







## ORIGINAL ARTICLE

# Trends in assisted peritoneal dialysis over the last decade: a cohort study from the French Peritoneal Dialysis Registry

Annabel Boyer <sup>1,2</sup>, Antoine Lanot <sup>1,2,3</sup>, Mark Lambie <sup>4,5</sup>,  
Sonia Guillouet <sup>1,2,3</sup>, Thierry Lobbedez<sup>1,2,3</sup> and Clémence Béchade<sup>1,2,3</sup>

<sup>1</sup>Centre Universitaire des Maladies Rénales, CHU de Caen, 14 033 Caen Cedex 9, France, <sup>2</sup>U1086, INSERM—ANTICIPE—Centre, Régional de Lutte contre, le Cancer, François Baclesse, Caen, France, <sup>3</sup>Normandie Université, Unicaen, UFR, de médecine, 2 rue des Rochambelles, 14032 Caen Cedex, France, <sup>4</sup>Renal Unit, Royal Stoke University Hospital, University Hospitals of North Midlands NHS Trust, Stoke-on-Trent, UK and <sup>5</sup>Faculty of Medicine and Health Sciences, Keele University, Keele, UK

Correspondence to: Annabel Boyer; E-mail: annabel.boyer@wanadoo.fr

## ABSTRACT

**Background.** There is limited information available on the use of assisted peritoneal dialysis (PD) over time and the impact of economic incentives on its utilization. The aim of this study was to describe the trends in assisted PD utilization and the type of assistance provided. We wanted to estimate if an economic incentive implemented in 2011 in France was associated with an increase in the utilization of nurse-assisted PD.

**Methods.** This retrospective, multicentre study, based on data from the French Language Peritoneal Dialysis Registry, analysed 11 987 patients who initiated PD in France between 1 January 2006 and 31 December 2015. Adjusted Cox regression with robust variance was used to examine the initiation of assisted PD, both nurse-assisted and family-assisted, accounting for the nonlinear impact of the PD starting time.

**Results.** There were 6149 (51%) incident patients on assisted PD, 5052 (82%) on nurse-assisted PD and 1097 (18%) on family-assisted PD over the study period. In the adjusted analysis, calendar time was associated with the assisted PD rate: it declined from 2008 until 2013 before flattening out and then it increased after 2014. Nurse-assisted PD utilization increased significantly after 2012, whereas family-assisted PD utilization decreased linearly over time (prevalence ratio = 0.94, 95% confidence interval 0.92–0.97).

**Conclusions.** The assisted PD rate decreased until 2013, mainly because of a decline in family-assisted PD. The uptake in nurse-assisted PD observed from 2013 reflects the effect of an economic incentive adopted in late 2011 to increase PD utilization.

**Keywords:** assisted peritoneal dialysis, chronic kidney disease, economic incentives, longitudinal trends, peritoneal dialysis

Received: 15.1.2020; Editorial decision: 16.3.2020

© The Author(s) 2020. Published by Oxford University Press on behalf of ERA-EDTA.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)

## INTRODUCTION

The initiation of dialysis can be emotionally challenging for patients and families; presenting patients with choices of dialysis modality may ease the burden of stress and anxiety. Older age, comorbidities, physical disabilities and psychosocial problems act as barriers to home dialysis [1–5].

Compared with in-centre haemodialysis (HD), peritoneal dialysis (PD) offers several advantages, such as the avoidance of transport to and from the dialysis unit, avoidance of difficulties in creating vascular access and haemodynamic instability during the HD session [3, 6–8]. By overcoming some of the conditions that act as a barrier to self-care PD [4, 9], assistance can improve the accessibility of home dialysis and thus favour quality of life in elderly patients [3, 9–11].

Home assistance programmes have been implemented in several countries in recent decades. Depending on the country, the assistance can be provided by a healthcare technician, a community nurse, and a trained family member or partner [12].

With the first programmes being implemented in the 1980s, France has one of the longest experiences of assisted PD [13, 14]. Nurse-assisted PD is fully covered by the French healthcare insurance. Notably, assisted PD remains cheaper than in-centre HD, even after the additional costs for nurse assistance [15]. Assisted PD allows patients to choose their PD modality [e.g. automatic peritoneal dialysis (APD) or continuous ambulatory PD (CAPD)] and the type of assistance (nurse or a family-assisted PD). According to the French Language Peritoneal Dialysis Registry (RDPLF), >50% of incident patients treated by PD from 1995 to 2006 were considered unable to perform self-care PD and needed assistance. The assistance was mainly provided by a private nurse (45%) and to a lesser extent by a family member (7%). In the elderly population, >80% needed assistance [16].

Strategic economic incentives to increase home dialysis by altering remuneration for these therapies are being introduced [17]. Despite these incentives and the many advantages home dialysis can offer, PD use has been declining in recent decades [18], while the total number of dialysis patients has increased [19, 20]. It is unclear whether this decline is linked to an ageing population, which may be associated with limited use of home therapy unless assistance is provided. With the population in CKD growing older and frailer, we could anticipate an increase in assisted PD use. One may also argue that the possibility of relying on family members for the assistance of PD patients could have decreased over time. To encourage PD in older patients in France, nurse-assisted PD in nursing homes became covered by healthcare insurance in 2011 [21]. To our knowledge, there are no data in the literature describing the longitudinal trends in the use of assisted PD.

The aim of this study was to describe the trends in assisted PD utilization, the trends in the type of assistance provided to PD patients and the PD modalities used for the assisted PD patients over the past decade in France. The secondary objective was to estimate whether the coverage of nurse-assisted PD in nursing home implemented at the national level in 2011 was associated with an increase in the utilization of nurse-assisted PD.

## MATERIALS AND METHODS

### Study population

This was a retrospective study using data from the RDPLF. All adults >18 years starting PD in France between 1 January 2006 and 31 December 2015 were included. No patient was lost to

follow-up. The RDPLF database has been shown to be reliable, with coverage of 99% in France in 2016 [22, 23].

