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The Influence of Centre Size on the Attitude of German Nephrologists towards Administering Peritoneal Dialysis to Comorbid Patients

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List of Abbreviations

APD	Automated Peritoneal Dialysis
CAPD	Continuous Ambulatory Peritoneal Dialysis
CHF	Congestive Heart Failure
CKD	Chronic Kidney Disease
Cs-HR	Cause Specific Hazard Ratio
DM	Diabetes Mellitus
ESRD	End Stage Renal Disease
HD	Haemodialysis
IPD	Intermittent Peritoneal Dialysis
NICE	National Institute for Health Care Excellence
OLS	Ordinary Least Squares (regression analysis)
PD	Peritoneal Dialysis
PP	Pre-dialysis Programme
RRT	Renal Replacement Therapy
RH	Relative Hazard
RR	Relative Risk
TF	Technique Failure

1. Summary

Peritoneal dialysis (PD) is a method of renal replacement therapy that offers both medical and economic advantages. To patients it offers a safe therapy option that can be administered autonomously at home. Nevertheless, its adoption has remained slow, and most health care systems are still dominated by in-centre haemodialysis. One factor that determines overall prescription of peritoneal dialysis is the attitude of nephrologists towards the method and their confidence in administering peritoneal dialysis, especially in cases where patients present various comorbidities. This study analyses data gathered in the Mau-PD project between 2018 and 2019. A questionnaire that was sent to all nephrologists in Germany working in the ambulatory sector was analysed to determine how they perceive peritoneal dialysis, how they view their training and if they would prefer peritoneal dialysis or haemodialysis in certain cases.

As a factor that may influence this inclination to favour one over the other, the size of dialysis centres in terms of absolute patient numbers was proposed as an explanatory variable in a linear regression model. So far, centre size has been studied in its effect on mortality and technique failure; however, its effect on nephrologist attitude and ultimately prescription habits, has so far not been studied.

The main findings of this study are that most German nephrologists view peritoneal dialysis as an equivalent method to haemodialysis in terms of medical outcome (90.88%). Only 23.33% of German nephrologists considered their training in peritoneal dialysis to be thorough.
When presented with patients presenting various comorbidities nephrologists, on the whole, preferred haemodialysis over peritoneal dialysis (3.42884; St. Err.: 0.0173021; 95%CI: 3.394856– 3.462824; on a 5-point scale where 1 = total preference for peritoneal dialysis and 5 = total preference for haemodialysis). This general inclination was shifted towards a preference for peritoneal dialysis as absolute numbers of PD patients increased (Coefficient: -0.1672043; Std. Err.: 0.0165543; 95% CI: -0.201291 -0.135801). According to the data gathered, between 40 and 50 patients in a dialysis centre seems to be the point where a preference for haemodialysis shifts to a preference for peritoneal dialysis.

Zusammenfassung

Die Peritonealdialyse ist ein Nierenersatzverfahren, welches sowohl medizinische wie auch ökonomische Vorteile bietet. Patient_innen bietet sie eine sichere Therapieoption, welche selbstständig von zuhause aus durchgeführt werden kann. Nichtsdestotrotz bleibt das Verfahren in seiner Verbreitung hinter der Hämodialyse in Dialysezentren zurück, welche auch weiterhin die meisten Gesundheitssysteme dominiert. Ein Faktor, welcher die Verschreibung der Peritonealdialyse maßgeblich beeinflusst, ist die Einstellung von Nephrolog_innen gegenüber der Methode und das Vertrauen in die eigene Fertigkeit bei der Behandlung von Patient_innen, insbesondere wenn diese Komorbiditäten aufweisen.

Diese Arbeit analysiert Daten, welche im Zuge des Mau-PD Projektes zwischen 2018 und 2019 gesammelt wurden. Ein Fragenbogen, welcher als Teil des Projektes der Gesamtheit aller niedergelassenen Nephrolog_innen in Deutschland zugesandt wurde, dient als Grundlage der Analyse. Ziel ist es zu ergründen wie die Peritonealdialyse, sowie die eigene Ausbildung an der Methode, bewertet werden, und welche Methode in gewissen Fällen bevorzugt würde.

Die Größe des jeweiligen Dialysezentrums im Sinne der angegebenen aktueller Patientenzahl wird als ein erklärender Faktor in einem Regressionsmodell herangezogen, um zu erklären, warum eine Methode der anderen vorgezogen wird. Bisher wurde die Größe der Dialysezentren in ihrem Effekt auf die Mortalität und Therapieabbrüche untersucht, jedoch wurden der Effekt auf die Einstellung und das daraus resultierende Verschreibungsverhalten noch nicht genauer beleuchtet.

Diese Arbeit zeigt, dass die meisten niedergelassenen Nephrolog_innen in Deutschland die Peritonealdialyse und Hämodialyse als medizinisch gleichwertige Therapiemethoden betrachten (90.88%). Nur 23.33% der Befragten berichten die Methode ausführlich in der Facharztausbildung kennengelernt zu haben. In Fällen mit verschiedenartig vorerkrankten Patient_innen bevorzugen die meisten Nephrolog_innen die Hämodialyse (3.42884; St. Err.: 0.0173021; 95%CI: 3.394856– 3.462824; auf einer 5-Punkte Skala wo 1 = immer Peritonealdialyse und 5 = immer Hämodialyse). Diese generelle Ausrichtung verschiebt sich in Richtung einer Bevorzugung der Peritonealdialyse mit dem Anstieg der absoluten Patientenzahlen (Koeffizient: -0.1672043; Std. Err.: 0.0165543; 95% CI: -0.201291 -0.135801). Eine vorsichtige Interpretation der Daten deutet darauf hin, dass eine Patientenzahl zwischen 40 und 50 Patient_innen zu einer Bevorzugung der Peritonealdialyse führt.

2. Introduction

PD is a form of renal replacement therapy (RRT) that relies on the peritoneal membrane to remove fluids and solutes from the blood. As an alternative to haemodialysis (HD), which remains the globally dominant mode of RRT, it offers several advantages. PD has been shown to preserve residual renal function [1], as well as increase survivability, especially early on [2]. The extent to which patient survival is improved with PD has, however, been a source of debate, as some authors have argued that comparisons of HD and PD have suffered from confounding factors, either unmeasured, or associated with better understood phenomena, such as "crash starters", i.e. patients with rapidly progressing chronic kidney disease (CKD) who start RRT with unfavourable preconditions. These patients are more likely to initiate RRT on a central venous catheter, thereby increasing the mortality risk due to infectious complications [3]. The overall picture seems to be that the difference is real and that the debate is partly affected by limitations of methodology in Cox-HR models [4]. Other benefits are due to the fact that PD is most often an ambulatory procedure, consequently having positive effects on cost [5] and patient quality of life [6].

Since PD has become a viable alternative to HD, a considerable effort has been made to study the perceived lack of adoption of the method in many parts of the world. From a global perspective, HD accounts for >80% of dialysis provision in 82% of countries for which data exists. PD is most widely used in Hong Kong, New Zealand, Qatar, and Colombia, where prevalence is >30%. Among the lowest ranking countries are Egypt, Bangladesh and Japan, the latter showing that prevalence does not simply correlate with income and the level of development of the medical sector [7]. Some regions exhibit a decline of PD use. Notable examples are the UK, where PD utilization has fallen from 24% in 2004 to 13,1% in 2016, and Hong Kong, usually perceived as PD's most successful example of wide-spread adoption, where prevalence has declined from 82,1% to 70,6% in the same time period [8]. Answers to the question of why PD is stagnating or declining are varied and not consistent over different regions. In general, health care systems in developing countries are more affected by direct economic issues, such as the cost of dialysis fluids and access to specialized training [9]. In many developed countries training of nephrologists plays an equally important role, however, whereas in developing countries training is intertwined with cost, in developed countries there seems to be a connection with motivation and lack of information for prescribers and patients. For example, Chan et al. [10] state that there is a lack of exposure to PD in the US health care system, which affects patients and providers alike, resulting in less willingness to start RRT on PD. Finkelstein [11] points out that the same structural barriers, pertaining to regulatory and educational problems, have been discussed in the US for the last 20 years. One solution for the growth of PD is a top-down regulatory approach, as was recently initiated in the US, where

the Presidential Executive Order on Advancing American Kidney Health (AAKH) aims to increase home-based dialysis modalities through a mix of financial bonuses and penalties. The goal is to increase home-based RRT, of which PD in its various forms is the prominent modality, as well as pre-emptive kidney transplantation. Other examples of increasing PD by legislative means exist, the most notable example being Hong Kong's PD-first policy, which has served as the model for a similar scheme in Thailand. Elsewhere there are systems where PD, if not mandatory, is favoured as principal mode of RRT, as is the case in China and Canada [12]. As may be seen by the example of Hong Kong, a PD-first policy does not preclude a subsequent decline of PD prevalence, although Li et al. state that the reduction has mainly been the consequence of a planned increase in HD as a pre-emptive means to prevent sudden modality switch in patients with eventual PD technique failure [12]. In any case, in health care systems where HD is entrenched as the primary RRT modality, even a mandated switch to PD may be difficult and a strategy for transition must be considered. Abra & Weinhandl [13] point out that the current US policy based on financial incentives is uncertain to be successful, as similar previous schemes have proven. Consequently, it remains worthwhile to study, which factors lead to a higher PD prevalence.

