

*Original Article***Cost analysis of the Spanish renal replacement therapy programme**Guillermo Villa^{1,2}, Ana Rodríguez-Carmona³, Lucía Fernández-Ortiz¹, Jesús Cuervo¹, Pablo Rebollo¹, Alfonso Otero⁴ and Javier Arrieta⁵¹Department of Health Outcomes Research, BAP Health Outcomes Research, Oviedo, Spain, ²Department of Medicine, Universidad de Oviedo, Oviedo, Spain, ³Department of Nephrology, Complejo Hospitalario Universitario A Coruña, A Coruña, Spain, ⁴Department of Nephrology, Complejo Hospitalario de Ourense, Ourense, Spain and ⁵Department of Nephrology, Hospital Universitario de Basurto, Bilbao, Spain*Correspondence and offprint requests to:* Guillermo Villa; E-mail: guillermo@baphealth.com**Abstract****Background.** A cost analysis of the Spanish Renal Replacement Therapy (RRT) programme in the year 2010, for end-stage renal disease (ESRD) patients, was performed from the perspective of the Public Administration.**Methods.** The costs associated with each RRT modality [hemodialysis (HD), peritoneal dialysis (PD) and kidney transplantation (Tx)] were analysed. The Spanish ESRD incidence and prevalence figures in the year 2010 were forecasted in order to enable the calculation of an aggregate cost for each modality. Costs were mainly computed based on a review of the existing literature and of the Official Bulletins of the Spanish Autonomous Communities. Data from Oblique Consulting eSalud health care costs database and from several Spanish public sources were also employed.**Results.** In the year 2010, the forecasted incidence figures for HD, PD and Tx were 5409, 822 and 2317 patients, respectively. The forecasted prevalence figures were 22 582, 2420 and 24 761 patients, respectively. The average annual per-patient costs (incidence and prevalence) were €2651 and €37 968 (HD), €1808 and €25 826 (PD) and €38 313 and €6283 (Tx). Indirect costs amounted to €8929 (HD), €7429 (PD) and €5483 (Tx). The economic impact of the Spanish RRT programme on the Public Administration budget was estimated at ~€1829 million (indirect costs included): €1327 (HD), €109 (PD) and €393 (Tx) million.**Conclusions.** HD accounted for >70% of the aggregate costs of the Spanish RRT programme in 2010. From a costs minimization perspective, it would be preferable if the number of incident and prevalent patients in PD were increased.**Keywords:** cost analysis; end-stage renal disease; haemodialysis; kidney transplantation; peritoneal dialysis**Introduction**

End-stage renal disease (ESRD) includes Stages 4 and 5 of the classification of the chronic kidney disease (CKD) proposed by the Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines [1]. According to the ERA-EDTA registry, Spain shows a higher ESRD prevalence than other European countries. In regard to ESRD incidence, i.e. the patients who start in any renal replacement therapy (RRT) modality for the first time, Spanish figures are similar to those from other nearby countries [2]. Specifically, in 2009, an incidence of 129 and a prevalence of 1039 patients per million population were registered by the Spanish Society of Nephrology (SEN, Spanish acronym) [3].

Due to the serious health care and economic implications of CKD, early detection is particularly important. This would require greater collaboration between the primary care doctors and the nephrologists [4–6]. In 2008, the SEN and the Spanish Society of Family and Community Medicine (semFYC, Spanish acronym) published a consensus document on CKD, in which they recommended patients in ESRD to be referred to nephrology for evaluation and follow-up [7].

From a clinical perspective, a timely diagnosis favours the slowing of the progression of the disease, while at the same time increasing the ability to control risk factors, such as cardiovascular events [8]. Different studies have shown that a delayed referral of the patient to nephrology leads to worse results in terms of morbidity and mortality [9–12], as well as in economic terms [13–17]. Likewise, follow-up of patients in ESRD-specific units enables them to be informed on the different RRT modalities [haemodialysis (HD), peritoneal dialysis (PD) and kidney transplantation (Tx)] and gives them the opportunity to make a choice and to provide informed consent for the selected modality. Different studies have shown that the number of patients who prefer home-based dialysis increases when they have such information available to make a choice [18–21].

Various studies have also proven that the costs associated to Tx are lower than the costs associated with the rest of the

RRT modalities, starting with the second year, since the greatest proportion of the treatment costs are incurred during the first year (admittance, surgery, greater immunosuppressant doses, etc.) [22, 23]. On the other hand, several studies have concluded that HD therapy is more expensive than PD therapy in developed countries [24–27]. In Spain, different cost analyses have reached the same conclusion [28, 29].