Age at PD start, gender, underlying nephropathy, diabetes mellitus, previous therapy before PD initiation (HD or renal transplantation), suboptimal starters (defined as a period of <30 days on HD before PD initiation) and centre category (academic, community, non-profit and private) were obtained from the registry [24]. To evaluate patient comorbidities, the Charlson comorbidity index (CCI) was extracted from the database, and the modified CCI was calculated by subtracting the age subscore. For centre size estimation, we calculated the number of incident PD patients per centre per year of participation during the study period [25].

### Events of interest

In the complete cohort, the events of interest were assisted PD, nurse-assisted PD and family-assisted PD at dialysis initiation. Assisted PD was defined as PD performed at the patient's home with the help of a community nurse (nurse-assisted PD) or a family member or a partner (family-assisted PD).

We also wanted to evaluate the use of CAPD over time and the association between type of assistance and PD modality (CAPD/APD). A second cohort included nurse- and family-assisted patients. In that part of the analysis, the event of interest was the use of CAPD at dialysis initiation.

To provide additional information, we have also estimated the occurrence of PD failure, caused by death or transfer to HD, and renal transplantation during the study period. The time from PD start to the first episode of peritonitis was also calculated. Both technique survival and peritonitis rates were evaluated in the complete cohort and in the nurse- and family-assisted cohort.

### Explanatory variable

The main explanatory variable was the time, or PD start year, between 1 January 2006 and 31 December 2015. For the secondary objective, the explanatory variable was the time period following the implementation of the coverage of nurse-assisted PD in nursing home (the number of years between 2011 and the year of PD start).

### Statistical analysis

Continuous variables were described by the median (first and third quartile), and categorical variables were described by frequencies and percentages. Regression splines were used to explore the functional form of the length of time from the inclusion date until the end of the inclusion period. Transformation of the continuous time variable to a categorical variable was performed based on the aspect of the graph of the functional form of the predictor.

When the proportion of the event of interest is >10%, the odds ratio (OR) overestimates the prevalence ratio (PR). Alternative methods have been described in the literature for the analysis of binary outcomes in longitudinal studies, including using the PR instead of the OR. The Cox model with robust variance is valid for estimating the PR [26].

To explore the association between the time variable and the events of interest in the complete cohort, PRs and 95% confidence intervals (CIs) were calculated using a Cox regression model with robust variance. As recommended, in the Cox model, a constant risk period equal to one was assigned to every patient in the cohort [26].

To evaluate the association between the time variable and CAPD utilization, analyses were restricted to the cohort of patients on assisted PD and subsequently to the nurse-assisted PD and family-assisted PD subgroups.

Cumulative incidence curves were drawn for each possible PD outcome (death, transfer to HD and renal transplantation) and for peritonitis events. Technique survival and peritonitis rates according to the type of assistance were compared using the Logrank test. Conditional probabilities for the event of interest were estimated at specific time points.

A bivariable analysis was performed to estimate the association between each variable and the event of interest. The time variable was included *a priori* in the multivariate analysis; otherwise, variables were included in the model based on the results of the change in the estimate procedure with a cut-off value of 10%. Interactions between time and the other covariates were tested in the multivariate models.

Missing data were <5%, enabling us to use a complete case analysis. Analyses were performed with R 3.4.3 (R Foundation for Statistical Computing, Vienna Austria, including the survival package).

## RESULTS

### Patient characteristics

Of the 11 987 incident patients on PD included in the study, 6149 (51%) patients were on assisted PD: 5052 (82%) were on nurse-assisted PD and 1097 (18%) were on family-assisted PD. The number of patients starting PD per year is displayed in Figure 1. The median [interquartile range (IQR)] time on PD was 19.3 months (8.4–34.5 months). Compared with self-care PD patients, those on assisted PD were older, more frequently diabetic and had more comorbidities. Patient characteristics according to the type of assistance are described in Table 1. Incident patients' age and CCI by year of PD start are described in Table 2.

### Association between calendar time and the rate of assisted PD utilization

In the multivariable analysis, time was associated with the assisted PD rate, whether included in the regression model as a regression spline (Figure 2) or as a categorical variable (Table 3).

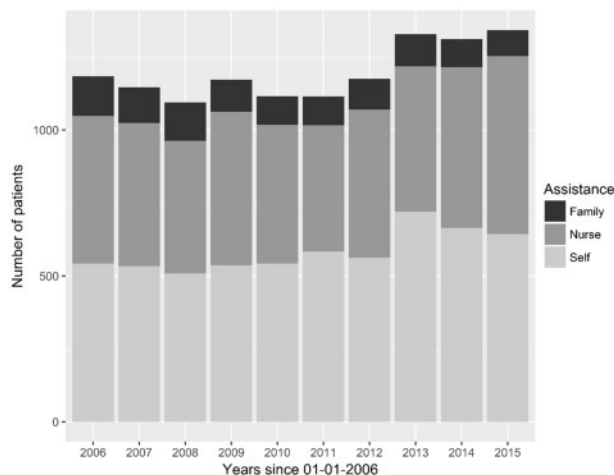


FIGURE 1: Number of patients starting PD per year over the study period.

The year 2013 was the time point with the lowest rate of assisted and nurse-assisted PD utilization and was chosen as the reference class in the corresponding modelling. There was a linear relationship between time and family-assisted PD utilization; thus, the PD start year was defined as a linear variable in this model.

Compared with 2013, starting PD in 2006, 2007, 2008, 2009, 2010, 2012 or 2015 was strongly associated with the utilization of assisted PD. Nurse-assisted PD utilization increased significantly after 2012, whereas family-assisted PD utilization decreased linearly over time (PR = 0.94, 95% CI 0.92–0.97; Table 3).

Age, gender, diabetes, modified CCI, a suboptimal start, underlying nephropathy, renal replacement therapy before PD initiation and centre experience were associated with assisted PD (Table 3). There were no significant interactions between PD start year and the other covariates.

### Association between calendar time and the rate of CAPD utilization in the assisted PD, nurse-assisted PD and family-assisted PD subgroups

Based on the shape of the regression spline, the PD start year for this part of the analysis was transformed into a categorical variable composed of three classes: 2006–10, 2010–12 (reference class) and 2012–15. In the unadjusted and adjusted analyses, the PD start year was associated with an increased rate of CAPD utilization, whether included in the Cox regression model as a regression spline (data not shown) or as a categorical explanatory variable (Table 4).