2.1. Nephrologists and Formal PD Training

One approach to exploring the issue of low prevalence of PD is to investigate the role played by nephrologists and their attitudes towards PD and its utilization. As PD rates ultimately depend on nephrologists actively prescribing this method over other RRTs, their opinions and decisions have a direct effect on PD utilization. It should be noted here that although the final decision on RRT is usually the result of a shared decision-making process, it is the nephrologist's responsibility to determine medical eligibility. In that sense nephrologists perform a selection of patients, the process of which is subject to influencing factors, which will be explored later. One fundamental variable in the context of nephrologists' attitude towards PD is the role of formal PD training. Several studies have been conducted on the state of nephrologist PD training; other studies that investigate attitudes towards PD utilization more generally usually also inquire on reported training experience. As a result, the literature allows for a broad view of nephrologist training in different geographic locations and types of health care system. Bouvier et al. [14] surveyed French nephrologists in 2009, 23% of which cited limited training as one of the main barriers to PD utilization, along with a lack of specialized nurses (48%), low reimbursement (25%) and limited hospital facilities (23%). The study was conducted in context of a rather low PD-prevalence of 8.9% in 2003. The authors separated respondents into high- and low-prevalence groups. Interestingly, respondents from high-prevalence groups were less likely to perceive limited training as a barrier to PD usage (14.7%) when compared to respondents from the low-prevalence group (26.3%). A more recent inquiry

into reasons for low PD prevalence in France conducted by Geneviève et al. [15] shows that French nephrologists see themselves as PD competent (62%) although only 22% have received initial training. Based on the data from 2019, PD prevalence in France had decreased to 6.3%; however the perceived barriers to an increase in PD (and HHD) seem to have shifted, as a lack of formal training was not cited as relevant in this study. Another European example in a low-prevalence environment is provided by Desmet et al. [16], who conducted a questionnaire in French-speaking parts of Belgium, where PD prevalence was 8.7% in 2009. Respondents reported that only 55% were currently treating PD patients and 39% had not received specific training in PD. Moreover, younger clinicians were even less likely to have received training than older generations. A similar downward trend can be observed in a study conducted among Saudi-Arabian nephrologists in 2016. Dahlan et al. [17] report that 87% of nephrologists who responded to their survey had received formal training in PD care. However, this effort seems wasted according to the authors, as prevalence is low with 9% in Saudi Arabia and further clinicians seem to lose their expertise by not practising PD. Moreover, 61% of respondents had not attended any PD-related education programs (such as courses, lectures, etc.) in the last year. The authors suggest that continued interest in PD among Saudi nephrologists is most significantly associated with an active PD programme in the workplace, indicating that formal education in PD as a one-off event in nephrology-specialization curricula may not be sufficient to promote PD, irrespective of the question of acquiring the necessary skills. An interesting perspective can be seen in Sokwala et al. [18], who studied perceptions of PD utilization in Kenya, where the total number of PD patients is supposed to be around 20. Here the majority of nephrologists (57%) have not had any formal PD training, although 78% had attended some form of continued medical education in the last three years. Despite the lack of formal training, 71% of respondents felt that this did not limit their utilization of PD, which is much more affected by technical factors, such as lack of hospital support (81%) and lack of adequate nursing (82%). Notably, respondents in this study were generally concerned with peritonitis (69%) and technique failure (55%), which is rather high when compared to nephrologists in western countries (as a European example cf. Bouvier et al. [14]). Of course, it can only be speculated if these attitudes are more affected by a lack of training, experience, or both.

Mehotra et al. [19] compared dialysis training between the US and Canada in 2002. In the US there were fewer PD patients per training fellow (6.7) as compared to Canada (35) and US training fellows also spent less time on PD (5% versus 10%). There was also a difference in the types of training facilities, as in Canada PD is mainly administered in academic university-affiliated centres, whereas in the US there are more free-standing small centres. Where these centres are involved in training, their small size may have a knock-on effect for nephrologist

training. The authors make a comparison to surgery and transplantation, where certain numbers of patients per centre are required to ensure the quality of staff training. The authors also note that virtually all programs in the United States and Canada offer didactic training but contend that this is unlikely to compensate for the limited exposure due to patient numbers. This can also be seen in Berns et al. [20], who surveyed perceptions of training among US nephrology fellows in 2010. About half (55.6%) of responding nephrologists felt well-trained in the care of chronic PD patients. There are currently no up-to-date studies that give insight into the development of PD training in the US; however, Mehotra [21] in an editorial article in 2018 contended that, at least anecdotally, reports suggest that the situation remains challenging.

2.2. Patient Selection and Relevant Comorbidities

Nephrologists ultimately determine PD rates through the process of patient selection. Patient selection in this context should be understood as the process of determining medical eligibility and weighing the merits of a particular therapy vis-à-vis other methods, in order to make a recommendation to patients. In this the nephrologists are not guided by clear recommendations as, to the knowledge of the author, there are no randomized controlled trials that would present clear-cut criteria. The most recently published International Society for Peritoneal Dialysis practice recommendations [22] state that PD should be prescribed using shared decision-making between the person receiving PD and the care team. Furthermore, emphasis is placed on national resources, the wishes and lifestyle considerations of patients and caregivers in assisting roles. In Germany guidelines published by the German Nephrology Society on a “dialysis standard” recommend that all RRT, including HD and PD, both in-centre and at-home therapies, as well as kidney transplantation, should be given as options to patients in stadium G4 of CKD. It also emphasizes aspects of shared decision-making and suggests visits to RRT centres and counselling by specialized nurses, psychologists and social workers [23].

Other examples of recent treatment guidelines, such as the UK’s National Institute for Health Care Excellence (NICE) guidelines from 2018 [24], mostly lack clear absolute contraindications. The most important factor, it seems, is a patient’s willingness to try the modality. Nevertheless, relative contraindications, perceived or real, may be an important factor in patient selection. There is an inchoate list of comorbidities, which may be regarded as relevant when it comes to selecting patients for PD therapy. Eroglu et al. [25] give an overview of recent and established findings on typical comorbidities that may influence patient selection. According to the authors between 70-80% of patients are potentially suitable for PD. An incomplete list of relative contraindications includes older age, diabetes mellitus, obesity, polycystic kidney disease, previous abdominal surgery, cirrhosis, previous liver transplantation, renal allograft failure and

heart-failure. These relative contraindications are not necessarily uncontested in their effect or relative importance, and many may be addressed by adequate countermeasures. Furthermore, other factors, not strictly medical, may be equally as important; some forms of PD require self-administering of dialysis fluid and necessitate hygienic handling of catheters. Self-reliability and/or a stable social environment that includes reliable caregivers is frequently cited as being of primary importance.

Diabetes mellitus (DM) and congestive heart failure (CHF) present perhaps the most common relevant comorbidities that may go hand in hand with, as well as be the cause of, end stage renal disease (ESRD) and subsequent indication to start RRT. DM is considered the leading cause for ESRD in most developed countries, for example, accounting for 30-50% of incident patients with ERSD in the US [26]. PD offers several advantages inherent to its method of ultrafiltration. These include the avoidance of aggressive fluid shifts and HD-induced myocardial stunning and coronary ischaemia. In addition, PD avoids the need to create an arteriovenous fistula, which increases cardiac load thereby accelerating heart failure, as well as the need for systemic anticoagulation and corresponding risks [27]. However, a potential disadvantage is the absorption of glucose in PD dialysate fluids, which may increase hyperglycaemia. It also presents a danger to the peritoneal membrane by exposing it to advanced glycated end-products. The risks of glucose intake may be avoided by utilizing icodextrin-containing dialysate fluids, which are not metabolized by the human body. It should be noted, however, that icodextrin leads to falsely elevated blood-glucose levels in some monitoring systems, hence patient education is vital to avoid the application of excessive insulin doses [25]. Also, these fluids might not be readily available in all health care systems when considering RRT at a global level. There is some controversy concerning the overall safety of PD in DM patients. Vonesh et al. [28] compared mortality among ERSD patients receiving PD versus HD in a variety of studies across several countries. Generally, PD was associated with equal or better survival among nondiabetic patients and younger diabetic patients, while among older diabetic patients results varied between countries, HD showing better results in some cases. A recent meta-analysis studying the safety of PD and HD in ESRD patients with DM suggests that PD shows a lower incidence of cardiovascular and cerebrovascular events, as well as bleeding complications, while HD had a better effect on levels of albumin and haemoglobin [29].

In cases of congestive heart failure, ultrafiltration achieved by methods of hemofiltration or dialysis is an alternative to diuretics to achieve fluid and salt homeostasis. Three randomised controlled trials - UNLOAD [30], RAPID-CHF [31], and CARRESS-HF [32] - have compared hemofiltration with the use of diuretics in acute decompensated heart failure. In the former two

trials ultrafiltration was found to be safe and comparable to diuretics in terms of weight-loss, although inferior in terms of reducing serum creatinine. In the latter trial, ultrafiltration was worse on both parameters and led to more adverse events. There has so far been no randomised controlled trial comparing PD to diuretics, however, some evidence suggests that the utilization of PD in patients with refractory congestive heart failure may offer benefits of reduced hospitalization and increased quality of life. Grosskettler et al. [33] conducted a registry data-based study, which included patients that were treated with PD and did not respond to diuretic-based strategies. They found a significant reduction in body weight and NYHA based functional class, as well as the frequency of hospitalizations and the total number of days of hospitalization. Their study cohort had a 1-year mortality of 39.6%, insinuating a strong survival benefit. According to the authors, congestive heart failure is accompanied by CKD in 63% of cases and is associated with very poor outcomes. The pathomechanisms of this cardio-renal syndrome are positively affected by PD, as it offers a gentle and continuous ultrafiltration that relieves renal venous and intraabdominal pressure, ultimately re-establishing glomerular filtration and increasing diuresis. Based on similar findings, the German Society for Cardiology offers a specific recommendation in cases of chronic cardiorenal syndrome, where peritoneal dialysis is suggested as the preferred method of ultrafiltration to achieve good fluid status [34].

