


# Comorbidity is not associated with dialysis modality choice in patients with end-stage kidney disease

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## Abstract

**Aim:** Over the past years the proportion of home dialysis patients has decreased in the Netherlands. In addition, the home dialysis use varies significantly among centres. It is unclear whether this is the result of differences in comorbidity, or other factors. Our aim was to investigate the association between comorbidity and dialysis modality choice.

**Methods:** The multi-centre DOMESTICO cohort study collected comorbidity data of patients who started dialysis in 35 Dutch centres from 2012 to 2016. Comorbidity was assessed by the Charlson comorbidity index. Home dialysis was defined as any peritoneal dialysis or home haemodialysis treatment during follow-up. Multivariable logistic regression analysis was used to assess the association between comorbidity and dialysis modality, with a mixed model approach to adjust for clustering of patients within dialysis centres.

**Results:** A total of 1358 patients were included, of whom 628 were treated with home dialysis. In crude mixed model analyses, the probability of receiving home

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dialysis was lower when comorbidity score was higher: having a high comorbidity score resulted in an odds ratio of 0.74 (95% CI 0.54–1.00) when compared with patients without comorbidities. After adjustments for age, sex, ethnic background, body mass index and dialysis vintage, there was no association between comorbidity and home dialysis.

**Conclusion:** Comorbidity was not significantly associated with home dialysis choice, after adjustment for several confounding factors including age and body mass index. Future studies should aim at unravelling the centre-specific characteristics that probably play a role in dialysis modality choice.

#### KEYWORDS

age, BMI, comorbidity, dialysis modality choice, home dialysis

#### SUMMARY AT A GLANCE

This study investigated the association between comorbidity and dialysis modality choice, using the multi-centre DOMESTICO cohort study that collected comorbidity data of patients who started dialysis in 35 Dutch centres from 2012 to 2016. Comorbidity, assessed by the Charlson comorbidity index, was not significantly associated with home dialysis choice, after adjustment for confounding factors including age and body mass index.

## 1 | INTRODUCTION

The proportion of home dialysis patients has declined in several European countries, including the United Kingdom and the Netherlands.<sup>1,2</sup> In the Netherlands, the proportion of prevalent home dialysis patients almost halved over 15 years: from 30% in 2003 to 18% in 2018.<sup>3</sup>

This decrease in home dialysis is often explained by the increasing number of patients with diabetes mellitus and cardiovascular disease.<sup>2,4</sup> Patients have to be able to perform dialysis at home and as a result a high degree of comorbidity may be seen as a barrier to home dialysis. Indeed, peritoneal dialysis (PD) patients in older cohorts had fewer comorbidities than in-centre haemodialysis (CHD) patients.<sup>5–9</sup> Another perceived barrier is advanced age of patients with kidney failure, caused by ageing of the general population and by more kidney transplantations in younger patients.<sup>2</sup> In a registry study among different European countries, it was found that elderly patients and patients with various comorbidities were less likely to receive PD.<sup>4</sup>

However, in the proportion of patients treated with home dialysis, a large variation exists among countries and even among dialysis centres within a country.<sup>3,4</sup> In the Netherlands, with a nation-wide home dialysis prevalence around 20%, the proportion of home dialysis varies considerably from 0% to even 40%.<sup>3</sup> This variation could be explained by different characteristics of dialysis patients among centres, most importantly regarding comorbidity and age. However, this variation could also indicate different selection criteria for home

dialysis among physicians. It remains unclear what the impact is of comorbidity on final dialysis modality choice.

The aim of this study is to investigate the association between comorbidity and type of dialysis treatment – home dialysis versus in-centre dialysis – in patients with end-stage kidney disease initiating dialysis between 2012 and 2017, accounting for centres' practice patterns.

## 2 | MATERIALS AND METHODS

### 2.1 | Study design and patient population

The Dutch nocturnal and hoME dialysis Study To Improve Clinical Outcomes (DOMESTICO) is a multi-centre retrospective cohort study investigating characteristics and outcomes of home and nocturnal dialysis patients, in comparison with in-centre dialysis patients. Eligible patients were adults who started maintenance dialysis treatment between 1 January 2012 and 1 January 2017, including those starting dialysis after transplant failure. Patients who stopped dialysis or died within 30 days after dialysis initiation were excluded. In DOMESTICO, all patients who were treated with home dialysis (or nocturnal dialysis) during the study period were selected and CHD patients were randomly selected in a systematic manner. Patients were followed until kidney transplantation, wish to stop dialysis, death or study end on 1 January 2017. Local medical ethics committees of all participating dialysis centres approved the study.