Starting PD in 2012, 2013, 2014 or 2015 was strongly associated with an increased rate of CAPD utilization (PR = 1.16, 95% CI 1.08–1.23). The PR change over time followed a similar pattern in nurse-assisted PD patients (PR = 1.13, 95% CI 1.05–1.21) and family-assisted PD patients (PR = 1.24, 95% CI 1.03–1.49; Table 4).

Age, gender, modified CCI, a suboptimal start, therapy before PD initiation and centre experience were associated with CAPD initiation (Table 4). There were no significant interactions between PD start year and the other covariates.

### Technique survival and peritonitis rates according to the type of assistance

The median (IQR) PD duration for the complete cohort was 16.9 months (7.38–30.9). There were 10 942 (91%) PD failures during the study period, including 4252 (35%) deaths and 3648 (30%) transfers to HD. Furthermore, 2262 (19%) patients had a renal transplantation. According to the type of assistance, the median (IQR) PD duration was 16.6 months (6.1–31.5) and 15.5 months (7.1–31.3) for patients on nurse- and family-assistance, respectively. Technique survival rates did not differ according to the type of assistance (P = 0.57). Conditional probabilities using the cumulative incidence method for the events are provided in Table 5.

In the complete cohort, there were 4421 (37%) episodes of peritonitis, with a median (IQR) time to peritonitis of 8.9 months (3.1–19.6). There were 1826 (36%) episodes of peritonitis in the nurse-assistance group and 406 (37%) in the family-assistance group. Median (IQR) time to peritonitis were of 8.8 months (2.8–19.8) and 8.5 months (2.2–20.3), respectively. Patients on nurse assistance tended to have less peritonitis compared with patients on family assistance even though the results were not significant (P = 0.08). The cumulative incidence of peritonitis at

Table 1. Patients characteristics according to the type of assistance (N = 11 987)

Variables	All patients (n = 11 987)	Nurse-assisted (n = 5052)	Family-assisted (n = 1097)	Self-care (n = 5838)
Age at PD initiation, median (IQR) <sup>a</sup>	69.2 (54.7–80.1)	79.6 (72.3–84.6)	74.3 (65–81.7)	56.5 (43.9–67.1)
Gender (male), n (%)	7101 (59)	2686 (53)	674 (62)	3741 (64)
Diabetes, n (%)	4026 (34)	2204 (44)	529 (48)	1293 (22)
Modified CCI, median (IQR)	3 (2–5)	4 (3–6)	5 (3–6)	3 (2–4)
Underlying nephropathy, n (%)				
Diabetic	2372 (20)	1247 (25)	312 (29)	813 (14)
Interstitial nephritis	784 (7)	276 (6)	64 (6)	444 (8)
Glomerulonephritis	1827 (15)	283 (6)	91 (8)	1453 (25)
Polycystic kidney disease	800 (7)	109 (2)	29 (3)	662 (11)
Unknown	1359 (11)	625 (12)	115 (10)	619 (11)
Uropathy	525 (4)	112 (2)	32 (3)	381 (6)
Vascular	3828 (32)	2256 (45)	412 (38)	1160 (20)
Systemic disease	333 (3)	83 (1)	22 (2)	228 (4)
Other	105 (1)	41 (1)	12 (1)	52 (1)
Missing	54	20	8	26
Suboptimal starters, n (%)	1131 (9)	558 (11)	105 (10)	468 (8)
Treatment before PD, n (%)				
No therapy	9486 (79)	4188 (83)	860 (78)	4438 (76)
HD	2072 (17)	815 (16)	222 (20)	1035 (18)
Renal transplantation	406 (4)	40 (1)	15 (2)	351 (6)
Missing	23	9	0	14
First PD modality (CAPD), n (%)	8971 (75)	4357 (86)	801 (73)	3813 (65)
Type of centre, n (%)				
Community hospital	5763 (48)	2562 (51)	528 (48)	2673 (46)
Academic hospital	2326 (20)	893 (18)	204 (19)	1229 (21)
Non-profit	2863 (24)	1107 (22)	268 (24)	1488 (25)
Private hospital	1035 (8)	490 (9)	97 (9)	448 (8)
Centre experience, n (%) (new patients per year)				
≤10	4746 (40)	1964 (39)	437 (40)	2345 (40)
>10	7241 (60)	3088 (61)	660 (60)	3493 (60)

<sup>a</sup>In years.

Table 2. Age and CCI of the incident patients, by year of PD start

PD start year	Age [median (IQR)]	CCI [median (IQR)]	CCI ≥7 [n (%)]
2006	71.5 (55–80.4)	4 (2–5)	96 (8)
2007	69.4 (55.9–79.7)	3 (2–5)	108 (9)
2008	68.8 (53.6–78.9)	3 (2–5)	109 (10)
2009	70.3 (54.8–80.9)	4 (2–5)	110 (9)
2010	69.8 (54.6–80.2)	4 (2–5)	108 (10)
2011	67.2 (53–80.2)	3 (2–5)	105 (9)
2012	70 (54.6–80)	3 (2–5)	110 (9)
2013	67.2 (53.9–80.1)	3 (2–5)	129 (10)
2014	68.4 (55.6–80.2)	3 (2–5)	136 (10)
2015	69.9 (56.2–80.7)	4 (2–5)	152 (11)

2 years was of 50.5, 49.4 and 52.1% for the complete cohort, nurse-assistance and family-assistance groups, respectively.