2.3. Centre-level Effects on Mortality and Treatment Failure – and Possibly Patient Selection?

Patient selection may be described here as a process of matching individual patients with the treatment modality that best suits their needs. That is why one approach has been a multi-disciplinary process as a means of preparation, which is usually referred to as pre-dialysis programme (PP). Bonekamp et al. [35] analysed the efficiency of a PP in a Dutch teaching hospital by studying which patient factors, represented by answers given in three different questionnaires filled in by patients, nephrologists and social workers, were associated with long-term home dialysis use (85% of home dialysis patients utilizing PD). In brief, they found that questions pertaining to the suitability of housing and social support were most associated with patients staying on home dialysis. Nephrologists viewed polycystic kidneys and previous abdominal surgery as absolute contraindications, however, they also considered intellectual disability, manic-depressive disorders, and lack of self-sufficiency in their assessment. In total, 80% of patients were seen as eligible for home dialysis in the overall assessment, although the nephrologists only considered 61% of patients as eligible for home dialysis. Interestingly, nephrologists and social workers agreed in only 69% of their assessments, leading to instances where a patient could start on home dialysis although a nephrologist judged the patient to be ineligible. Final choice of RRT was done by patients after education and further

consultation with the nephrologist. The authors state that the impetus for the study was the observation of a marked increase in home dialysis prescription after the adoption of a PP. The study not only demonstrates that a PP may be a suitable means of facilitating the process of patient selection, but it also indicates that psychosocial factors may play an important role alongside purely medical considerations. Moreover, it suggests that there is an effect on the decision-making process of nephrologists from the dialysis centre.

Dialysis centre effect has so far been studied mostly in terms of its influence on mortality and technique failure (TF) rates, i.e. the percentage of patients switching from PD to other RRTs (in most cases switching to HD). A widely adopted approach to measuring the effect of inter-centre variation has been to study centre size or volume, i.e. the number of PD patients treated. It should be noted at this point that in the literature both “centre size” and “centre volume” are utilized to signify absolute, relative, or cumulative patient numbers. Here “centre size” refers to absolute patient numbers (as this is the main independent variable in the statistical analysis), unless reference is made to a specific study, in which case those authors’ terminology and definitions are retained. Schaubel et al. [36] studied centre size in terms of cumulative patients treated and its effect on mortality, as well as the percentage of patients initiating on PD and its effect on TF rates. For the former they observed a smooth dose-response relationship, ranging from a relative risk (RR) = 1 in centres that treated ≤ 99 patients, to RR=0.71 in centres that treated ≥ 500 patients. For the latter a significant decrease of TF rates was observed with RR = 1.75 for centres with ≤ 29% patients initiating on PD relative to centres with ≥ 60%. Huisman et al. [37] also measured the effect of centre size on TF rates. In their analysis they split centre sizes into three groups, representing small, intermediate, and large centres. They found that centres with less than 20 patients on PD had a significant risk of higher TF with a RR of 1.68 when compared to the two larger groups. Similarly, centres with less than 20% of patients on PD showed a higher risk of TF. Both in absolute and relative terms there was, however, no significant difference between intermediate and large centres. According to the authors, the difference reflects the experience of staff members with PD. They surmise that experience and a corresponding positive attitude towards PD are most effective for good technique survival, which is reflected in their study, as age distribution was consistent over the most analysed centres, indicating that higher technique survival was not the result of choosing younger, healthier patients. Jaar et al. [38] studied the effect of centre size on a wider ranging set of outcomes, including: TF, cardiovascular events, cardiovascular mortality, and all-cause mortality. They observed that being treated at a clinic with ≥ 50 patients (at one specific point of time) was associated with a reduced risk of TF (Relative Hazard (RH) = 0.13) and fewer cardiovascular events (RH = 0.62), when compared to centres with < 50 patients. They did not find a significant relationship between centre size and both modalities of mortality rates. They

posit that this may be due to the cross-sectional determination of the number of patients in their study design and point towards the results of Schaubel et al. [36]. It should be noted, however, that similar studies have also not observed an effect on mortality. In a comparable study conducted by Evans et al. [39] TF was seen to be sensitive to higher volume centres (Cause specific Hazard Ratio (cs-HR) = 0.46) with ≥ 60 patients when compared to centres with 0-10 patients (in a twelve month period), whereas no significant association was found between centre volume and risk of transplantation or death.

The authors of the last study adjusted their model on patient characteristics, including age, sex, comorbidity index, diabetes, previous treatment, and type of assistance. Adjusting for patient-level confounding is common and had been done by previous studies. In this case the authors also adjusted their model for unmeasured confounding at the centre-level. The authors included this method based on the clinical observation that clinicians with a positive attitude towards PD tend to initiate more patients on PD and tend to remain with PD in the face of technical difficulties. This would then lead to a correlation between high PD volume and lower TF. The authors posit that this hypothesis is consistent with their study, as they found very low cs-HR with increasing volume for early technique failure (early technique failure presumably indicating less willingness to struggle through initial complications).

In summary, it can be seen that PD offers medical and economic advantages, but its adoption remains difficult. Patient selection is not a straight-forward process and comorbidities may affect nephrologists' recommendations. Another possible influencing factor is the role of the dialysis centre, as there seems to be inter-centre variation in prescription habits. Centre size has mainly been studied in its effect on TF and mortality. Although some influence of centre size on the attitude of nephrologists and its resulting effect on patient selection has been noted or treated as a confounding variable. So far, the link between centre size and its influence on patient selection has not been studied in sufficient detail.

2.4. Research Question

The literature implies that nephrologists in centres with more PD patients and consequently more experience with the method tend to have a more positive view towards PD. Huisman et al. [37] refer to a "positive attitude" as an important factor in TF rates but do not specify if this attitude is the result or cause of treating more patients, stating that "this attitude *and* experience" are the single most important factor in lowering TF rates. Evans et al. [39] rather seem to treat attitude as a predetermined confounding variable, which leads to higher attempt rates and consequently higher numbers of patients on PD, but in turn do not specify the origin of this attitude. Other characterizations exist, for example, Hingwala et al. [40] note higher PD-

attempt rates in clinicians with an "aggressive PD approach". The unspoken hypothesis in these characterizations is that more PD patients lead to nephrologists attempting PD with patients that could be seen as more complicated cases, i.e. patients that exhibit more and severer comorbidities. "Attitude" in this sense may also be understood as "confidence" based on experience. So far, studies have concentrated on the question of whether increased centre size leads to better results in terms of mortality and TF. The latter result is also relevant to the topic of underutilization, as reduced TF rates would lead to higher prevalence, as patients stay on PD longer. However, if PD rates are to increase in the long term, arguably there needs to be an increase in incidence, that is attempting PD as initial and long-term RRT.

This study analyses the effect of centre size on presumed prescription habits in a group of German nephrologists. The aim is to find out how the experience gained by treating more PD patients effects prescription habits when treating patients that present various comorbidities.

The overall research question is:

What is the effect of the number of PD patients on German nephrologists' preferred RRT (PD or HD) in patients that present relevant comorbidities and psychosocial obstacles?

It should be noted here that this research considers presumed prescription habits, as the data used is based on a questionnaire sent to German nephrologists. Accordingly, one can only speak of "preference" and only indirectly infer real-world effects. The overall aim is to understand how far increased centre size could lead to an increased adoption of PD, by making it a more viable alternative to HD, even in more complicated cases. This is particularly relevant in the case of the German health care system, where HD is particularly entrenched and often administered by small- and medium-scale centres, which is a result of the prominence of private practices in the ambulatory sector inherent to the German healthcare system.

3. Material and Methods

This study uses data gathered in the course of the Mau-PD project, a multidimensional project that aims to determine the reasons for low PD rates in Germany [41]. Between 2018 and 2019 a survey was presented to all German nephrologists working in the German ambulatory sector (n=1501), of which 38% returned the questionnaire (n = 573). The survey included a total of 114 items, a select few of which will be utilized in the main analysis. These include items concerning nephrologists' opinions and attitudes towards PD and their inclination to prescribe either PD or HD when confronted with a variety of comorbidities. Several items covered the workplace, training, and socio-demographic parameters, which will be utilized as explanatory variables. Furthermore, to gain further insight into the general state of PD utilization in Germany and the framework of RRT in the German ambulatory sector, various other items will be included in the analysis. These will be drawn from a set of descriptive statistics, including frequencies and percentages, as well as mean, median and standard deviation, where applicable.

The main analysis will be an OLS linear regression model. The analysis was conducted using Stata 17 BE software. The dependent variable was derived from a Likert-scale, composed of 5-point Likert-items; it asked nephrologists what their preferred treatment option would be (1 = rather PD; 3 = both methods equivalent; 5 = rather HD), for a theoretical patient with a certain comorbidity or psychosocial obstacle. The list of comorbidities includes diabetes mellitus, congestive heart failure, malnutrition, ascites, adipositas, cardial instability, cystic kidneys, chronic inflammatory bowel disease, heparin intolerance, hernia, colostomy, reduced motor function, and reduced vision. Furthermore, several items on the same scale are psychosocial obstacles that may also shape a nephrologist's treatment decision. These are: cognitive impairment, living alone, lack of personal hygiene, distance to dialysis centre > 20km, and lack of dependability. A mean (3.42884; St. Err.: 0.0173021; 95%CI: 3.394856– 3.462824) was calculated to obtain a numeric dependent variable that showed a high internal consistency (Cronberg's Alpha = 0.8429). A value closer to 1 represents a general preference for while a value closer to 5 represents a general preference for HD. This variable (dubbed "PD confidence index") represents a nephrologist's general inclination towards either treatment option, thereby displaying what has been called "attitude" and "aggressive PD approach", or lack thereof. It should be noted that five items were dropped from the Likert-scale. One item, self-reliance (whether the patient is self-reliant), was phrased inversely in the sense of presenting a positive and not a negative trait. Furthermore, employment status (whether the patient is employed) and distance to dialysis centre > 20km are neither clearly positive nor negative traits. Although both items are interesting and relevant in themselves, including them into the main analysis would have confused the results as both depend on a subjective point

of view to determine if these characteristics are to be regarded as complicating or not. Two more items were dropped from the analysis as they do not relate to patient characteristics, these are costs for the health care system and profitability for the practice.