Within the Spanish National Health System (SNS, Spanish acronym), RRT is free of charge for the patient, but the high impact of the RRT programme costs on the national budget needs to be considered. This study seeks to estimate the costs of providing RRT health care for the ESRD patients in Spain, from the perspective of the Public Administration. It is possible to estimate the global cost of treating all RRT patients in a nephrology unit and, based on that estimate, to calculate the average cost for a single patient [30]. This study, conversely, chooses to analyse the costs of the individual items, which are then added up to provide annual per-patient average figures as well as aggregate costs for each RRT modality. This approach constitutes a more realistic approximation of the cost, according to a rigorous methodology [31].

Materials and methods

A cost analysis of the Spanish RRT programme in the year 2010 was carried out from the perspective of the Public Administration. Direct (medical and nonmedical) and indirect costs were considered. Additionally, the incidence and prevalence figures of the different RRT modalities in the year 2010 were forecasted employing the nonparametric regression methodology proposed by Villa *et al.* [32] and using the publicly available data from the SEN [33] and the Spanish National Transplant Organization (ONT, Spanish acronym) [34] registries. Firstly, the original data from those registries were collected and weighted in order to account for the whole Spanish population. Secondly, linear trends were fitted by means of nonparametric quantile regressions (QR) with bootstrapped SE. QR is suitable in the case of tailed-distributed dependent variables and in the possible presence of outliers, since it predicts the conditional median of the response, instead of its conditional mean [ordinary least squares (OLS) approach]. The forecasted incidence and prevalence figures allowed the calculation of an aggregate cost for each RRT modality.

Costs, described below in detail, were estimated based on a systematic review of the existing literature and of the Official Bulletins of the Spanish Autonomous Communities. Data from Oblique Consulting eSalud health care costs database [35] and from the Spanish National Statistics Institute (INE, Spanish acronym) [36] were also collected. Regarding the update of past costs to January 2010, either the general consumer price index (CPI) or the specific CPI for the medical sector was applied, both of them provided by the INE.

Direct medical costs

Vascular (HD) and peritoneal (PD) accesses

In order to estimate the cost of the vascular access, the average number of arteriovenous fistulas (AVF) performed was considered. The average number of intravenous catheters and the number of days of hospitalization were also taken into account [37]. Regarding the peritoneal access costs, a total cost including laboratory, personnel, surgical materials, health care materials, anesthesia, drugs and other costs was computed [38].

Training

Regarding PD, a distinction was made between training in a hotel, inpatient or outpatient mode [39]. A weighted average was computed from the percentage of patients who start in continuous ambulatory peritoneal dialysis (CAPD) (64%) or in ambulatory peritoneal dialysis (APD) (36%)

[40]. Training costs included the costs of personnel, health care materials and drug consumption.

HD treatment session

Regarding hospital haemodialysis (HHD), the focus was placed on the patients who were considered a group at risk for the hepatitis C virus (HCV). Since these patients need to be isolated from the rest of patients, the way that nursing personnel takes care of them is different from that required for the rest of the unit. A weighted average was calculated based on the consideration that the prevalence of antibodies against the HCV in patients within the HD programme was 12% [39]. The cost of the HD treatment session included the costs of applying a bicarbonate-based solution. A weighted average cost was calculated based on the distribution observed [45% of the patients in HHD and 55% in incenter haemodialysis (ICHHD)] [41].

PD treatment session

The cost of the treatment session was estimated assuming that half of the patients used a non-buffered glucose solution and that the remaining patients used a buffered one. Again, a weighted average was estimated from the proportion of patients in APD and CAPD.

Drug consumption

The immunosuppressant medication was considered for Tx and the recombinant human erythropoietin (rHuEPO) and the intravenous iron consumption was taken into account for HD and PD [42]. There is evidence that the residual renal function is better maintained in patients treated under PD compared to HD [43, 44]. In turn, a greater dose of rHuEPO is required for HD patients [45].

Vascular (HD) and peritoneal (PD) accesses complications

Regarding HD, the cost of a thrombosis was considered taking into account the various treatment options (surgical thrombectomy, mechanical or endovascular thrombolysis and pharmacomechanical thrombolysis) [46]. After thrombectomy or thrombolysis, a fistulography must be performed to detect any possible stenosis as the cause of the thrombosis. For the estimation of the average number of thrombosis that a single patient will suffer within a year, the type of vascular access was taken into account, since the frequency of complications differs depending on whether the access is an AVF, a catheter or a polytetrafluoroethylene (PTFE) prosthesis. Specifically, it was assumed that patients with AVF (81%) suffer ¼ thromboses per year, as compared to ½ thromboses suffered by catheterized patients (10%) and ½ suffered by patients with PTFE prostheses (9%) [47]. The costs stemming from the vascular access complications depend on whether a patient starts in HD as scheduled or unscheduled. This cost was already included within the vascular access costs, so the present cost refers to posterior complications. Regarding PD, one of the most frequent complications is peritonitis. It can be assumed, as a general rule, that ½ episodes will occur every year [48]. The costs derived from the PD access complications and the treatment of peritonitis included laboratory, personnel, health care material and drug consumption [38].