## 2.2 | Determinants

Comorbidity was assessed with Deyo's Charlson comorbidity index (CCI).<sup>10</sup> The adaptation of Deyo et al., in which lymphoma and leukaemia are scored under the condition 'malignancy', is most frequently used.<sup>10,11</sup> The CCI was calculated from the presence of a total of 17 conditions with several assigned weights ranging from 1 to 6 (Table S1).<sup>10,12</sup> The total score in dialysis patients ranges from 2 to 29, as ESKD results in a CCI score of 2 points. The score was divided into three groups according to literature: a score of 2 reflecting no comorbidity (only ESKD), a score of 3–4 reflecting intermediate comorbidity, and a score of 5 or more points reflecting high comorbidity.<sup>12</sup>

In addition, the association of various single comorbidities with dialysis modality was evaluated. These comorbidities were: diabetes mellitus, ischemic heart disease, heart failure, cerebrovascular disease, any malignancy and chronic lung disease.

## 2.3 | Data collection

All comorbidities were collected at dialysis initiation from patients' medical charts. Also age, sex, body mass index (BMI), ethnic background, cause of kidney failure, presence and duration of previous dialysis (i.e., dialysis vintage), and presence of previous transplantation were identified from patients' charts. BMI was divided into three groups according to the WHO classification: BMI <25 kg/m<sup>2</sup>, BMI 25–30 kg/m<sup>2</sup> (overweight), and BMI ≥30 kg/m<sup>2</sup> (obese). A high home dialysis volume was considered a marker for a successful home dialysis programme. Home dialysis centre size was thus defined based on the mean annual number of prevalent home dialysis patients according to registry data and subsequently dichotomized into <30 and ≥30 home dialysis patients.

## 2.4 | Outcome

In the present study, dialysis modality was defined as CHD (including nocturnal in-centre haemodialysis) or home dialysis, the latter including both PD and home haemodialysis (home HD). All patients who started with home dialysis or were ever treated with home dialysis during the follow-up were defined as home dialysis patients to reflect dialysis modality choice. If a patient was treated with both PD and home HD during the study period, the first episode of home treatment determined the category of home dialysis treatment.

## 2.5 | Statistical analyses

All normally distributed continuous variables were reported as means with standard deviation (SD), non-normally continuous variables as median with interquartile range (IQR), and categorical variables as proportions. For examining differences between patients

groups, *t*-tests, Mann–Whitney, and Chi-square tests were used where appropriate.

To assess the association between comorbidity and dialysis modality, logistic mixed model analysis was performed with CCI or single comorbidities as determinant. The assumption of linearity was validated and if violated, the CCI score was presented as categories. A mixed model – also known as multilevel model or hierarchical model – was chosen to account for the dependency of patients within a centre. This correction was performed by means of applying a random intercept for dialysis centre. Individual patients (level 1) were thus clustered within dialysis centres (level 2). The addition of a random slope was also tested, to allow for the association between comorbidity and dialysis modality to be different among dialysis centres. All analyses were corrected for age, sex, BMI, ethnic background, and dialysis vintage at study start. To investigate possible interaction of dialysis centres and case mix variables on the association between comorbidity and dialysis choice, interactions for home dialysis centre size, age, and BMI were investigated. In addition, important confounders were evaluated as individual risk factors as well. BMI was missing in 17% of the cases, therefore weight and length were imputed with standard multiple imputation techniques using 10 repetitions and predictive mean matching (SPSS).

Three sensitivity analyses were conducted, 1) using the Davies comorbidity score instead of the CCI; 2) including only patients with home dialysis as initial therapy; and 3) defining home dialysis as PD only, excluding all home HD patients.<sup>13,14</sup> The latter was performed because the association between comorbidity and home dialysis could be different for the two individual types of home dialysis. Finally, the two types of home dialysis were analysed separately using a multinomial logistic regression, in which outcomes were CHD, PD, and home HD.

A *p*-value of <.05 was considered statistically significant. All analyses were performed using SPSS Statistics version 26 (IBM Corp) or STATA 14 (StataCorp LP).