The main predictor variable is the stated current number of patients in the centre, given in absolute terms. This variable was transformed using logarithmic transformation ($\log_e x$), to strengthen the regression model by improving the normality of the data. Further predictor variables were chosen from the available data based on their relevance to the research question. As baseline covariates, the age and sex of nephrologists were added. Furthermore, an item concerning perceived exposure to PD during nephrology training was added (this was phrased as "getting to know PD during specialization training"; 1 = very thoroughly; 4 = not at all), as were the stated number of years working in the dialysis centre and the stated number of years since attaining the nephrology specialization. Training could be seen to play a more important role than experience gained through treating patients, as training is by definition supposed to prepare clinicians for the practical application of a given treatment, which includes evaluating and managing comorbidities. Lastly the number of years since attaining nephrology specialization and the number of years a nephrologist worked at a dialysis centre were added. The last two predictors were included as markers for experience. During their careers all medical practitioners are generally exposed to more difficult cases and complications over time. This general growth of experience could translate into more confidence with particular therapies such as PD. A simple linear regression was conducted with all predictor variables separately. In a second step, an adjusted model was created using a backwards approach. The final model was selected based upon the highest achieved adjusted R^2.

Where applicable, answers of "99" or "999" were recoded as missing observations, the total amount being 108 across all items. Furthermore, n=2 observations were excluded from the regression analysis, due to being outliers that exerted particularly high influence and/or leverage on the model. This was done to improve the model's overall fit.

4. Results

4.1. Descriptive Statistics

4.1.1. Nephrologists and Dialysis Centres

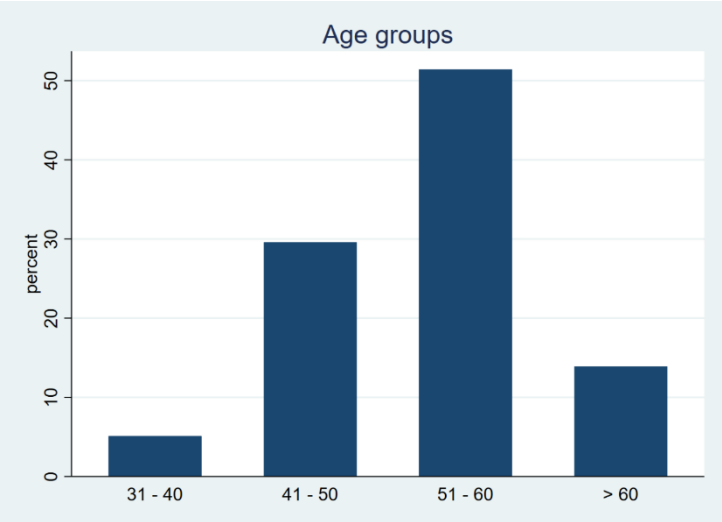

Figure 1: distribution of age groups

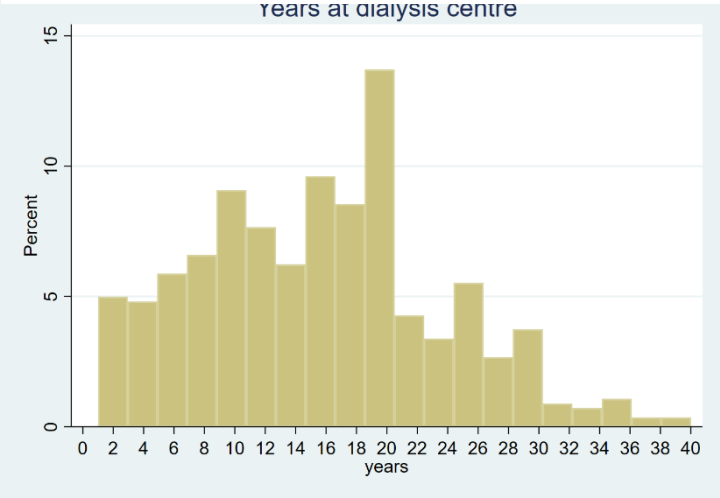

Figure 2: years working at the current dialysis centre

On average, nephrologists stated that their respective dialysis centre currently treated 12.47 PD patients (SD 17.34), ranging between 0 and 180. In contrast, the mean number of HD patients was 128.40 (SD 75.96), ranging between 10 and 420 patients. Concerning the various modalities of PD treatment, 94.21% of nephrologists stated their centre offered continuous ambulatory PD (CAPD), 87.02% automated PD (APD), 70% intermittent PD (IPD) and 38.77% assisted PD. In total, 94.74% of nephrologists stated they had previous experience with PD as a treatment modality. The average dialysis centre staffed 4.57 nephrologists (SD 3.45), ranging between 1 and 16. Concerning nursing staff, 11.05% stated their centre had specialized PD-nursing staff who exclusively treated PD patients, the average number being 1.39 (SD 1.60); 58.25% stated that their centre had nurses who primarily treated PD patients, whereas 28.95% stated there was no specialized staff.

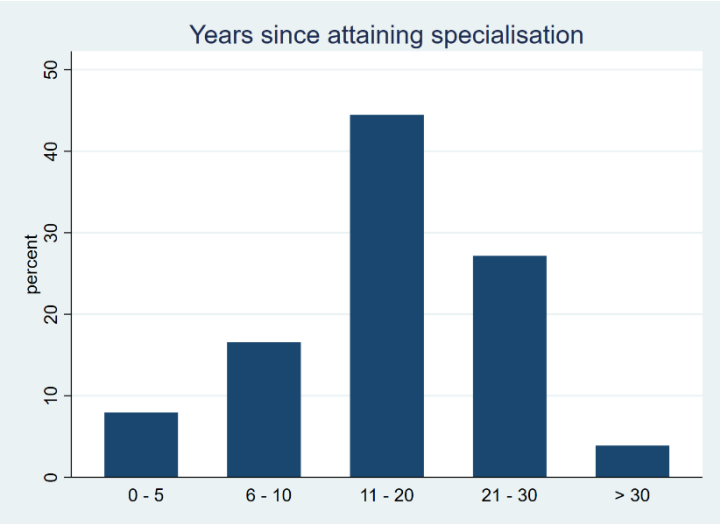

Figure 3: years since attaining nephrology specialization

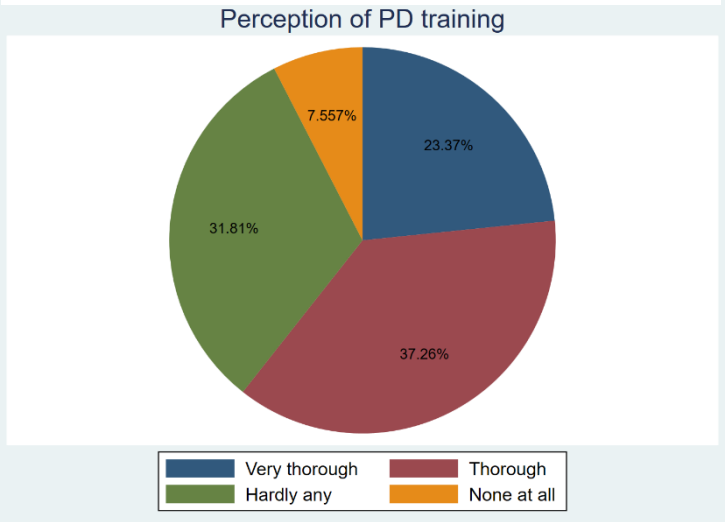

Figure 4: perception of thoroughness of PD training

Of the participating nephrologists, 72.98% were male. 51.23% were aged between 51-60, and 29% between 41-50. Only 5.09% were between 31-40, the rest being older than 60. Most nephrologists, 44.21%, had been fully trained nephrologists for between 11-20 years, 27.02% between 21-30 years, and 16.49% between 6-10 years. On average, nephrologists had been working in their respective dialysis centres for 16.69 years (SD 12.76).

In terms of medical outcome, 90.88% of nephrologists considered PD an equivalent RRT when compared to HD in their dialysis centre. 50.52% either agreed or completely agreed that PD offers better quality of life than in-centre HD. When asked whether patient preference should be a deciding factor in RRT choice, 33.68% completely agreed, 45.09% agreed, 15.44% neither agreed nor disagreed, 4.39% disagreed, and 0.7% completely disagreed. Concerning the importance of factors that have an influence on RRT choice, 58.95% regarded quality of life as very important, 50.88% regarded patient preference as very important, whereas only 35.79% regarded clinical outcomes as very important, and 24.21% regarded life-expectancy as very important. Nephrologists considered 25.02% of their patients eligible for self-reliant use of PD, and considered 24.63% of patients eligible for assisted PD. However, they stated that only 15.40% of patients would want to utilize PD. When asked whether PD was only expedient in a few cases 83.16% disagreed or completely disagreed. Concerning their opinion on the utilization of PD in difficult circumstances, 29.3% completely agreed that it is functional with the right experience, whereas 50.53% agreed, 11.40% neither agreed nor disagreed, 6.67% disagreed, and 1.4% disagreed completely.

