Brazil	US $	28,570[f]	27,158[f]	2013
Vaccaro et al. [25]	Italy	€	38,656.6[f, g]	26,835.9[f, g]	2017
Conde-Olasagasti et al. [16]	Spain	€	48,021[f]	48,703[f]	2017
Koukou et al. [26]	Greek	€	48,230.4[i]	39,051.6[i]	2017
Wong et al. [27]	Hong-Kong	HK$	380,490.5[j, k]	99,631.5[j, k]	2019
Zhang et al. [28]	China	CNY	94,760.5[l]	80,762.9[l]	2020
Current study	Spain	€	51,421.7[f, m]	21,124.0[f, m]	N.A.

[a]*Continuous ambulatory peritoneal dialysis (CAPD).*
[b]*Cost of automated peritoneal dialysis (APD): 21,655 £.*

[c]*Hospital based HD.*
[d]*Cost of satellite-unit-based HD: 32 669 £.*
[e]*Total cost per patient, including health costs, inpatient costs, other services for outpatient office visits and other costs.*
[f]*Weighted average for Hospital HD and incenter HD or APD and CAPD, as appropriate.*
[g]*Total cost per prevalent patient year was calculated multiplying the average cost per week per 52 weeks per year.*
[h]*Weighted average for 2012 and 2013.*
[i]*Total cost per prevalent patient year was calculated multiplying the average cost per month per 12 months per year.*
[j]*Weighted average for the first and second year of treatment.*
[k]*Equivalent cost in euros 2019: 42,940.4€ and 11,243.9€ for HD and PD, respectively.*
[l]*Direct medical costs.*
[m]*Weighted average for 2017 and 2018*

The higher costs associated with HD treatment comparing with PD treatment is not surprising [5,14-16,20,23-28]. In the HDH patients' group, the cost of hospital staff (doctors, nurses and nurse assistants) represented the greatest weight on the total costs (487,450.7 € and 436,198.7 € in 2017 and 2018, respectively). In fact, personnel costs were a 32.0% and a 32.8% of the total cost associated with HDH in 2017 and 2018, respectively. These results did no differ from those reported by Vaccaro & Sopranzi in 2017 [25], who showed that personnel associated costs had the greatest impact on the direct costs of HD.

Although in agreement with Vaccaro & Sopranzi [25] the cost of hospital staff for PD was significantly lower representing a 6.5% and a 7.4% of the total costs of PD in 2017 and 2018, respectively, these figures are lower than those reported by them [25]. The cost associated with dialysis, either HD or PD, was slightly greater than that reported by Wong et al. [27], especially for PD, which resulted to be an 87.8% more expensive in our study, while HD resulted to be a 19.8% more expensive in ours.

When comparing the results of this study with those published in a Spanish setting, we also found that costs associated with HD are higher than those of PD [5,16]. Villa et al. [5] reported a total cost of 37,968 € and 25,826 € for HD and PD, respectively, in 2010 year. When we update the prices by using the CPI it results in an increase of the 8.6% between December 2010 and December 2018 [29]. With this rate of variation, the updated costs of Villa et al. are 41,233.2 € and 28,047.0 € for the HD and PD, respectively. The weighted average costs for HD (HDH and CHDC) and for PD (CAPD and APD) in 2017 and 2018 in our study were 51,412.1 € and 21,124.0 €, respectively. These results actually mean that costs associate with HD in our study were greater than those reported by Villa et al., being the costs of PD lower [5].

When comparing our results (weighted average costs for 2017 and 2018 years) with those of Conde-Olasagasti et al. [16] (without CPI update), we found that while the cost of HD (both HDH and CHDC) was similar, the cost of the PD was 27,580 € lower in our study. This might be explained by a more efficient ratio of nurse/patient and by a low rate of complications.

The selection of a dialysis modality critically depends on disease progression at the time of referral to Nephrology. Early detection certainly bears on the variety of treatment options. Although patient outcomes with PD are comparable to or better than those with HD, and PD results in lower costs, not all the patients are candidates to initiate a RRT with PD. Some patients do not start on PD due to clinical reasons [30], but other ones due to patient-related challenges, including limited health literacy, cognitive decline, depression, comorbidities, cultural differences, etc. [31].

As the majority of patients could choose either PD or HD, it is extremely important to engage patient in dialysis modality decision [32]. A greater involvement and education of patients, caregivers and hospital personnel (doctors, nurses and nurse assistants) will help in the decision-making process for choosing the dialysis modality that best fits for each patient, which, therefore, will significantly improve clinical and HRQoL outcomes [33]. As mentioned in the introduction section, the dialysis provision is covered by the NHS resulting in a huge cost for the Public Administration. From the NHS perspective not only the clinical criteria but also the economic one matters when selecting therapeutic strategies. From a public budget holder perspective, the results of the current study suggested that treating 2.4 PD (weighted average for APD and CAPD) patients equates to providing dialysis to only one patient on HD (weighted average for HDH and CHDC), which in terms of cost is relevant for the sustainability of the NHS.

This fact may also have played a role in the relatively high rate of patients on PD found in our study (30.4% and 31.2% in 2017 and 2018, respectively) as compared with the figures published by Li et al. [11] or by the Spanish Renal Registry: 2017 report [12], which found that only an 11.0% and a 5.2% of the prevalent dialysis patients, respectively, were on PD. These findings may lead to the hypothesis that the health care financing model of a country or a region might have a significant influence on the RRT modality selection [5].

Finally, total cost of patient transportation per prevalent patient/year was 4,968.1 € for 2017 and 2018 each, respectively. These results are in line with those reported by Villa et al. [5] (5,515.8€, when updating the prices by using the CPI [29], but they were a 41.4% lower than those reported by Conde Olasagasti et al. [16]. Such a difference might be mainly due to the huge difference in surface area between Gerona (5,910 km2) and Toledo (15,369 km2).

This study has limitations that should be taken into account when interpreting its results. The first one is its single center design. The costs of dialysis may only reflect the reality of Catalonia and more specifically, that in Gerona province. Although the methodology could be easily replicated in other regions, the important dispersion regarding healthcare budgets, healthcare expenditure per capita, prices and the specific body that holds each budget line, in other words, the concrete funding model for dialysis treatments, among the autonomous communities (and even between hospitals) would probably deliver different results in terms of dialysis costs.

The second limitation is the fact that we have used an "intent-to-treat" approach for cost calculation. Therefore, transfers between modalities definitively imply costs that may make difficult to allocate each of the modalities. Despite these limitations, this study provides a detailed cost analysis of both HD and PD, from the perspective of the Public Healthcare Administration as budget holder. This study suggested that total costs were lower on PD compared to HD, either HDH or CHDC, and that they were lower for HD in the Josep Trueta Hospital than the contracted out-patient HD center. Additionally, it should be highlighted the relatively high rate of patients on PD. Further studies, preferably prospective cost-effectiveness analysis should be performed to elucidate the most cost-effective RRT strategy.

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