## 3 | RESULTS

A total of 1358 patients were included in this study, of whom 46% was treated with home dialysis during the study period: 41% was treated with PD (*n* = 564) and 5% with home HD (*n* = 64). Most home dialysis patients (72%) started home dialysis as initial therapy. Median follow-up time, that is, inclusion in the study to end of the study (kidney transplantation, death, stop of dialysis, or January 1st 2017), was 1.7 years (IQR 0.8–2.9). Baseline characteristics of the patients are described in Table 1. The prevalence of comorbidity was: diabetes mellitus 34%, ischaemic heart disease 28%, heart failure 11%, cerebrovascular disease 14%, any malignancy 14% and chronic lung disease 13%. Mean age at dialysis initiation was slightly higher in CHD patients compared with home dialysis patients (63.1 ± 15.8 vs. 61.6 ± 15.6 years, resp.). Patients receiving home dialysis were more likely to be Caucasian, had a shorter dialysis vintage at dialysis

**TABLE 1** Characteristics of the 1358 included dialysis patients, divided by dialysis modality

	All patients (n = 1358)	Home dialysis (n = 628)	In-centre haemodialysis (n = 730)	p-value
Male sex, n (%)	832 (61)	390 (62)	442 (61)	.58
Age (year), mean ± SD	62.4 ± 15.7	61.6 ± 15.6	63.1 ± 15.8	.08
Body mass index (kg/m <sup>2</sup> ), mean ± SD	26.8 ± 5.6	26.4 ± 5.1	27.2 ± 6.0	.01
Ethnic background, n (%)				<.001
Caucasian	805 (59)	403 (64)	402 (55)	
Moroccan/Turkish	73 (5)	13 (2)	60 (8)	
Asian	71 (5)	35 (6)	36 (5)	
Afro-American	60 (4)	21 (3)	39 (5)	
Unknown	330 (24)	146 (23)	184 (25)	
ERA-EDTA code, n (%)				.62
Glomerulonephritis/pyelonephritis	261 (19)	125 (20)	136 (19)	
Cystic kidney disease	78 (6)	39 (6)	39 (5)	
Renovascular kidney disease	355 (26)	164 (26)	191 (26)	
Diabetes mellitus	243 (18)	102 (16)	141 (19)	
Other/unknown	421 (31)	198 (32)	223 (31)	
Previous dialysis, n (%)	276 (20)	121 (19)	155 (21)	.38
Dialysis vintage (mo), median (IQR) <sup>a</sup>	29.4 [11.0–57.7]	17.7 [2.2–45.4]	38.4 [15.4–62.8]	<.001
Previous renal transplant, n (%)	241 (18)	92 (15)	149 (20)	.007
Charlson comorbidity index, n (%)				.16
2 (no comorbidity)	409 (30)	202 (32)	207 (28)	
3–4 (intermediate comorbidity score)	553 (41)	257 (41)	296 (41)	
≥5 (high comorbidity score)	396 (29)	169 (27)	227 (31)	
Davies comorbidity score, n (%)				.43
0 (no comorbidity)	398 (29)	194 (31)	204 (28)	
1–2 (intermediate risk)	722 (53)	330 (53)	392 (54)	
≥3 (high comorbidity score)	238 (18)	104 (17)	134 (18)	
Diabetes mellitus, n (%)	465 (34)	193 (31)	272 (37)	.012
Ischaemic heart disease, n (%)	378 (28)	182 (29)	196 (27)	.40
Heart failure, n (%)	149 (11)	83 (13)	66 (9)	.018
Cerebrovascular disease, n (%)	187 (14)	84 (13)	103 (14)	.75
Any malignancy, n (%)	192 (14)	81 (13)	111 (15)	.24
Chronic lung disease, n (%)	159 (12)	67 (11)	92 (13)	.27

<sup>a</sup>Dialysis vintage presented for patients with previous dialysis only.

initiation, and less often a previous renal transplant. In Table 2, clinical characteristics of patients from small and large home dialysis centres are shown. No differences in CCI, age and BMI were found between patients from small and large home dialysis centres.

### 3.1 | Association between comorbidity and dialysis modality

Table 3 shows the association between comorbidity and home dialysis as dialysis modality choice. CCI was analysed in categories, since the linearity assumption was violated. Intermediate comorbidity, that is, 3–4 points, was not associated with home dialysis as modality choice (unadjusted OR 0.97, 95% CI 0.73–

1.28). A high comorbidity score, that is, a score of ≥5 points, was associated with a lower probability of receiving home dialysis (unadjusted OR 0.74, 95% CI 0.54–1.00, *p*-value .05). After adjustments for age, sex, BMI, ethnic background, and dialysis vintage, a higher comorbidity score was no longer associated with home dialysis (adjusted OR 0.88, 95% CI 0.63–1.23). Age and BMI were the most important confounders in the model, they induced the greatest change in the regression coefficient respectively 28% and 30%. The other confounders induced changes of less than 10%. Adding a random slope to the model with CCI as a continuous variable did not change our results, indicating that dialysis centre did not influence the association between CCI and dialysis modality choice. This suggests that comorbidity was not weighted differently among centres.