4.1.2. RRT Modality Preference

When presented with patients that presented various comorbidities nephrologists in many cases favoured either PD or HD. In terms of favouring PD, i.e. nephrologists answering to choose PD or rather PD, numbers were lowest in cases of: colostomy (0.36%), chronic inflammatory bowel disease (0.88%), reduced vision (1.58%), hernia (1.76%), and reduced motor function (2.98%). Numbers were highest in cases of ascites (86.85%), cardial instability (84.21%), and congestive heart failure (80.7%). Some cases showed more discrepancies between nephrologists' opinions. In cases of diabetes mellitus, 7.72% elected PD, 12.98% favoured PD, 57.37% saw both treatments as equivalent, whereas 20% either elected or favoured HD. Malnutrition saw a particularly even spread of answers, 10.18% choosing PD, 34.04 favouring PD, 29.30% seeing equivalence, 20.88% favouring HD, although only 3.86% chose HD over PD. In cases of cystic kidneys few favoured or chose PD (6.5%), however, the majority saw equivalence (44.39%), whereas 37.89% favoured HD and 10.35% chose HD.

Presented with patients that presented psychosocial obstacles, nephrologists were overall less inclined to prescribe PD. The lowest numbers were seen with patients that presented a lack of personal hygiene (0.18%), a lack of dependability (0.53%), followed by cognitive impairment (1.76%). An interesting case is living alone: whereas only 4.39% of nephrologists favoured or chose PD, 57.89% saw equivalence, 28.42% favoured HD and 8.42% chose HD. The presence of self-reliance and employment were both seen as traits that favoured PD, with 80.53% and 66.85% respectively either favouring or choosing PD.

*Table 1: comorbidities and preferred treatment options, means; * = excluded from main analysis*

Variable	Obs	Mean	Std. Dev.
Diabetes mellitus	559	2.940966	.8540982
C.heart failure	569	2	.859905
Malnutrition	560	2.7375	1.031189
Ascites	567	1.864198	.9309587
Adipositas	563	3.781528	.6907213
Cardial instability	566	1.971731	.8131091
Cystic kidneys	565	3.504425	.8221652
Infl.bowel disease	567	4.432099	.6527136
Heparin intolerance	565	2.180531	.8203807
Hernia	566	4.083039	.6977805
Colostomy	566	4.561837	.5758191
Red.mot.funct.	563	3.914742	.7521117
Reduced vision	564	4.021277	.6896143
Cogn.impairment	564	4.210993	.7322704

Living alone	565	3.389381	.7676254
Lack o.hygiene	567	4.368607	.6002962
Employed*	565	2.148673	.8416375
Self-reliance*	561	1.823529	.7717436
Distance >20km*	562	2.096085	.7371132
Lack o.depend.	565	4.346903	.6072947
Cost f. health care*	564	2.441489	.7760504
Profitability*	565	2.971681	.8604251

*Table 2: comorbidities and preferred treatment options, proportions; * = excluded from main analysis*

Variable	Proportion	Std. Err.	95%Conf.intervall	
Diabetes mellitus				
PD	.0739367	.0113922	.0534833	.0987277
Rather PD	.1285988	.0146659	.10243	.1602596
Equivalent	.596929	.0214898	.5540927	.6383361
Rather HD	.1746641	.0166341	.1443511	.209782
HD	.0268714	.0070845	.0159582	.0449072
Cardial instability				
PD	.2610365	.0192417	.2250364	.300562
Rather PD	.5393474	.0218375	.4962612	.5818536
Equivalent	.1305182	.0147587	.1041561	.1623435
Rather HD	.0575816	.0102057	.0405154	.081228
HD	.0115163	.0046744	.0051732	.0254383
Malnutrition				
PD	.0921305	.0126705	.0700781	.1202253
Rather PD	.353167	.0209395	.3131953	.3953038
Equivalent	.2975048	.0200286	.2597104	.338286
Rather HD	.2207294	.01817	.1871031	.2584773
HD	.0364683	.0082124	.0233551	.0565181
Ascites				
PD	.3570058	.0209905	.316907	.3992131
Rather PD	.5201536	.0218876	.4771115	.5628985
Equivalent	.0556622	.0100444	.0389186	.0790169
Rather HD	.0364683	.0082124	.0233551	.0565181
HD	.0307102	.0075587	.0188757	.0495895

Adipositas				
PD	.0057582	.0033149	.0018534	.0177431
Rather PD	.0211132	.0062983	.0117139	.0377666
Equivalent	.2744722	.0195505	.2377745	.3144968
Rather HD	.5930902	.0215224	.5502191	.6345888
HD	.1055662	.0134623	.0818895	.1350814
Cardial instability				
PD	.2476008	.0189096	.2123435	.2865821
Rather PD	.6084453	.021384	.5657295	.6495621
Equivalent	.0921305	.0126705	.0700781	.1202253
Rather HD	.0422265	.0088106	.0279351	.0633527
HD	.0095969	.0042712	.0039919	.022891
Cystic kidneys				
PD	.0191939	.0060111	.0103427	.0353491
Rather PD	.0441459	.0089996	.0294808	.0656129
Equivalent	.4548944	.0218161	.4124722	.4979816
Rather HD	.3761996	.0212233	.3355077	.418717
HD	.1055662	.0134623	.0818895	.1350814
Infl. bowel disease				
PD	.0019194	.0019175	.0002691	.0135543
Rather PD	.0076775	.003824	.0028779	.0203187
Equivalent	.0575816	.0102057	.0405154	.081228
Rather HD	.4299424	.0216893	.3879501	.4729676
HD	.5028791	.021905	.4599306	.5457852
Heparin intolerance				
PD	.1880998	.0171209	.1567456	.2240594
Rather PD	.4836852	.0218937	.4409001	.5267109
Equivalent	.2859885	.0197974	.2487272	.3264066
Rather HD	.0287908	.007326	.0174092	.0472553
HD	.0134357	.005044	.0064074	.0279565
Hernia				
PD	.0019194	.0019175	.0002691	.0135543
Rather PD	.0172745	.0057082	.0089983	.0329097
Equivalent	.1516315	.0157133	.1232691	.1851416
Rather HD	.5777351	.021639	.5347509	.6195733
HD	.2514395	.0190069	.2159653	.2905811

Colostomy				
PD	.0019194	.0019175	.0002691	.0135543
Rather PD				
Equivalent	.0287908	.007326	.0174092	.0472553
Rather HD	.3819578	.0212862	.3411014	.4245547
HD	.5873321	.0215687	.5444136	.6289629
Reduced mot. funct.				
PD	.0076775	.003824	.0028779	.0203187
Rather PD	.024952	.0068336	.014524	.042544
Equivalent	.2168906	.0180556	.1835142	.2544456
Rather HD	.5508637	.0217918	.5077813	.5931963
HD	.1996161	.0175117	.1674205	.2362463
Reduced vision				
PD	.0076775	.003824	.0028779	.0203187
Rather PD	.0095969	.0042712	.0039919	.022891
Equivalent	.1535509	.0157946	.1250172	.1872036
Rather HD	.6142035	.0213263	.571557	.6551661
HD	.2149712	.0179976	.1817214	.252428
Cog. impairment				
PD	.0057582	.0033149	.0018534	.0177431
Rather PD	.0095969	.0042712	.0039919	.022891
Equivalent	.1151631	.0139852	.0904071	.1456129
Rather HD	.5009597	.0219054	.4580247	.5438805
HD	.3685221	.0211345	.328059	.4109238
Living alone				
PD	.024952	.0068336	.014524	.042544
Rather PD	.0172745	.0057082	.0089983	.0329097
Equivalent	.5834933	.0215978	.5405466	.625209
Rather HD	.293666	.0199532	.256046	.3343295
HD	.0806142	.0119271	.0600767	.1073705
Lack. o. hygiene				
PD				
Rather PD	.0019194	.0019175	.0002691	.0135543
Equivalent	.0614203	.010519	.0437263	.0856332
Rather HD	.5086372	.0219021	.4656519	.5514952
HD	.428023	.0216772	.3860683	.4710389

Employed*				
PD	.2207294	.01817	.1871031	.2584773
Rather PD	.452975	.0218083	.4105821	.4960613
Equivalent	.2917466	.0199149	.254215	.33235
Rather HD	.0211132	.0062983	.0117139	.0377666
HD	.0134357	.005044	.0064074	.0279565
Self-reliance*				
PD	.3646833	.0210879	.3243389	.407023
Rather PD	.4510557	.0218002	.4086926	.4941403
Equivalent	.1746641	.0166341	.1443511	.209782
Rather HD	.0019194	.0019175	.0002691	.0135543
HD	.0076775	.003824	.0028779	.0203187
Distance >20km*				
PD	.1957774	.017384	.1638572	.232189
Rather PD	.5316699	.0218614	.4885938	.5742791
Equivalent	.2591171	.0191957	.2232203	.2985677
Rather HD	.0076775	.003824	.0028779	.0203187
HD	.0057582	.0033149	.0018534	.0177431
Lack o. depend.				
PD	.0019194	.0019175	.0002691	.0135543
Rather PD	.0038388	.0027092	.0009572	.015263
Equivalent	.049904	.0095397	.0341671	.0723462
Rather HD	.5451056	.0218161	.5020184	.5875278
HD	.3992322	.0214559	.3579192	.442031
Cost f. health care*				
PD	.1381958	.0151193	.1110804	.1706595
Rather PD	.3166987	.0203803	.2780806	.35802
Equivalent	.5239923	.0218802	.4809364	.5666945
Rather HD	.0134357	.005044	.0064074	.0279565
HD	.0076775	.003824	.0028779	.0203187
Profitability*				
PD	.0537428	.0098797	.0373282	.0767997
Rather PD	.168906	.0164145	.1390601	.2036423
Equivalent	.571977	.0216772	.5289611	.6139317
Rather HD	.1573896	.0159545	.1285185	.1913226
HD	.0479846	.0093638	.0325972	.0701092

4.2. Regression Analysis

In the main analysis, the PD confidence index (3.42884; St. Err.: 0.0173021; 95%CI: 3.394856– 3.462824) portrays a general tendency to prescribe HD over PD. In the simple linear regression, a significant relationship (Prob > F = 0.0000; R^2 = 0.1642) was observed between the **logarithmised stated number of PD patients** and the PD confidence index. The observed coefficient indicates that a 1% increase in the number of patients would, on average, reduce the index value by 0.17, i.e. towards a preference for PD.