Nephrology general expenses, equipment depreciation, maintenance and external services

These costs were calculated using data from the SEN Costs Working Group [49]. In the case of HHD, they included general direction, administrative management, personnel costs, expenses related to the hospital structure and overhead, general maintenance expenses, purchasing and storage. For ICHHD, they included administrative management, medical monitoring, use of specialized care, patient follow-up and checkups. In the case of PD, they included general direction, administrative management, personnel management and expenses related to the hospital structure.

Utilities

Utilities included telephone, water and electricity [50].

Kidney transplantation

The cost of the surgery was taken into account as well as the amount incurred by readmittance, revisions and medication for the first year. Additionally, the costs corresponding to the subsequent years were also considered [35].

Nonmedical direct costs

Transport

This information was gathered from Hospital Perpetuo Socorro, a public hospital in Alicante, Spain, where 41% of the patients were living within the metropolitan area and the remaining 59% used interurban public transport to get to the hospital. It was assumed that the average distance was 69 km. It was also considered that 62% of the patients went to the hospital by taxi, 24% by ambulance and 14% by their own vehicle [28].

Indirect costs

From a human capital perspective, the costs associated to the patient lost labor productivity due to ESRD morbidity and mortality were estimated [51]. These costs were determined based on the Spanish average salaries and unemployment rates, as well as on the retirement and mortality rates observed for each RRT modality. Those were the items for which reliable information was available, since other items, such as the patient lost domestic productivity or the caregiver lost leisure time, were very difficult to quantify objectively. The following sources of information were employed: the Spanish Salary Structure Survey (EES, Spanish acronym) from the INE and the Active Population Survey (EPA, Spanish acronym) from the INE and the Spanish National Institute of Social Security (INSS, Spanish acronym) [52]. In order to perform the calculations, it was considered that 28% of the patients in PD continued working, as compared to 13% of the patients in HD and 46% of the patients in kidney transplantation, according to the data from the Kidney Patients Information Unit of the Spanish Autonomous Community of the Basque Country.

Results

For the year 2010, an estimate was made of an incidence of 5409 (HD), 822 (PD) and 2317 (Tx) patients. The forecasted prevalence figures were 22 582, 2420 and 24 761 patients, respectively. Figures 1 and 2 show the registered data and the forecasted trends for the prevalence and incidence figures in the different RRT modalities in the period of 1996/2010.

Table 1 presents detailed information on the annual per-patient costs of the different RRT modalities, as well as average annual costs for HD, PD and Tx. Regarding HD, weighted average (ICHHD and HHD) costs of €2651 (incidence) and €37 968 (prevalence) were obtained. The indirect costs amounted to €8929. In regard to PD, weighted average costs (CAPD and APD) amounted to €1808 (incidence) and €25 826 (prevalence), while the indirect costs added up to €7429. The estimated cost during the first year of kidney transplantation was €38 313, while it was only €6283 in the subsequent years. Kidney transplantation indirect costs amounted to €5483.

Table 2 presents the forecasted incidence and prevalence figures for the different RRT modalities. Based on this estimates as well as on the average annual costs for each modality, aggregate costs of €1077 (HD), €85 (PD) and €244 (Tx) million were estimated, if indirect costs were not included. These amounts increased up to €1327, €109 and €393 million, respectively, if indirect costs were included.

The total budgetary impact of the Spanish RRT programme for the Public Administration amounted to ~€1407 million (indirect costs not included) and €1829 million (indirect costs included). HD accounted for between 77% (indirect costs not included) and 73% (indirect cost included) of the aggregate costs of the Spanish RRT programme in 2010. The balance of costs was for Tx (between 17 and 21%) and PD (6%) patients.