**TABLE 2** Characteristics of patients from small and large home dialysis centres

	Patients from centres with <30 home dialysis patients (N = 535)	Patients from centres with ≥30 home dialysis patients (N = 823)	p-value
CCI of CHD patients, n (%)			.45
2 (no comorbidity)	94 (27)	113 (29)	
3–4 (intermediate comorbidity score)	147 (43)	149 (38)	
≥5 (high comorbidity score)	101 (30)	126 (32)	
CCI of home dialysis patients, n (%)			.24
2 (no comorbidity)	69 (36)	133 (31)	
3–4 (intermediate comorbidity score)	80 (41)	177 (41)	
≥5 (high comorbidity score)	44 (23)	125 (29)	
Mean age (±SD)	62.4 ± 15.0	62.4 ± 16.1	.98
Mean BMI (±SD)	26.9 ± 5.7	26.7 ± 5.5	.50

Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index; CHD, in-centre haemodialysis.

**TABLE 3** Association of comorbidity and treatment with home dialysis, compared with in-centre haemodialysis

	Logistic mixed model regression analysis <sup>a</sup>					
	Odds ratio [95% CI] crude	p-value	Odds ratio [95% CI] adjusted <sup>b</sup>	p-value	Odds ratio [95% CI] adjusted <sup>c</sup>	p-value
Charlson comorbidity index						
CCI 2	REF		REF		REF	
CCI 3–4	0.97 [0.73–1.28]	.82	1.05 [0.78–1.41]	.73	1.10 [0.82–1.49]	.53
CCI ≥5	0.74 [0.54–1.00]	.05	0.84 [0.61–1.17]	.30	0.88 [0.63–1.23]	.44
At least 1 comorbidity	0.86 [0.67–1.12]	.26	0.97 [0.74–1.27]	.81	1.01 [0.77–1.33]	.93
Diabetes mellitus <sup>d</sup>	0.75 [0.59–0.97]	.03	0.78 [0.61–1.01]	.06	0.83 [0.64–1.08]	.17
Ischaemic heart disease	1.08 [0.83–1.40]	.57	1.17 [0.89–1.55]	.26	1.23 [0.93–1.63]	.15
Heart failure	1.47 [1.01–2.14]	.05	1.54 [1.05–2.25]	.03	1.60 [1.09–2.37]	.02
Cerebrovascular disease	0.79 [0.57–1.11]	.18	0.83 [0.59–1.17]	.28	0.81 [0.57–1.15]	.24
Any malignancy	0.91 [0.65–1.28]	.58	0.92 [0.65–1.30]	.65	0.89 [0.63–1.26]	.50
Chronic lung disease	0.83 [0.58–1.21]	.34	0.88 [0.61–1.29]	.52	0.88 [0.60–1.29]	.50

Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index.

<sup>a</sup>Logistic mixed model regression analysis with dialysis centre as random intercept, with individual patients as first level.

<sup>b</sup>Adjusted for age, sex, and BMI.

<sup>c</sup>Adjusted for age, sex, BMI, ethnic background, and dialysis vintage.

<sup>d</sup>Adjusted for age, sex, ethnic background, and dialysis vintage.

Patients with heart failure ( $n = 149$ ) were more likely to receive home dialysis, even after adjustments for confounders (adjusted OR 1.60, 95% CI 1.09–2.37). Diabetic patients were less likely to receive home dialysis in the unadjusted analysis, but after correction for confounders this association lost significance (adjusted OR 0.83, 95% CI 0.64–1.08). Patients with ischaemic heart disease, cerebrovascular disease, malignancies or chronic lung disease were as likely to receive home dialysis as CHD. The Davies comorbidity score had also no association with home dialysis choice (Table S2). Comparable results to the original analysis were also found in a sensitivity analysis that included only patients with home dialysis as initial therapy.

### 3.2 | Interaction of dialysis centre, age, and BMI on the association between comorbidity and dialysis modality

Home dialysis centre size and age were no interactions in the association between comorbidity and home dialysis choice (Tables S3 and S4). However, obese patients (BMI  $\geq 30$  kg/m<sup>2</sup>) with an intermediate or high comorbidity score were significantly less likely to receive home dialysis compared with obese patients without comorbidities, adjusted OR 0.40 (95% CI 0.18–0.86,  $p$ -value .02) for intermediate comorbidity score and adjusted OR 0.43 (95% CI 0.20–0.93) for high comorbidity score (Table 4). Patients with a BMI  $< 25$  kg/m<sup>2</sup> with an

**TABLE 4** Interaction of BMI in the association between CCI and treatment with home dialysis, compared with in-centre haemodialysis