Table 3: simple regression, number of PD patients(log)

n° Observations	P>F	R^2	Adj. R^2
511	0.0000	0.1642	0.1626

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
PD patients(log)	-.1650801	.0165068	-10.00	0.000	-.19751 -.1326502
Intercept	3.739787	.0384004	97.39	0.000	3.664344 3.81523

Statistically significant results were also achieved for:

age (Prob > F = 0.0085; R^2 = 0.0122), the coefficient indicating that an increase in age group, e.g. from 31-40 to 41-50, on average, results in a 0.06 increase in the index value, i.e. towards a preference for HD.

Table 4: simple regression, age

n° Observations	P>F	R^2	Adj. R^2
566	0.0085	0.0122	0.0105

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
Age	.0602055	.0227861	2.64	0.008	.0154495 .1049615
Intercept	3.202496	.0869939	36.81	0.000	3.031624 3.373368

number of years working in at the dialysis centre (model: Prob > F = 0.0006; R^2 = 0.0206), the coefficient indicating that for every year working at the dialysis centre the index value would, on average, increase by 0.007, i.e. towards a preference for HD.

Table 5: simple regression, number of years at the dialysis centre

n° Observations	P>F	R^2	Adj. R^2
560	0.0006	0.0206	0.0189

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
Years at PD centre	.0072377	.0021106	3.43	0.001	.0030921 .0113834
Intercept	3.314194	.0370019	89.57	0.000	3.241514 3.386874

In the **adjusted model,** the best fit (Prob > F = 0.0000; R^2 = 0.1919; adj. R^2 = 0.1870) could be achieved by a model that included the sex of the nephrologist and the number of years working at the dialysis centre as covariates. In this model, a 1% increase in PD patients resulted in a shift of the index number towards PD preference by, on average, 0.17. Furthermore, for every year working at the dialysis centre, the value would, on average, increase by 0.006.

Table 6: complete regression model

n° Observations	P>F	R^2	Adj. R^2
499	0.0000	0.1968	0.1870

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
PD patients(log)	-.168546	.0166658	-10.11	0.000	-.201291 -.135801
Sex male	.0822434	.0360153	2.28	0.023	.0114807 .1530062
age	-.0080606	0336325	-0.24	0.811	-.0741416 .0580203
Years at PD centre	.0091945	.0030765	2.99	0.003	.0031498 .0152391
Years since specialisation	-.028354	.0280156	-1.01	0.312	-.083399 .0266911
Training	-.0220735	.0176048	-1.25	0.210	-.0566633 .0125163
Intercept	3.707037	.1057623	35.05	0.000	3.499236 3.914839

Table 7: adjusted regression model

n° Observations	P>F	R^2	Adj. R^2
500	0.0000	0.1919	0.1870

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
PD-patients(log)	-.1672043	.0165543	-10.10	0.000	-.1997294 -.1346792
Sex male	.0840387	.0353337	2.38	0.018	.0146166 .1534609
Years at PD centre	.0060609	.0019007	3.19	0.002	.0023266 .0097953
Intercept	3.585831	.0521859	68.71	0.000	3.483299 3.688364

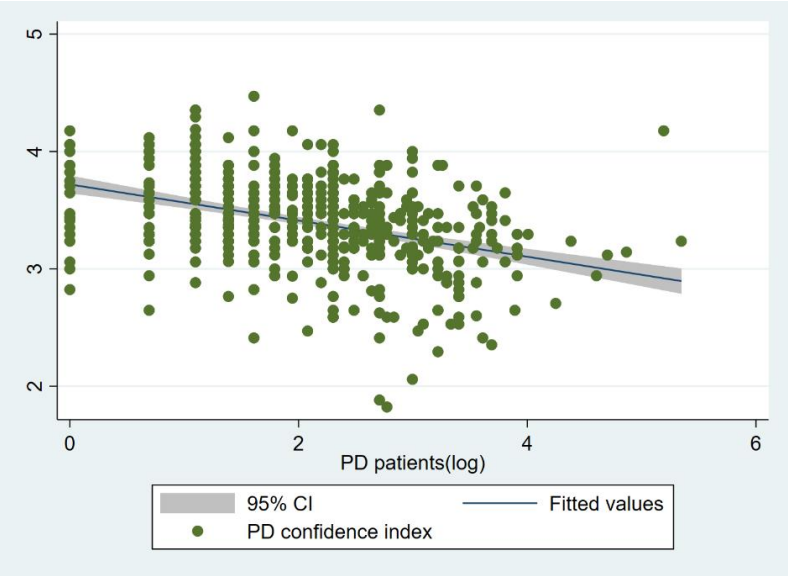

Figure 5: PD confidence index value by number of PD patients (log) with 95%CI

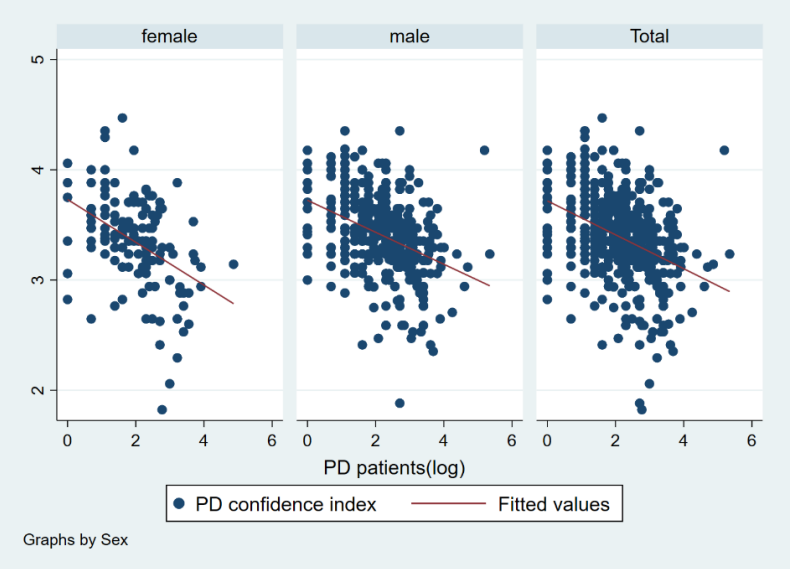

Figure 6: PD Confidence index by number of PD patients (log) in sex subcategories

In order to achieve a more illustrative result, a further version of the adjusted model was created where the dependent variable was transformed using logarithmic transformation ($\log_e x$). This allowed for an interpretation of the dependent variable in terms of percentage change. However, this transformation reduced the normality of residuals in the regression analysis, thereby weakening the overall explanatory power of the model.

In this model (Prob > F = 0.0000; R^2 = 0.1823; adj. R^2 = 0.1774), a 1% increase in PD patients resulted, on average, in a 0.05% decrease of the index number towards PD preference. Furthermore, for every year working at the dialysis centre, the index value would, on average, increase by 0.002%.

Table 8: adjusted regression model, dependent variable logarithmised

n° Observations	P>F	R^2	Adj. R^2
500	0.0000	0.1823	0.1774

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
PD patients(log)	-.0508939	.0051826	-9.82	0.000	-.0610764 -.0407113
Sex male	.0283397	.0110618	2.56	0.011	.0066059 .0500735
Years at PD centre	.0017005	.000595	2.86	0.004	.0005314 .0028696
Intercept	1.273967	.0163377	77.98	0.000	1.241868 1.306067

To further illustrate the results, a model was created without any transformations. In this model (Prob > F = 0.0000; R^2 = 0.1780; adj. R^2 = 0.1734), for every one patient increase of PD patients, the index value was, on average, decreased by 0.013. Furthermore, for every year working at the dialysis centre the index value would, on average, increase by 0.006. Although this model also suffers from a reduced normality of residuals, it allows for a linear prediction that can give basic insight into the magnitude of PD patient numbers that shift nephrologists' attitudes towards patient selection. Based on this model, a number between 40 and 50 patients, on average, contains the point where both treatment options are regarded as equal. Hence, 50 roughly represents the threshold value of PD patients that leads to a favoured selection of PD in patients that present relevant comorbidities and psychosocial obstacles.