Discussion

A cost analysis of the Spanish RRT programme, for the year 2010 and from the perspective of the Public

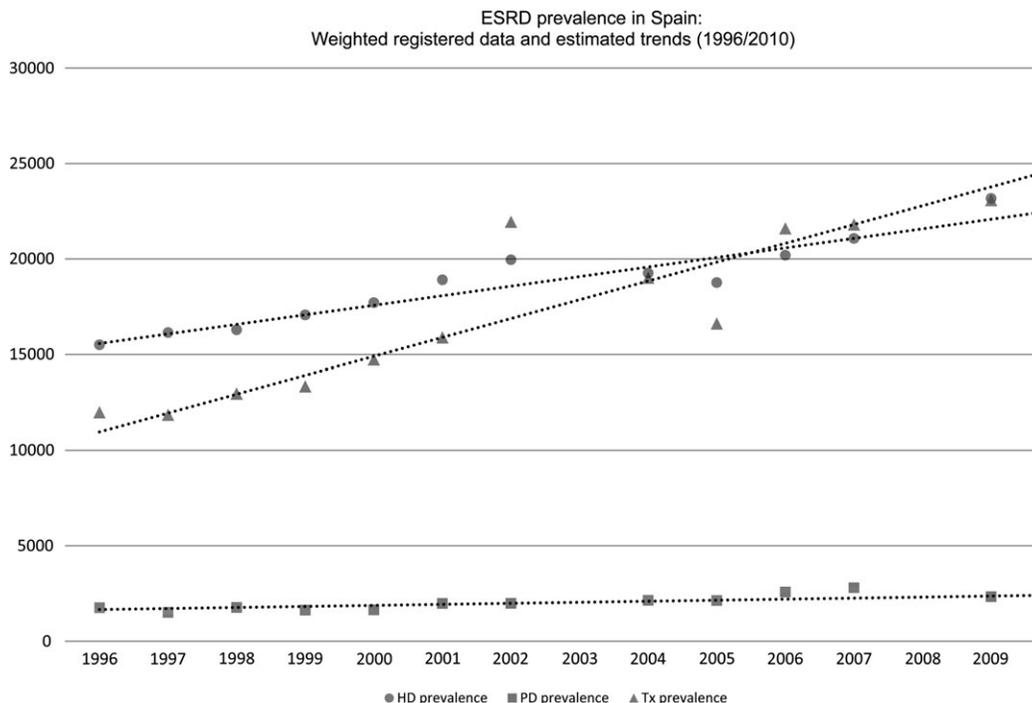


Fig. 1. ESRD prevalence in Spain: weighted registered data and estimated trends (1996/2010).

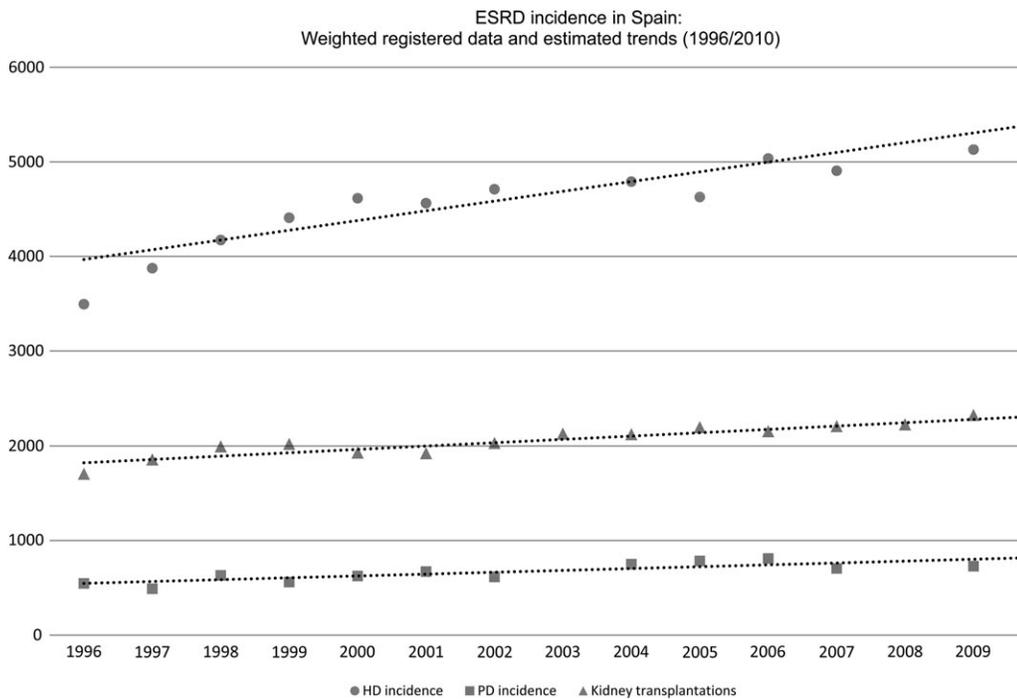


Fig. 2. ESRD incidence in Spain: weighted registered data and estimated trends (1996/2010).