## DISCUSSION

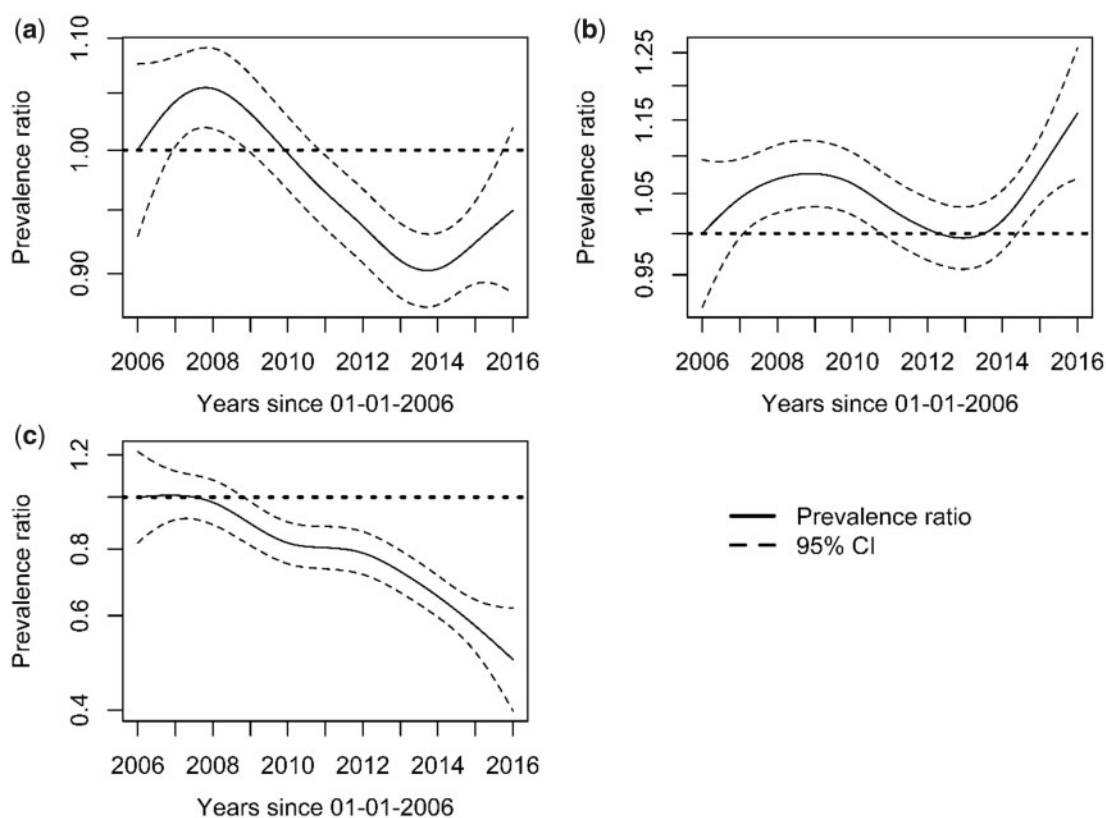
Assisted PD programmes are available in different countries around the world, with differences from one country to another [12]. To our knowledge, the trend in the utilization of assisted PD among incident PD patients over time has not yet been documented at a national level. We hereby provide a description of

the utilization of assisted PD over a decade in a country where assisted PD has been available for >30 years and is fully covered by healthcare insurance. The high exhaustivity of the RDPLF makes it a reliable database [22, 23].

With the CKD population growing older and frailer, it would be anticipated that the use of assisted PD should increase over the years. However, our results show a different pattern; there was a decline in the rate of assisted PD until 2013, while the total number of dialysed patients continued to increase [19]. The decline in the assisted PD rate was mainly attributed to a linear decline in family-assisted PD utilization.

In contrast, after 2013, there was an increased utilization of nurse-assisted PD over time (Figure 2). Surprisingly, patients' age and comorbidities remained stable during the study period (Table 2), leading to the hypothesis that the potential rate of patients who needed assistance did not decrease during the decade.

The linear decline observed in family-assisted PD utilization could be explained by several factors. First, there was a modification in the state of health of caregivers. In a French survey published in 2008, 48% of the caregivers were suffering from chronic disease, and 29% declared that they were suffering from anxiety and stress [27]. Life expectancy has been rising in France over the past decade; however, while life expectancy without disability remains stable (64.5 years old for women and 63.4 years old for men) [28], the number of people suffering from



**FIGURE 2:** PR of assisted PD initiation over time. Change in the PR of assisted PD initiation over time. Solid lines represent the rates of receiving assisted PD at any point during follow-up, by the year PD was initiated, when compared with 2006 (expressed as a PR). The analysis was adjusted for age, gender, ethnicity and underlying nephropathy using a Cox regression model with robust variance (95% CI shown by dashed lines). The assisted PD PR over the study period was not linear. The PR for assisted PD was defined as PD performed at the patient's home with the help of a community nurse or a family member (a), for nurse-assisted PD only (b) and family-assisted PD only (c).

chronic disease has been constantly rising [29, 30]. The number of caregivers in France is estimated to be 11 million, of which almost 35% are aged >60 years old, and 74% feel that being a caregiver has an impact on their own health [31, 32].

Secondly, social deprivation in the elderly (>75 years old) has been increasing steadily; in 2014, 27% of elderly individuals were considered to live with social deprivation compared with 16% in 2010. The population with social deprivation is now composed of more than a quarter of the people aged >75 years. This increase has been associated with a combination of several factors: an increase in the proportion of elderly people with disabilities, a relative decline in associative practices and a loosening in family relationships [33].

Finally, the proportion of patients on PD with a CCI >7 did not decrease over time (Table 2), reflecting frailty and dependency, which could influence the caregiver's burden. The increase in caregiver burden, often associated with a reduction in psychological health, has been previously reported [34, 35]. It has recently been shown that a high proportion of patients will observe a decline in functional status in the first 6 months after initiating dialysis. In this study, the percentage of caregivers reporting a high burden of care increased from 23 to 38% after dialysis initiation [36]. In a study from our team, compared with autonomous PD patients, patients with nurse assistance had a lower risk of transfer to HD, while those with family assistance had a similar risk of transfer to HD. This finding could be partly explained by the usefulness of nurse assistance to reduce the burden of PD for both patients and their families [11, 37, 38]. As

the caregiver burden increased over time, family assistance declined. Interventions will be needed in the future to remove this burden and facilitate the task of caregivers.

On the other hand, the recent uptake in nurse-assisted PD could be explained by economic incentives and/or better coverage of home dialysis.

Economic incentives to increase home dialysis by altering remuneration for these therapies are being introduced in some countries. A recent workshop concluded that economic incentives were effective at increasing the use of home dialysis [17]. However, the time until an impact on incident home dialysis numbers can be observed remains unclear.