Table 9: adjusted regression model, no transformations

n° Observations	P>F	R^2	Adj. R^2
540	0.0000	0.1780	0.1734

Variable	Coefficient	Std. Err.	T-test	P>T	95% CI
PD patients	-.0128171	.0012954	-9.89	0.000	-.0153618 -.0102725
Sex male	.0958179	.0371926	2.58	0.010	.0227569 .1688789
Years at PD centre	.0063949	.0020056	3.19	0.002	.002455 .0103347
Intercept	3.400074	.0448182	75.86	0.000	3.312034 3.488115

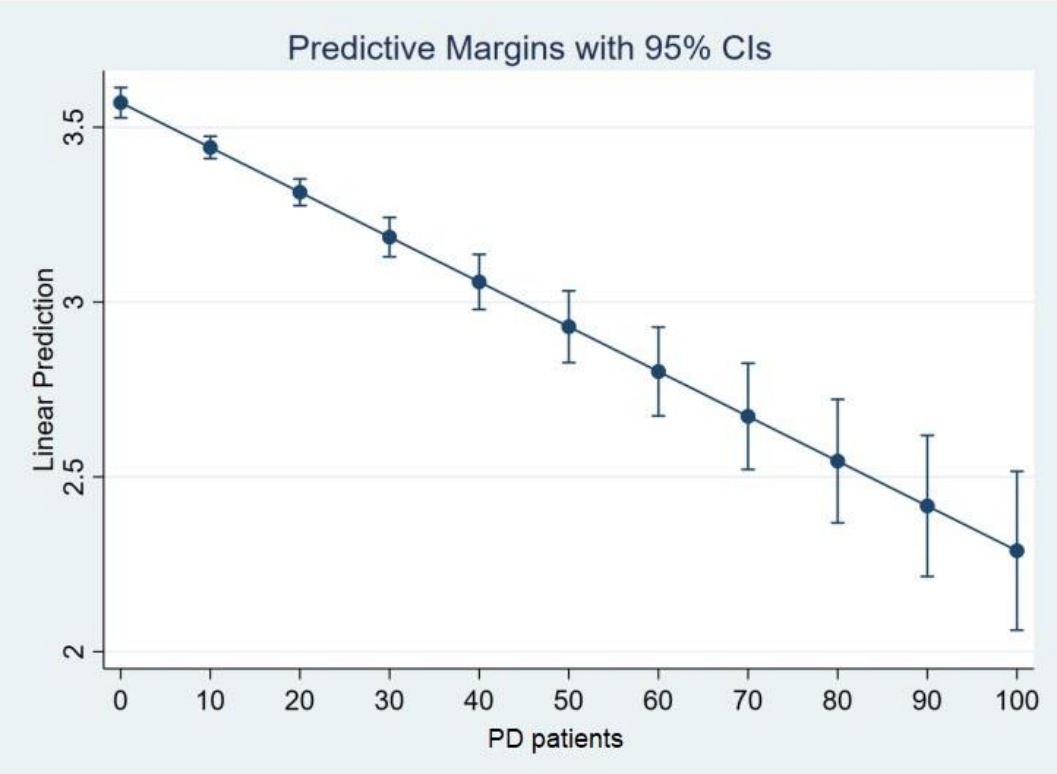

Figure 7: linear prediction of the PD confidence index by PD patients with 95%CI

5. Discussion

This study aims to further the insight into factors which shape the opinion of nephrologists on their choice of RRT. To do so it created a marker for nephrologists' inclination to prescribe PD in cases where patients presented a series of complications. This marker showed high internal consistency and portrayed a general tendency towards prescribing HD in these cases. A series of predictor variables showed the influence of increased age (a tendency to prescribe HD), an increased number of years working at a dialysis centre (a tendency to prescribe HD) and of more time having passed since attaining nephrology specialization (a tendency to prescribe HD). These results, however, showed very small coefficients and the models suffered from very low values for R^2, indicating that the models accounted for very little variance in the change in the dependent variable. A better result was achieved for the main predictor variable, the stated current absolute number of PD patients at a nephrologist's dialysis centre. In the final adjusted model, roughly 20% of the change ($R^2 = 0.1919$) in the dependent variable was explained by the predictor values. It should be noted that the final model still only observed a small influence and only accounted for a small proportion of the change on the dependent variable. While the results of the simple regression models should rather be disregarded altogether, the adjusted model may nevertheless show a general trend. At the cost of further decreasing the statistical validity, it can be stated that, when presented with a patient that presents certain complications, all other factors being equal, working at a dialysis centre that treats between 40 and 50 PD patients, on average, leads to a shift from favouring HD to preferring PD.

From the questionnaire responses presented in this study it could be seen that German nephrologists generally consider PD equivalent to HD (90.88%), yet only half agreed that it offers better quality of life results than in-centre HD. This seems like a slight decrease when compared to results by Fluck et al. [42], who found in an international questionnaire study that roughly 60% of German nephrologists agreed to a similar question. The authors note that there is a noticeable discrepancy between physicians' preference and their actual prescribing habits. They surmise that availability is a likely explanation. In their study they found that 19% of participating German nephrologists' dialysis centres did not offer any form of PD, while most centres in the present study offered CAPD, APD and IPD. Only assisted PD was rarer with 38.77%. This indicates that availability has generally increased, while prescription does not seem to have increased markedly, suggesting that availability as such is not the only explanatory factor. The authors also found that over half of participants (from all countries represented in the study) would only prescribe PD (and home HD) to their healthiest patients. This result is largely reflected by the general trend of the comorbidity confidence index.

Several studies have explored nephrologists' attitudes towards PD and which factors ultimately shape their treatment decisions. In an early study Jung et al. [43] found that patient preference (4.4 out of 5) and quality of life (4.06) were the most important factors for a group of Canadian nephrologists to decide on RRT modality, while morbidity (3.97) and mortality (3.85) were slightly less important, and physician reimbursement (1.62) played a minor role. Similarly, when investigating the attitudes of US nephrologists, Mendelssohn et al. [44] found patient preference (4.54 out of 5) and quality of life (4.18) to be the deciding factors, although morbidity (4.02) and mortality (3.9) scored slightly higher compared to the previous study. The authors also note that US nephrologists would increase PD prevalence between two- and threefold over current practices in a hypothetical question on ideal distribution of RRT modality. Jassal et al. [45] conducted a comparable questionnaire study in the UK, where patient preference (4.4) was also regarded as the most important factor, while morbidity (3.6) was seen as less important. British nephrologists saw most comorbidities as a reason to favour HD, although 52% favoured PD in cases of heart disease and 33% in cases of diabetes. In the present study, most comorbid conditions also favoured HD, and both cardial instability (84.21%) and congestive heart failure (80.7%) showed a strong tendency towards PD, while diabetes mellitus could be described as a neutral factor with close to 60% regarding both treatment options as equivalent. These results broadly reflect the current state of research on the influence of these comorbidities, as PD is recommended for patients with chronic cardio-renal syndrome, while the literature on PD for DM patients is more contested. German nephrologists also generally considered patient preference to be the deciding factor. Furthermore, German nephrologists considered about 25% of patients to be eligible for PD, but suggested that only 15% would want to receive it. Given either value there seems to be a discrepancy between these numbers and the most recent data on PD prevalence in Germany (6.08%). Jassal et al. [45] note that their study shows comparable attitudes between UK, Canadian and US nephrologists and that nephrologists in all three countries would generally like to increase PD prevalence, but contend that these countries exhibit very different health care systems and different prevalence rates. They conclude that reasons for low prevalence are accordingly rather shaped by factors external to the attitudes of physicians. The case of Germany, it seems, can be added to this list in the sense that nephrologists' attitudes towards PD are comparable to previous surveys in many respects.

Desmet et al. [16] conducted a questionnaire in French-speaking parts of Belgium, where PD prevalence was particularly low with 8.7% in 2009. Respondents reported that only 55% were currently taking care of PD patients and 39% had not received specific training in PD. When asked to name three barriers out of a group of twelve given options, 29% perceived easy access to HD, 28% patients' refusal to try the technique and 26% nephrologists' lack of

motivation as impediments to the wider adoption of PD. The respondents also considered comorbidities as contraindications, 16% stating that these were numerous and 26% considering the association of relative contraindications as an absolute contraindication. This survey again shows a marked difference between hypothetical attitude and reported practice; 80% considered PD as effective as HD and the preferred hypothetical ratio of PD in Belgium was placed between 20-25%. The authors suggest that their survey reveals a lack of exposure and training. According to them the result is a "vicious cycle of less education leading to less knowledge and practice and once again to less training" [16]. This example is instructive as it underlines the interaction between low exposure and experience and the opinions of nephrologists. Belgian nephrologists seem to rate a lack of motivation of clinicians and patients as prominent in the low utilization of PD; they also place importance to contraindications in treatment decisions, giving the overall impression of a pessimistic attitude. Perhaps nephrologists' attitude towards PD and external factors are not completely separable, as Jassal et al. [45] seem to suggest in their analysis. Rather, a low number of PD patients can lead to a self-reinforcing pattern of preferring HD as the "safe method", which is also suggested in a narrative review of the reasons for less success of PD in Europe by van Biesen et al. [46].

The danger of the creation of a vicious cycle is, of course, also a concern in terms of medical outcome. Krediet et al. [47] give the example of poor outcomes from catheter insertions, which they view as a result of many Dutch dialysis centres being rather small. They also describe a vicious cycle and a resulting defeatist attitude, which also results in low prescription rates. Finally, it must be remembered that vicious cycles can also turn into virtuous cycles. Li and Chow [48] note that staff in Hong Kong dialysis centres are highly experienced due to large and specialized dialysis centres, most of which treat around 300 patients. As a result, they have become more adept at managing infectious disease, catheter insertion and the process of patient selection.

These considerations are particularly relevant in the case of Germany, where the average number of PD patients is rather small with a value of 12.47. Before this study, a detailed breakdown of PD patients per centre had not been conducted in Germany. Quality control data is published regularly, the most recent report showing that in 2019 6.08% of all long-term dialysis patients received PD. In total, there were 719 dialysis centres in Germany, treating 93089 long-term dialysis patients [49]. The data is broken down according to federal state, however, the data does not record the patient numbers of respective dialysis centres. The data collected in the present survey suggest that many centres are small in terms of PD patients and not very specialized, which can be seen by only 11.05% having specialized PD nursing staff. As a rough comparison, Krediet et al. [47] state that there are 112 dialysis centres in the

Netherlands where the population size is roughly a quarter of Germany's. If one were to scale up this number to the size of the German population (setting aside the issue of area), the Netherlands would have roughly 300 fewer dialysis centres. If one considers the case of the Netherlands as having issues resulting from many small centres, as suggested by the authors of the Dutch study, the German case seems even more laden with that particular burden.