Table 1. Annual per-patient costs^a

	ICHD	HHD	HD (weighted average)	CAPD	APD	PD (weighted average)	Tx
Medical direct costs							
Scheduled vascular access	928	928	928				
Unscheduled vascular access	4595	4595	4595				
Peritoneal access				808	808	808	
Training				681	1568	1000	
Kidney transplantation (first year)							38 313
Average incidence costs			2651			1808	38 313
Kidney transplantation (subsequent years)							6283
Treatment session	20 376	30 084	24 745	17 081	25 306	20 042	
Equipment depreciation		1084	488	209	209	209	
Utilities		274	123	37	37	37	
Nephrology general expenses	1977	5492	3559	1955	2860	2281	
Equipment maintenance		610	275				
External services		919	414	165	165	165	
Drug consumption	2975	2975	2975	2975	2975	2975	
Access complications	311	311	311	117	117	117	
Nonmedical direct costs							
Transport	5079	5079	5079				
Average prevalence costs			37 968			25 826	6283
Indirect costs							
Lost labor productivity due to mortality	904	904	904	518	518	518	124
Lost labor productivity due to morbidity	8025	8025	8025	6911	6911	6911	5359
Average indirect costs			8929			7429	5483

^aTx, kidney transplantation.

Administration, has been carried out. It was concluded (indirect costs included) that 73% of the aggregate RRT costs in 2010 came from patients in HD, 21% of the costs were associated to patients in kidney transplantation and only ~6% of the costs were due to patients in PD.

The higher costs of HD are explained by the greater proportion of patients in this modality, as well as by the

higher average cost estimated. This finding is in agreement with previous research [24–26, 28, 29]. Our results are similar to the ones obtained in a study by Hernandez-Jaras *et al.* [30], in which the average annual per-patient cost in HD (updated to 2010) was €37 438, as compared to €37 968 in this article, despite both studies do not perform costing on the same elements nor use the same methods.

Table 2. Annual incidence, prevalence and aggregate costs in 2010^a

	HD	PD	Tx
Forecasted incidence (patients)	5409	822	2317
Forecasted prevalence (patients)	22 582	2420	24 761
Annual incidence costs (in €)	2651	1808	38 313
Annual prevalence costs (in €)	37 968	25 826	6283
Annual indirect costs (in €)	8929	7429	5483
Aggregate costs (in million €) (indirect costs not included)	1077	85	244
Aggregate costs (%) (indirect costs not included)	77	6	17
Aggregate costs (in million €) (indirect costs included)	1327	109	393
Aggregate costs (%) (indirect costs included)	73	6	21

^aTx, kidney transplantation.

Additionally, in accordance with other studies, our research estimated a greater cost for HHD, as compared to ICHD, as well as a greater cost for APD as compared to CAPD [25, 28]. On the other hand, this study confirms that, starting in the second year, kidney transplantation presents a lower annual per-patient cost compared to the dialysis modalities. This finding also agrees with the evidence from previous studies [22, 23].

As mentioned in this paper, the number of patients who prefer PD over HD increases when patients have information about the different dialysis modalities available prior to choosing [18–21]. Nevertheless, the Spanish incidence and prevalence figures in HD are far higher than those in PD. If it is also considered that HD is the most costly modality for the Public Administration, it seems logical to think that, both from the perspective of the patients' rights to choose the therapy for which they are best suited, as well as from the economic benefits to the society, it would be preferable if the number of incident and prevalent patients in PD were increased. As a continuation of this research, a cost-effectiveness analysis of the different RRT modalities might contribute to confirm and extend the findings presented in here.

It is important to highlight that the dialysis modality chosen depends heavily on the progression of the pathology at the time of referral to nephrology, since early detection allows the patient to be informed about the treatment options. The timing for dialysis initiation is critical for the patients, so they can be educated, have appropriate peritoneal or vascular accesses performed early and start in RRT as scheduled, unlike what happens to patients referred to nephrology in a delayed manner, who, in many cases, must have urgent dialysis performed.

As mentioned earlier, RRT in Spain is free of charge for the patient, but it causes high health care costs for the Public Administration. This study estimates and compares the costs of the different Spanish RRT programme modalities. It is important to point out that the established therapeutic model in a country is a consequence of a decision which is not only based on clinical criteria but also on economic criteria. De Vecchi *et al.* [27] compared the costs of different RRT modalities in countries with different types of funding mechanisms. They concluded that PD is the least costly technique from the perspective of publicly funded health care systems. So, home-based dialysis is more predominant in countries with public funding as com-

pared to countries with predominant private health care systems. This finding leads to the conclusion that the health care financing model of a country might influence the use of the various RRT modalities [31].

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