In France, nursing homes receive a financial budget from the healthcare insurance that covers collective medical costs (human resources and medical devices). The nursing time dedicated to each patient is based on a standard medical care evaluation. However, patients on PD might need assistance up to four times a day, 7 days a week, increasing the need for human resources. Nurse-assisted PD is fully covered by the healthcare insurance in France; however, prior to 2011, no fee was paid if the patient resided in a nursing home [39]. According to Dratwa *et al.*, the evaluated additional costs generated by nurse-assistance were ~23 400 €/patient/year for CAPD (four exchanges per day) and 18 200 €/patient/year for APD [39]. Most nursing homes were not willing to pay for these additional charges. As a consequence, most end-stage renal disease patients on PD did not have access to nursing homes or had to change modality to HD to be accepted. Thanks to an economic

Table 3. Association between PD start year and the PR of assisted PD initiation, adjusting for patient characteristics, for each type of assistance

Explanatory variable	All assistance	Nurse-assistance	Family-assistance
	PR (95% CI)	PR (95% CI)	PR (95% CI)
PD start year (reference = 2013)			PD start year <sup>a</sup>
2006	1.17 (1.07–1.29)	1.08 (0.96–1.22)	0.94 (0.92–0.97) <sup>a</sup>
2007	1.27 (1.15–1.39)	1.19 (1.05–1.34)	
2008	1.24 (1.12–1.37)	1.13 (0.99–1.27)	
2009	1.21 (1.10–1.32)	1.18 (1.05–1.33)	
2010	1.14 (1.04–1.26)	1.14 (1.02–1.28)	
2011	1.09 (0.99–1.21)	1.08 (0.96–1.21)	
2012	1.16 (1.06–1.28)	1.15 (1.03–1.27)	
2013	Reference	Reference	
2014	1.08 (0.99–1.19)	1.14 (1.02–1.29)	
2015	1.12 (1.03–1.23)	1.24 (1.11–1.34)	
Age, for a 10-year increase	1.79 (1.75–1.83)	1.83 (1.79–1.88)	1.19 (1.14–1.25)
Gender, male	0.71 (0.68–0.74)	0.70 (0.66–0.73)	1.06 (0.94–1.20)
Diabetes	1.13 (1.07–1.20)	1.10 (1.03–1.18)	1.21 (1.02–1.44)
Modified CCI (per unit)	1.09 (1.08–1.11)	1.06 (1.05–1.08)	1.14 (1.10–1.18)
Suboptimal starters	1.11 (1.04–1.19)	1.17 (1.07–1.26)	0.90 (0.73–1.10)
Underlying nephropathy			
Polycystic kidney disease	Reference	Reference	Reference
Diabetes	2.30 (1.93–2.74)	2.16 (1.77–2.63)	1.93 (1.26–2.96)
Interstitial nephritis	2.16 (1.79–2.61)	2.04 (1.65–2.51)	2.02 (1.28–3.18)
Glomerulonephritis	1.36 (1.13–1.63)	1.26 (1.02–1.55)	1.42 (0.92–2.18)
Unknown	2.18 (1.83–2.59)	2.09 (1.72–2.54)	1.73 (1.13–2.66)
Uropathy	1.84 (1.48–2.29)	1.72 (1.34–2.21)	1.79 (1.06–2.99)
Vascular	2.35 (1.99–2.78)	2.22 (1.84–2.68)	1.91 (1.27–2.87)
Systemic disease	1.87 (1.47–2.38)	1.77 (1.35–2.33)	1.72 (0.97–3.04)
Other	2.23 (1.68–2.95)	2.06 (1.50–2.82)	2.43 (1.18–5.01)
Therapy before PD initiation			
No therapy	Reference	Reference	Reference
HD	1.14 (1.08–1.20)	1.04 (0.97–1.12)	1.32 (1.13–1.54)
Transplantation	0.54 (0.41–0.71)	0.54 (0.39–0.74)	0.67 (0.39–1.15)
Type of centre			
Academic hospital	Reference	Reference	Reference
Community hospital	1 (0.95–1.07)	1.03 (0.96–1.11)	0.94 (0.79–1.11)
Non-profit	1 (0.93–1.07)	0.98 (0.90–1.07)	1.08 (0.90–1.30)
Private hospital	0.94 (0.87–1.02)	0.94 (0.84–1.04)	0.99 (0.77–1.28)
Centre experience (new patients per year)			
≤10	Reference	Reference	Reference
>10	1.14 (1.09–1.20)	1.17 (1.10–1.23)	0.99 (0.87–1.13)

<sup>a</sup>According to the spline regression, PD start year was modelled as a linear variable (per year).

incentive implemented in November 2011, the fees generated by nurse assistance are now fully covered, even if the patients reside in a nursing home [21]. That means that private nurses are paid, since 2011, to perform PD in the nursing home. We believe that this incentive translated into an increase in nurse-assisted PD from 2013.

The funding models for dialysis can also impact the use of home dialysis. In the USA, the prospective payment system, a bundle payment, for the US Medicare End-Stage Renal Disease Programme was launched in January 2011. It reduced financial disincentives for facility use of home therapies. PD payment was set to be equivalent to in-centre HD treatment. The number of patients on PD increased by 15% between 2011 and 2013 [17, 40]. There was an increasing tendency of patients on PD to be treated in facilities with less PD experience, without any changes in mortality rates. This finding suggests a link between the funding model and the modality distribution [17, 40, 41].

As shown by the adjusted Cox model, the relative use of CAPD increased over the study period, notably between 2012

and 2015 (PR = 1.16, 95% CI 1.08–1.23). This increase was noted in both nurse- (PR = 1.13, 95% CI 1.05–1.21) and family-assisted PD (PR = 1.24, 95% CI 1.03–1.49). In a recent study from our team, technique survival and peritonitis-free survival were similar between CAPD and APD in assisted PD patients [42]. In addition, a study of incident self-PD patients demonstrated a similar quality of life in both modalities, underlining the importance of the patient's choice [43]. Both modalities should be offered to assisted PD patients; however, in view of the CAPD rate, one may wonder if APD is considered by the PD team to be equally suitable as CAPD for assisted patients with physical disabilities or cognitive dysfunctions. Moreover, nursing homes are often reluctant to deal with cyclers during the night because of the small number of caregivers available at night in those facilities.