Logistic mixed model regression analysis <sup>a</sup>					
		Odds ratio [95% CI] crude	p-value	Odds ratio [95% CI] adjusted <sup>b</sup>	p-value
<b>Patients with BMI &lt;25 kg/m<sup>2</sup> (N = 493)<sup>c</sup></b>					
Charlson comorbidity index					
CCI 2	REF			REF	
CCI 3–4		1.37 [0.89–2.11]	0.15	1.59 [1.01–2.49]	.04
CCI ≥ 5		1.03 [0.62–1.69]	0.92	1.22 [0.72–2.07]	.46
<b>Overweight patients (BMI 25–30 kg/m<sup>2</sup>) (N = 379)<sup>c</sup></b>					
Charlson comorbidity index					
CCI 2	REF			REF	
CCI 3–4		1.00 [0.61–1.64]	0.99	1.10 [0.66–1.83]	.72
CCI ≥ 5		0.71 [0.41–1.24]	0.22	0.76 [0.43–1.35]	.36
<b>Obese patients (BMI ≥30 kg/m<sup>2</sup>) (N = 257)<sup>c</sup></b>					
Charlson comorbidity index					
CCI 2	REF			REF	
CCI 3–4		0.40 [0.19–0.86]	0.02	0.40 [0.18–0.86]	.02
CCI ≥ 5		0.42 [0.20–0.88]	0.02	0.43 [0.20–0.93]	.03

Note: BMI was divided according to the WHO classification: BMI <25 kg/m<sup>2</sup>, BMI 25–30 kg/m<sup>2</sup> (overweight), and BMI ≥30 kg/m<sup>2</sup> (obese).

Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index.

<sup>a</sup>Logistic mixed model analysis with dialysis centre as random intercept, with individual patients as first level.

<sup>b</sup>Adjusted for age, sex, ethnic background, and dialysis vintage.

<sup>c</sup>A total of 1358 patients were analysed: for 229 patients imputed data for BMI were used.

intermediate comorbidity score were significantly more likely to receive home dialysis compared with patients with a BMI <25 kg/m<sup>2</sup> without comorbidities (adjusted OR 1.59, 95% CI 1.01–2.49, *p*-value .04).

### 3.3 | Association between age or BMI and dialysis modality

Older age, analysed as an individual risk factor, was associated with a lower probability of receiving home dialysis both in unadjusted and adjusted analyses (Table S5). Elderly patients (≥65 years of age) were less likely to receive home dialysis compared with patients younger than 65 years of age, adjusted OR 0.67 (95% CI 0.53–0.86, *p*-value .002). Also BMI, analysed as an individual risk factor, was associated with dialysis modality choice (Table S6). Obese patients were less likely to receive home dialysis compared with patients with a BMI <25 kg/m<sup>2</sup>, adjusted OR 0.68 (95% CI 0.48–0.96, *p*-value .03).

### 3.4 | Association between comorbidity and PD or HDD

A sensitivity analysis comparing PD with CHD, revealed similar results as the original analysis (Table S7). Finally, the two types of home dialysis were analysed separately using a multinomial logistic regression,

with CHD as reference treatment (Table S8). A high comorbidity score of ≥5 was significantly associated with a lower probability of receiving peritoneal dialysis compared with CHD, with a crude OR of 0.74 (95% CI 0.55–0.98, *p*-value .04). After adjusting for confounders, the association lost significance (OR 0.83, 95% CI 0.61–1.14). The adjusted OR for a high comorbidity score and receiving home HD was 1.42 (95% CI 0.69–2.93).

## 4 | DISCUSSION

In this study, ESKD patients with a high comorbidity score measured by CCI were less likely to receive home dialysis as compared with CHD. However, when adjusted for confounders including age and BMI, we found no association between comorbidity and dialysis modality choice. In addition, no association was found with diabetes mellitus, ischaemic heart disease, malignancy and cerebrovascular disease. Patients with heart failure were more likely to receive home dialysis, while obese patients with comorbidities were more likely to receive CHD.