Older age, diabetes, a higher CCI and underlying nephropathy were also associated with an increased probability of assisted PD initiation, likely a reflection of increased comorbidity, frailty and dependency. Similar findings have been described previously [11, 25]. It has been demonstrated that functional

Table 4. Association between PD start year and the PR of CAPD initiation, adjusting for patient characteristics, for each type of assistance

Explanatory variable	All assistance	Nurse-assistance	Family-assistance
	PR (95% CI)	PR (95% CI)	PR (95% CI)
PD start year (category)	Reference	Reference	Reference
2010–12	Reference	Reference	Reference
2006–10	1.04 (0.97–1.11)	1.02 (0.94–1.09)	1.17 (0.98–1.41)
2012–15	1.16 (1.08–1.23)	1.13 (1.05–1.21)	1.24 (1.03–1.49)
Age, for a 10-year increase	1.20 (1.17–1.23)	1.17 (1.14–1.21)	1.21 (1.15–1.29)
Gender, male	0.95 (0.91–1.01)	0.96 (0.91–1.01)	0.98 (0.86–1.12)
Diabetes	0.99 (0.94–1.06)	1.02 (0.95–1.08)	0.90 (0.76–1.07)
Modified CCI (per unit)	1.02 (1.01–1.03)	1.02 (1.01–1.03)	1.02 (0.99–1.06)
Suboptimal starters	0.90 (0.83–0.97)	0.92 (0.84–0.99)	0.77 (0.59–0.99)
Underlying nephropathy			
Polycystic kidney disease	Reference	Reference	Reference
Diabetes	1.03 (0.86–1.24)	1.07 (0.87–1.32)	0.93 (0.60–1.46)
Interstitial nephritis	1.13 (0.93–1.38)	1.15 (0.93–1.44)	1.04 (0.64–1.70)
Glomerulonephritis	1.04 (0.85–1.27)	1.10 (0.88–1.37)	0.88 (0.55–1.42)
Unknown	1.07 (0.89–1.28)	1.14 (0.93–1.40)	0.78 (0.49–1.25)
Uropathy	1.21 (0.96–1.52)	1.27 (0.99–1.63)	1.11 (0.63–1.96)
Vascular	1.18 (0.99–1.40)	1.21 (1–1.46)	1.10 (0.72–1.68)
Systemic disease	0.94 (0.72–1.24)	1 (0.74–1.36)	0.72 (0.37–1.38)
Other	0.96 (0.68–1.35)	1 (0.69–1.45)	0.91 (0.39–2.11)
Therapy before PD initiation			
No therapy	Reference	Reference	Reference
HD	0.86 (0.80–0.93)	0.86 (0.80–0.93)	0.91 (0.77–1.09)
Transplantation	0.71 (0.50–1.01)	0.63 (0.42–0.95)	1.01 (0.54–1.88)
Type of centre			
Academic hospital	Reference	Reference	Reference
Community hospital	0.84 (0.79–0.90)	0.79 (0.74–0.85)	1.01 (0.54–1.88)
Non-profit	0.99 (0.93–1.06)	0.92 (0.86–0.99)	1.37 (1.12–1.66)
Private hospital	0.94 (0.86–1.03)	0.87 (0.80–0.96)	1.31 (1.04–1.67)
Centre experience (new patients per year)			
≤10	Reference	Reference	Reference
>10	0.93 (0.88–0.97)	0.91 (0.87–0.96)	0.94 (0.82–1.08)

Table 5. Cumulative incidence of PD outcomes at specific times points with the cumulative incidence function estimate

Event per type of assistance	6 months	12 months	18 months	24 months
All patients				
Death	8.7	17.2	26.4	37.7
Transfer to HD	9	16.6	25.5	34.5
Renal transplantation	3.3	9.8	16.6	24.5
Nurse-assisted PD patients				
Death	15.9	30.2	45.9	64.2
Transfer to HD	8.7	13.9	20.3	26.4
Renal transplantation	0.5	1	1.8	2.6
Family-assisted PD patients				
Death	13.6	28.8	41.4	60.9
Transfer to HD	8.7	17.2	27.7	34.1
Renal transplantation	0.8	3.3	6.1	7.6

Results are expressed as percentages.

impairment is highly prevalent in older patients on assisted PD and is associated with comorbidities [44].

Technique survival and peritonitis rates in our population were similar to previous studies [11, 45]. Both types of assistance have been associated with a lower risk for technique failure or transplantation, but a higher risk for death as

the patients were older and frailer [11]. In older patients, nurse assistance has been associated with a lower risk for peritonitis [45]. Our findings are in line with previous studies, demonstrating the sustainability of assisted PD.

The use of PD remains low in France, with <10% of patients utilizing this modality [19]. Over time, patients starting dialysis seem to be older and more likely to be diabetic and have cardiovascular or respiratory comorbidities [19]. The use of assisted PD could reflect a nephrologist preference for this modality for older and frailer patients.

Our study has limitations; by nature, the observational design cannot lead to conclusions regarding causality. We have shown results on the use of assisted PD compared with all PD utilization; however, this study was not designed to show an effect on overall PD utilization as this would require data on all renal replacement therapy patients. Although the use of assistance can change over time, only the assistance at dialysis start was used for the analysis. Because of the particularity of the coverage in France, assisted PD utilization might differ from other countries, which could limit the generalizability of our results. However, we believe that the results of our study could help centres anticipate what could possibly happen in the future when implementing an assisted PD programme.

Our study also shows that, due to a decline in family assistance, assisted PD currently relies mainly on nurse assistance. It has been demonstrated that widespread adoption of assisted

PD services would significantly increase PD initiation [46]. Although there are added costs to nurse-assisted PD, a Netherlands study demonstrated that it is a cost-effective option [47] in elderly patients. To further develop PD utilization in developed countries, nurse assistance should be promoted. We believe that assisted PD programmes, notably nurse assistance, should be implemented in every PD centre to increase PD utilization [48]. Alternatively, economic incentives to the patient's family could be considered, to convince relatives to participate in PD care. Such incentives do not exist in France currently.

In conclusion, this study shows that in France, the assisted PD rate decreased until 2013, mainly because of the decline of family assistance. The uptake in nurse-assisted PD observed from 2013 probably reflects the effect of an economic incentive adopted in late 2011 to increase PD utilization for end-stage renal disease patients in nursing homes.