The association between comorbidities and PD as home dialysis modality has been investigated in different populations, including in the USA and Europe.<sup>4–9,15,16</sup> Similar results were found in an older European cohort from 1998 to 2006, in which a high comorbidity score was highly associated with receiving CHD in unadjusted analyses yet almost lost significance in analyses adjusted only for age and

sex.<sup>4</sup> However in their study, patients with malignancy and cerebrovascular disease were less likely to receive PD while patients with diabetes mellitus were more likely to receive PD (adjusted OR 1.09 [1.00–1.20]). In contrast, in another study, French patients with diabetes mellitus were more likely to receive CHD and patients with heart failure were more likely to receive PD, both similar to our results.<sup>6</sup> In studies from the USA, both heart failure and higher comorbidity scores were associated with a lower probability of receiving PD.<sup>5,7,8</sup> These studies however originate from before 2000, when the use of PD was historically low in the USA making comparisons with the current population difficult.<sup>17</sup> Finally, in a study from Australia and New Zealand, several comorbidities including diabetes mellitus were associated with a lower probability of receiving home dialysis.<sup>16</sup> Overall, these discrepancies among countries indicate that wide variation in selection of home dialysis exists and that comorbidity alone is not a justified contraindication for home dialysis.

In our study, both age and BMI were important confounders in the association between comorbidity and dialysis modality. Thus far, only few other studies corrected for both factors.<sup>7,15</sup> In the French study of Couchoud et al., only patients aged  $\geq 75$  years and single comorbidities were evaluated.<sup>15</sup> They found a positive association between heart failure and home dialysis (adjusted OR 1.8, 95% CI 1.5–2.3). The study of Stack et al. from USA, also evaluated single comorbidities only and was conducted prior to 2000.<sup>7</sup> Although few studies correct for age and BMI, increasing age is associated with a lower probability of receiving home dialysis in recent studies,<sup>4,16</sup> as is obesity.<sup>16</sup> The often-reported association between comorbidity and dialysis modality may be largely explained by the confounding effect of age. The same may be true for BMI, as many conditions including cardiovascular disease are initiated by an unhealthy lifestyle.

Age should not be a barrier to receive home dialysis. Although elderly patients frequently have functional limitations and cognitive impairment that may limit the possibilities for self-care, this does not necessarily rule out a home-based treatment.<sup>18</sup> Assisted PD is an important and emerging treatment option for older dialysis patients with similar outcomes to CHD, such as mortality, hospitalization rates, and health-related quality of life.<sup>19,20</sup> Moreover, PD provides ultrafiltration more slowly and is not associated with intradialytic hypotension frequently occurring in CHD, which is especially important in frail elderly patients.<sup>21</sup> Because of the considerable growth in the number of elderly dialysis patients, it is essential to consider home dialysis treatment as a feasible option for elderly patients.

Obese patients were less likely to receive home dialysis treatment in several studies.<sup>6,7,16</sup> It is possible that in obese patients CHD is preferred, due to the survival advantage known as the ‘obesity paradox’ in obese CHD patients that lacks in PD.<sup>22</sup> Another explanation may be that obesity (BMI  $>30$  kg/m<sup>2</sup>) in PD patients is associated with higher risk of leakage and PD-associated infections.<sup>23–25</sup> The latter could be related to the common co-existence of Diabetes Mellitus and lower socioeconomic status in obese patients, or it might be due to obese abominable folds.<sup>23,24</sup> But, using extended catheters or even pre-sternal catheters reduced this risk of infections in several studies.<sup>26</sup> Many nephrologists may consider obesity a contraindication for

treatment with PD as PD can induce weight gain, but this issue is controversial.<sup>21</sup> Overall, obesity may not be considered an absolute contraindication for performing PD.

In keeping with findings of previous studies, our study identified that heart failure is associated with a higher probability of receiving home dialysis.<sup>6,15</sup> PD is indeed suggested as ultrafiltration treatment in patients with diuretic-resistant heart failure.<sup>27</sup> In this seriously ill-group, percutaneous PD catheter insertion under local anaesthesia may be performed by interventional radiologists to avoid general anaesthesia.<sup>26</sup> Since PD lacks the intradialytic hypotension known in CHD, it is a suitable treatment option in all patients with heart failure.<sup>27</sup>

Comorbidity alone does not explain the variation in percentage of home dialysis among centres. The present study results suggest that other factors in modality selection are weighted differently among centres. These factors likely include age and BMI, but since these factors were not different between centres with a high or low volume of home dialysis patients – considering a high volume a proxy for a successful home dialysis programme – other factors must also define dialysis modality choice. Indeed, in a French study analysing differences between centres in the use of PD, there was variation in PD use among regions but also huge variation in the evaluation of different patient characteristics.<sup>6</sup> The authors thus suggested that other regional practice patterns, such as the organization of a home dialysis programme, play a role in modality selection. Ethier et al., reporting on the ANZDATA registry and using a mixed model, stated that variation in the use of home dialysis among centres was associated more with centre factors, such as centre size and proportion of patients with a vascular access at dialysis initiation, than patient characteristics.<sup>16</sup> Also, logistic and financial factors form barriers for home dialysis and can be weighed differently by individual dialysis centres.<sup>28,29</sup> Further studies are needed to explore these centre-specific factors that might also influence dialysis modality selection.

The strengths of this study include the extensive statistical analyses and the definition of both determinant and outcome. The latter was defined as a start with or transfer to home dialysis during follow-up, reflecting dialysis modality choice. The determinant comorbidity was defined both in validated scores and in single comorbidities providing insight in the association from several points of view, especially heart failure was positively associated with home dialysis. With mixed models, we corrected for centre differences in patient selection which has not often been performed in studies.<sup>5,16</sup> However, we had a relatively small sample compared with others.<sup>4,6,7,15</sup> Although CHD patients were randomly selected, the DOMESTICO study was not designed for the present research question and the population used might not represent a true reflection of modality selection. For this research question, it might have been better to match patients according to their total duration of follow-up. Due to the retrospective design of the study, we were unable to investigate causes of low use of home dialysis, but mere associations instead. Finally, CCI and Davies are developed for mortality predictions and not for dialysis modality choice. These scores might not adequately reflect the impact of comorbidity on dialysis modality choice, especially since the various single comorbidities had associations in different directions.

Notwithstanding these limitations, in this study comorbidity was not significantly associated with home dialysis choice if corrected for age, BMI and centre. Only obese patients with comorbidities were significantly less likely to receive home dialysis. Other factors than comorbidity possibly also influence dialysis modality choice. Differences in prevalence of obesity and age distribution, but probably also centre-specific factors may be related to the variation in the proportion of patients treated with home dialysis among centres. We suggest that future studies should focus on the centre-specific factors that determine dialysis modality selection.

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## CONFLICT OF INTEREST

A.E.S. and A.C.A. have received speaker honoraria from Baxter Healthcare. All other authors declare no conflict of interest. The results in this article have not been published previously in whole or part, accept in abstract form at the American Society of Nephrology Kidney Week 2021.

## AUTHOR CONTRIBUTIONS

Anna A. Bonenkamp, Frans J van Ittersum and Brigit C van Jaarsveld designed the research question. Anna A. Bonenkamp and Anita van Eck van der Sluijs collected data. Anna A. Bonenkamp performed the statistical analyses, with support from Tiny Hoekstra and Brigit C. van Jaarsveld. Anna A. Bonenkamp, Tiny Hoekstra, Frans J. van Ittersum, and Brigit C. van Jaarsveld interpreted the data. Sanne Vonk, Alferso C. Abrahams, Yolande M. Vermeeren, and Anita van Eck van der Sluijs provided intellectual content of critical importance to the work described. Anna A. Bonenkamp drafted the manuscript. All authors critically edited the manuscript and approved the final version.

## DATA AVAILABILITY STATEMENT

The data underlying this article will be shared upon reasonable request to the corresponding author and approval of the DOMESTICO steering group.