## ACKNOWLEDGEMENTS

The authors thank the participating centres of the French Language Peritoneal Dialysis Registry.

## CONFLICT OF INTEREST STATEMENT

None declared.

## REFERENCES

- Povlsen JV, Ivarsen P. Assisted peritoneal dialysis: also for the late referred elderly patient. *Perit Dial Int* 2008; 28: 461–467
- Povlsen JV, Ivarsen P. Assisted automated peritoneal dialysis (AAPD) for the functionally dependent and elderly patient. *Perit Dial Int* 2005; 25: S60–S63
- Bechade C, Lobbedez T, Ivarsen P et al. Assisted peritoneal dialysis for older people with end-stage renal disease: the French and Danish experience. *Perit Dial Int* 2015; 35: 663–666
- Oliver MJ, Garg AX, Blake PG et al. Impact of contraindications, barriers to self-care and support on incident peritoneal dialysis utilization. *Nephrol Dial Transplant* 2010; 25: 2737–2744
- Povlsen JV, Ivarsen P. Assisted peritoneal dialysis. *Adv Chronic Kidney Dis* 2007; 14: 279–283
- Brown EA. Should older patients be offered peritoneal dialysis? *Perit Dial Int* 2008; 28: 444–448
- Brown EA, Wilkie M. Assisted peritoneal dialysis as an alternative to in-center hemodialysis. *Clin J Am Soc Nephrol* 2016; 11: 1522–1524
- Blake PG. Peritoneal dialysis: a “kinder, gentler” treatment for the elderly? *Perit Dial Int* 2008; 28: 435–436
- Oliver MJ, Quinn RR, Richardson EP et al. Home care assistance and the utilization of peritoneal dialysis. *Kidney Int* 2007; 71: 673–678
- Brown EA, Johansson L, Farrington K et al. Broadening options for long-term dialysis in the elderly (BOLDE): differences in quality of life on peritoneal dialysis compared to haemodialysis for older patients. *Nephrol Dial Transplant* 2010; 25: 3755–3763
- Lobbedez T, Verger C, Ryckelynck JP et al. Is assisted peritoneal dialysis associated with technique survival when competing events are considered? *Clin J Am Soc Nephrol* 2012; 7: 612–618
- Giuliani A, Karopadi AN, Prieto-Velasco M et al. Worldwide experiences with assisted peritoneal dialysis. *Perit Dial Int* 2017; 37: 503–508
- Issad B, Benevent D, Allouache M et al. 213 elderly uremic patients over 75 years of age treated with long-term peritoneal dialysis: a French multicenter study. *Perit Dial Int* 1996; 16: S1–S418
- Durand PY, Verger C. The state of peritoneal dialysis in France. *Perit Dial Int* 2006; 26: 654–657
- Haute Autorité de Santé: Évaluation médico-économique des stratégies de prise en charge de l'insuffisance rénale chronique terminale en France. 2014. [www.has-sante.fr/upload/docs/application/pdf/2014-11/argumentaire\\_irct\\_vf\\_2014-11-06\\_19-21-13\\_876.pdf](http://www.has-sante.fr/upload/docs/application/pdf/2014-11/argumentaire_irct_vf_2014-11-06_19-21-13_876.pdf) (19 December 2019, date last accessed).
- Verger C, Ryckelynck JP, Duman M et al. French peritoneal dialysis registry (RDPLF): outline and main results. *Kidney Int* 2006; 70: S12–S20
- Manns B, Agar JWM, Biyani M et al. Can economic incentives increase the use of home dialysis? *Nephrol Dial Transplant* 2019; 34: 731–741
- Jain AK, Blake P, Cordy P et al. Global trends in rates of peritoneal dialysis. *J Am Soc Nephrol* 2012; 23: 533–544
- Couchoud C, Lassalle M. Rapport Annuel REIN 2016. 2016. <https://www.francerein.org/files/2018-06/rapport-rein-2016-resultats-cl-s.pdf> (19 December 2019, date last accessed).
- United States Renal Data System: USRDS annual data report: ESRD in the United States. Incidence, Prevalence, Patient Characteristics, and Treatment Modalities. 2018. [https://www.usrds.org/2018/view/v2\\_01.aspx](https://www.usrds.org/2018/view/v2_01.aspx) (19 December 2019, date last accessed).
- Décret n° 2011-1602 du 21 Novembre 2011 relatif à la prise en charge des actes de dialyse péritonéale réalisés par les infirmiers libéraux en établissement d'hébergement pour personnes âgées dépendantes. 2011. <https://www.legifrance.gouv.fr/eli/decret/2011/11/21/ETSS1116727D/jo/texte> (19 December 2019, date last accessed).
- Couchoud C, Duman M, Frimat L et al. Verger C: RDPLF and rein, 2 complementary registries: a comparison of the collected data. *Nephrol Ther* 2007; 3: 27–32
- RDPLF: RDPLF registre de dialyse peritoneale de langue française. 2019. [https://www.rdplf.org/images/PDF/RDPLF\\_presentation.pdf](https://www.rdplf.org/images/PDF/RDPLF_presentation.pdf) (19 December 2019, date last accessed)
- Lobbedez T, Verger C, Ryckelynck JP et al. Outcome of the sub-optimal dialysis starter on peritoneal dialysis. Report from the French language peritoneal dialysis registry (RDPLF). *Nephrol Dial Transplant* 2013; 28: 1276–1283
- Guillouet S, Lobbedez T, Lanot A et al. Factors associated with nurse assistance among peritoneal dialysis patients: a cohort study from the French language peritoneal dialysis registry. *Nephrol Dial Transplant* 2018; 33: 1446–1452
- Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003; 3: 21
- Direction de la Recherche dé, de l'Évaluation et des Statistiques: Handicap-santé “aidants informels” (HSA). Présentation des pondérations de l'enquête. 2008. [https://drees.solidarites-sante.gouv.fr/IMG/pdf/ponderations\\_HSA.pdf](https://drees.solidarites-sante.gouv.fr/IMG/pdf/ponderations_HSA.pdf) (19 December 2019, date last accessed)
- Moisy M. Direction de la Recherche dé, de l'Évaluation et des Statistiques: En 2018, l'espérance de vie sans incapacité est de 64,5 ans pour les femmes et de 63,4 ans pour les hommes. 2019. [https://drees.solidarites-sante.gouv.fr/IMG/pdf/er\\_1046\\_-\\_esperance\\_de\\_vie.pdf](https://drees.solidarites-sante.gouv.fr/IMG/pdf/er_1046_-_esperance_de_vie.pdf) (19 December 2019, date last accessed)
- CNAMTS-DSES: Effectifs, prévalences et caractéristiques des personnes prises en charge pour ALD par type d'affection et modalité