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## REFERENCES

- ERA-EDTA Registry: ERA-EDTA Registry Annual Report 2018. Amsterdam UMC, location AMC, Department of Medical Informatics, Amsterdam, the Netherlands. 2020:2018.
- van de Luitgaarden MW, Jager KJ, Segelmark M, et al. Trends in dialysis modality choice and related patient survival in the ERA-EDTA registry over a 20-year period. *Nephrol Dial Transplant*. 2016;31(1):120-128.
- Hoekstra T, Dekker FW, Cransberg K, Bos WJ, van Buren M, Hemmelder MH. *RENINE Annual Report 2018*. Nefrovisie; 2018. Accessed January 04, 2021. <https://www.nefrovisie.nl/jaarrapportages/>.
- van de Luitgaarden MW, Noordzij M, Stel VS, et al. Effects of comorbid and demographic factors on dialysis modality choice and related patient survival in Europe. *Nephrol Dial Transplant*. 2011;26(9):2940-2947.
- Miskulin DC, Meyer KB, Athienites NV, et al. Comorbidity and other factors associated with modality selection in incident dialysis patients: the CHOICE study. Choices for healthy outcomes in caring for end-stage renal disease. *Am J Kidney Dis*. 2002;39(2):324-336.
- Couchoud C, Savoye E, Frimat L, Ryckelynck JP, Chalem Y, Verger C. Variability in case mix and peritoneal dialysis selection in fifty-nine French districts. *Perit Dial Int*. 2008;28(5):509-517.
- Stack AG. Determinants of modality selection among incident US dialysis patients: results from a national study. *J Am Soc Nephrol*. 2002;13(5):1279-1287.
- Vonesh EF, Snyder JONJ, Foley RN, Collins AJ. The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. *Kidney Int*. 2004;66(6):2389-2401.
- Jager KJ, Korevaar JC, Dekker FW, Krediet RT, Boeschoten EW, Netherlands Cooperative Study on the Adequacy of Dialysis Study G. The effect of contraindications and patient preference on dialysis modality selection in ESRD patients in The Netherlands. *Am J Kidney Dis*. 2004;43(5):891-899.
- Deyo Rac DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45(6):613-619.
- Sharabiani MTA, Aylin P, Bottle A. Systematic review of comorbidity indices for administrative data. *Med Care*. 2012;50(12):1109-1118.
- Charlson Mep P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chron Dis*. 1987;40(5):373-383.
- Davies SJ, Russell L, Bryan J, Phillips L, Russell GI. Comorbidity, urea kinetics, and appetite in continuous ambulatory peritoneal dialysis patients: their interrelationship and prediction of survival. *Am J Kidney Dis*. 1995;26(2):353-361.
- Davies SJ, Phillips L, Naish PF, Russell GI. Quantifying comorbidity in peritoneal dialysis patients and its relationship to other predictors of survival. *Nephrol Dial Transplant*. 2002;17(6):1085-1092.
- Couchoud C, Moranne O, Frimat L, Labeeuw M, Allot V, Stengel B. Associations between comorbidities, treatment choice and outcome in the elderly with end-stage renal disease. *Nephrol Dial Transplant*. 2007;22(11):3246-3254.
- Ethier I, Cho Y, Hawley C, et al. Effect of patient- and center-level characteristics on uptake of home dialysis in Australia and New Zealand: a multicenter registry analysis. *Nephrol Dial Transplant*. 2020;35:1938-1949.
- Li PK-T, Chow KM, Van de Luitgaarden MWM, et al. Changes in the worldwide epidemiology of peritoneal dialysis. *Nat Rev Nephrol*. 2017;13(2):90-103.
- Brown EA, Finkelstein FO, Iyasere OU, Klinger AS. Peritoneal or hemodialysis for the frail elderly patient, the choice of 2 evils? *Kidney Int*. 2017;91(2):294-303.
- Iyasere O, Brown E, Gordon F, et al. Longitudinal trends in quality of life and physical function in frail older dialysis patients: a comparison of assisted peritoneal dialysis and in-center hemodialysis. *Perit Dial Int*. 2019;39(2):112-118.
- Béchéde C, Lobbedez T, Ivarsen P, Povlsen JV. Assisted peritoneal dialysis for older people with end-stage renal disease: the French and Danish experience. *Perit Dial Int*. 2015;35(6):663-666.
- Eroglu E, Heimburger O, Lindholm B. Peritoneal dialysis patient selection from a comorbidity perspective. *Semin Dial*. 2020;35:25-39.
- Ladhani M, Craig JC, Irving M, Clayton PA, Wong G. Obesity and the risk of cardiovascular and all-cause mortality in chronic kidney disease: a systematic review and meta-analysis. *Nephrol Dial Transplant*. 2017;32(3):439-449.
- Nessim SJ, Komenda P, Rigatto C, Verrelli M, Sood MM. Frequency and microbiology of peritonitis and exit-site infection among obese peritoneal dialysis patients. *Perit Dial Int*. 2013;33(2):167-174.



24. Jegatheesan D, Johnson DW, Cho Y, et al. The relationship between body mass index and organism-specific peritonitis. *Perit Dial Int.* 2018;38(3):206-214.
25. Obi Y, Streja E, Mehrotra R, et al. Impact of obesity on modality longevity, residual kidney function, peritonitis, and survival among incident peritoneal dialysis patients. *Am J Kidney Dis.* 2018;71(6):802-813.
26. Crabtree JH, Shrestha BM, Chow KM, et al. Creating and maintaining optimal peritoneal dialysis access in the adult patient: 2019 update. *Perit Dial Int.* 2019;39(5):414-436.
27. Puttagunta H, Holt SG. Peritoneal dialysis for heart failure. *Perit Dial Int.* 2015;35(6):645-649.
28. de Jong RW, Stel VS, Heaf JG, Murphy M, Massy ZA, Jager KJ. Non-medical barriers reported by nephrologists when providing renal replacement therapy or comprehensive conservative management to end-stage kidney disease patients: a systematic review. *Nephrol Dial Transplant.* 2021;36(5):848-862.
29. van de Luitgaarden MWM, Jager KJ, Stel VS, et al. Global differences in dialysis modality mix: the role of patient characteristics, macroeconomics and renal service indicators. *Nephrol Dial Transplant.* 2013;28(5):1264-1275.

#### SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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