- d'ALD, pour le régime général en 2008. [https://www.ameli.fr/fileadmin/user\\_upload/documents/ald2008\\_tableau\\_I.xls](https://www.ameli.fr/fileadmin/user_upload/documents/ald2008_tableau_I.xls) (19 December 2019, date last accessed)
30. CNAMTS-DSES: *Effectifs, prévalences et caractéristiques des personnes prises en charge pour ALD par type d'affection et modalité d'ALD, pour le régime général en 2015*. [https://www.ameli.fr/fileadmin/user\\_upload/documents/Prevalence\\_ALD\\_tableau1\\_2015\\_arrondi.xls](https://www.ameli.fr/fileadmin/user_upload/documents/Prevalence_ALD_tableau1_2015_arrondi.xls) (19 December 2019, date last accessed)
  31. Haute Autorité de Santé: *Le soutien des aidants non professionnels. Une recommandation à destination des professionnels du secteur social et médico-social pour soutenir les aidants de personnes âgées, adultes handicapés ou souffrant de maladie chronique vivant à domicile*. 2015. [https://www.has-sante.fr/jcms/c\\_2835782/fr/le-soutien-des-aidants-non-professionnels-une-recommandation-a-destination-des-professionnels-du-secteur-social-et-medico-social-pour-soutenir-les-aidants-de-personnes-agees-adultes-handicapees-ou-souffrant-de-maladie-chronique-vivant-a-domicile](https://www.has-sante.fr/jcms/c_2835782/fr/le-soutien-des-aidants-non-professionnels-une-recommandation-a-destination-des-professionnels-du-secteur-social-et-medico-social-pour-soutenir-les-aidants-de-personnes-agees-adultes-handicapees-ou-souffrant-de-maladie-chronique-vivant-a-domicile) (19 December 2019, date last accessed)
  32. Fondation April/BVA: *Baromètre des aidants*. 2016. <https://www.fondation-april.org/barometres-et-etudes/barometre-des-aidants-1/42-barometre-des-aidants-2016/file> (19 December 2019, date last accessed)
  33. Institut TMO Régions pour l'Observatoire de la Fondation de France: *Les solitudes en France*. 2014. [https://www.fondationde-france.org/sites/default/files/atoms/files/dp\\_solitudes\\_2014\\_def\\_fiches\\_exemples.pdf](https://www.fondationde-france.org/sites/default/files/atoms/files/dp_solitudes_2014_def_fiches_exemples.pdf) (19 December 2019, date last accessed)
  34. Kang A, Yu Z, Foo M et al. Evaluating burden and quality of life among caregivers of patients receiving peritoneal dialysis. *Perit Dial Int* 2019; 39: 176–180
  35. Wilkie M. Peritoneal dialysis for people with functional impairment-what about carer support? *Perit Dial Int* 2019; 39: 101–102
  36. Goto NA, Van Loon IN, Boereboom FTJ et al. Association of initiation of maintenance dialysis with functional status and caregiver burden. *Clin J Am Soc Nephrol* 2019; 14: 1039–1047
  37. Belasco A, Barbosa D, Bettencourt AR et al. Quality of life of family caregivers of elderly patients on hemodialysis and peritoneal dialysis. *Am J Kidney Dis* 2006; 48: 955–963
  38. Fan SL, Sathick I, McKitty K et al. Quality of life of caregivers and patients on peritoneal dialysis. *Nephrol Dial Transplant* 2008; 23: 1713–1719
  39. Dratwa M. Costs of home assistance for peritoneal dialysis: results of a European survey. *Kidney Int Suppl* 2008; 108: S72–5
  40. Brunelli SM, Monda KL, Burkart JM et al. Early trends from the study to evaluate the prospective payment system impact on small dialysis organizations (STEPPS). *Am J Kidney Dis* 2013; 61: 947–956
  41. Young EW, Kapke A, Ding Z et al. Peritoneal dialysis patient outcomes under the medicare expanded dialysis prospective payment system. *Clin J Am Soc Nephrol* 2019; 14: 1466–1474
  42. Guilloteau S, Lobbedez T, Guillouet S et al. Impact of assisted peritoneal dialysis modality on outcomes: a cohort study of the French language peritoneal dialysis registry. *Am J Nephrol* 2018; 48: 425–433
  43. Michels WM, Van Dijk S, Verduijn M et al. Quality of life in automated and continuous ambulatory peritoneal dialysis. *Perit Dial Int* 2011; 31: 138–147
  44. Ulutas O, Farragher J, Chiu E et al. Functional disability in older adults maintained on peritoneal dialysis therapy. *Perit Dial Int* 2016; 36: 71–78
  45. Duquennoy S, Béchade C, Verger C et al. Is peritonitis risk increased in elderly patients on peritoneal dialysis? Report from the french language peritoneal dialysis registry (RDPLF). *Perit Dial Int* 2016; 36: 291–296
  46. Boyer A, Solis-Trapala I, Tabinor M et al. Impact of the implementation of an assisted peritoneal dialysis service on peritoneal dialysis initiation. *Nephrol Dial Transplant* 2020 [Epub ahead of print]
  47. Laplante S, Krepel H, Simons B et al. Offering assisted peritoneal dialysis is a cost-effective alternative to the current care pathway in frail elderly Dutch patients. *Int J Healthc Manag* 2013; 6: 27–36
  48. Oliver MJ, Salenger P. Making assisted peritoneal dialysis a reality in the United States: a Canadian and American viewpoint. *Clin J Am Soc Nephrol* 2019 [Epub ahead of print]