This study has suffered from limitations to the validity of the model it is based on. Most importantly from a simultaneous causality bias, which is a form of endogenous bias. As the number of PD patients is affected by the willingness to select PD as a treatment option, the independent variable is to some extent affected by the variable it tries to explain. While that is a serious caveat, it is not necessarily unique. When studying the effect of centre size on TF rates, for example, a similar problem occurs, as lower TF rates lead to higher absolute numbers of PD patients at any given time. Another limitation, partly unavoidable, is the bias caused by an attitude-behaviour gap. More concrete results could be achieved with access to patient databases which, for example, allow a link to be made between certain comorbidities and actually administered RRT. Moreover, when utilizing real-world numbers, such as patient numbers, derived from answers to a questionnaire, several layers of bias, mistake and misinterpretation may reduce the validity of results. Respondents might not remember correctly, make rough guesses, incur significant rounding mistakes, or at worst make outright false statements, all of which cannot be accounted for. Lastly, it should be noted that the research of PD prevalence suffers from the conflation of PD and other home dialysis modalities. Home HD is, of course, very different from PD in its various forms, however, if one were to exclude all studies that also include Home HD, the resulting view of the topic would not reflect the real world. This is inevitable as PD is the prominent form of home dialysis, hence many studies that are concerned with PD utilization also include Home HD and vice-versa.

6. References

1 Jansen MAM, Hart AAM, Korevaar JC, Dekker FW, Boeschoten EW, Krediet RT. Predictors of the rate of decline of residual renal function in incident dialysis patients. *Kidney Int* 2002; **62:** 1046–53. https://doi.org/10.1046/j.1523-1755.2002.00505.x.

2 Kumar VA, Sidell MA, Jones JP, Vonesh EF. Survival of propensity matched incident peritoneal and hemodialysis patients in a United States health care system. *Kidney Int* 2014; **86:** 1016–22. https://doi.org/10.1038/ki.2014.224.

3 Perl J, Wald R, McFarlane P, et al. Hemodialysis vascular access modifies the association between dialysis modality and survival. *J Am Soc Nephrol* 2011; **22:** 1113–21. https://doi.org/10.1681/ASN.2010111155.

4 Marshall MR. The benefit of early survival on PD versus HD-Why this is (still) very important. *Perit Dial Int* 2020; **40:** 405–18. https://doi.org/10.1177/0896860819895177.

5 Walker R, Marshall MR, Morton RL, McFarlane P, Howard K. The cost-effectiveness of contemporary home haemodialysis modalities compared with facility haemodialysis: a systematic review of full economic evaluations. *Nephrology (Carlton)* 2014; **19:** 459–70. https://doi.org/10.1111/nep.12269.

6 Jung H-Y, Jeon Y, Park Y, et al. Better Quality of Life of Peritoneal Dialysis compared to Hemodialysis over a Two-year Period after Dialysis Initiation. *Sci Rep* 2019; **9:** 10266. https://doi.org/10.1038/s41598-019-46744-1.

7 Briggs V, Davies S, Wilkie M. International Variations in Peritoneal Dialysis Utilization and Implications for Practice. *Am J Kidney Dis* 2019; **74:** 101–10. https://doi.org/10.1053/j.ajkd.2018.12.033.

8 Saran R, Robinson B, Abbott KC, et al. US Renal Data System 2016 Annual Data Report: Epidemiology of Kidney Disease in the United States. *Am J Kidney Dis* 2017; **69:** A7-A8. https://doi.org/10.1053/j.ajkd.2016.12.004.

9 Li PK-T, Chow KM, van de Luijtgaarden MWM, et al. Changes in the worldwide epidemiology of peritoneal dialysis. *Nat Rev Nephrol* 2017; **13:** 90–103. https://doi.org/10.1038/nrneph.2016.181.

10 Chan CT, Wallace E, Golper TA, et al. Exploring Barriers and Potential Solutions in Home Dialysis: An NKF-KDOQI Conference Outcomes Report. *Am J Kidney Dis* 2019; **73:** 363–71. https://doi.org/10.1053/j.ajkd.2018.09.015.

11 Finkelstein FO. Barriers to optimal peritoneal dialysis. *Semin Dial* 2020; **33:** 464–67. https://doi.org/10.1111/sdi.12912.

12 Li PK-T, Lu W, Mak S-K, et al. Peritoneal dialysis first policy in Hong Kong for 35 years: Global impact. *Nephrology (Carlton)* 2022; **27:** 787–94. https://doi.org/10.1111/nep.14042.

13 Abra G, Weinhandl ED. Pulling the goalie: What the United States and the world can learn from Canada about growing home dialysis. *Perit Dial Int* 2021; **41:** 437–40. https://doi.org/10.1177/08968608211034696.
14 Bouvier N, Durand P-Y, Testa A, et al. Regional discrepancies in peritoneal dialysis utilization in France: the role of the nephrologist's opinion about peritoneal dialysis. *Nephrol Dial Transplant* 2009; **24:** 1293–97. https://doi.org/10.1093/ndt/gfn648.
15 Geneviève M, Bataille S, Beaume J, et al. Home dialysis : what are the barriers . A French nephrologist survey. *Bull Dial Domic* 2019; **2:** 47–53. https://doi.org/10.25796/bdd.v2i2.20463.
16 Desmet J-M, Fernandes V, Des Grottes J-M, et al. Perceptive barriers to peritoneal dialysis implementation: an opinion poll among the French-speaking Belgian nephrologists. *Clin Kidney J* 2013; **6:** 358–62. https://doi.org/10.1093/ckj/sft041.
17 Dahlan R, Qureshi M, Akeely F, Al Sayyari AA. Barriers to Peritoneal Dialysis in Saudi Arabia: Nephrologists' Perspectives. *Perit Dial Int* 2016; **36:** 564–66. https://doi.org/10.3747/pdi.2015.00232.
18 Sokwala SAK, Odhiambo JO, Sokwala AP. Perceived Barriers to Peritoneal Dialysis Among Kenyan Nephrologists: A Cross-Sectional Descriptive Study. *Can J Kidney Health Dis* 2022; **9:** 20543581221107756. https://doi.org/10.1177/20543581221107756.
19 Mehrotra R, Blake P, Berman N, Nolph KD. An analysis of dialysis training in the United States and Canada. *Am J Kidney Dis* 2002; **40:** 152–60. https://doi.org/10.1053/ajkd.2002.33924.
20 Berns JS. A survey-based evaluation of self-perceived competency after nephrology fellowship training. *Clin J Am Soc Nephrol* 2010; **5:** 490–96. https://doi.org/10.2215/CJN.08461109.
21 Mehrotra R. Peritoneal dialysis education: Challenges and innovation. *Semin Dial* 2018; **31:** 107–10. https://doi.org/10.1111/sdi.12666.
22 Brown EA, Blake PG, Boudville N, et al. International Society for Peritoneal Dialysis practice recommendations: Prescribing high-quality goal-directed peritoneal dialysis. *Perit Dial Int* 2020; **40:** 244–53. https://doi.org/10.1177/0896860819895364.
23 Deutsche Gesellschaft für Nephrologie. Dialysestandard. Deutschen Gesellschaft für Nephrologie in Zusammenarbeit mit dem Verband Deutscher Nierenzentren e.V. sowie der Gesellschaft für Pädiatrische Nephrologie (GPN). Überarbeitete, aktualisierte Fassung vom 17.02.2022. https://www.dgfn.eu/dialyse-standard.html (accessed Jul 02, 2023).
24 National Institute for Health and Care Excellence. Renal replacement therapy and conservative management. NICE guideline [NG107]. https://www.nice.org.uk/guidance/ng107 (accessed Jul 02, 2023).

25 Eroglu E, Heimbürger O, Lindholm B. Peritoneal dialysis patient selection from a comorbidity perspective. *Semin Dial* 2022; **35:** 25–39. https://doi.org/10.1111/sdi.12927.
26 Umanath K, Lewis JB. Update on Diabetic Nephropathy: Core Curriculum 2018. *Am J Kidney Dis* 2018; **71:** 884–95. https://doi.org/10.1053/ j.ajkd.2017.10.026.
27 Cotovio P, Rocha A, Rodrigues A. Peritoneal dialysis in diabetics: there is room for more. *Int J Nephrol* 2011; **2011:** 914849. https://doi.org/10.4061/2011/914849.
28 Vonesh EF, Snyder JJ, Foley RN, Collins AJ. Mortality studies comparing peritoneal dialysis and hemodialysis: what do they tell us? *Kidney Int Suppl* 2006: S3-11. https://doi.org/10.1038/sj.ki.5001910.
29 Zou M, Xie J, Lan L, et al. Safety and efficacy of hemodialysis and peritoneal dialysis in treating end-stage diabetic nephropathy: a meta-analysis of randomized controlled trials. *Int Urol Nephrol* 2022; **54:** 2901–09. https://doi.org/10.1007/s11255-022-03194-5.
30 Costanzo MR, Guglin ME, Saltzberg MT, et al. Ultrafiltration versus intravenous diuretics for patients hospitalized for acute decompensated heart failure. *J Am Coll Cardiol* 2007; **49:** 675–83. https://doi.org/10.1016/j.jacc.2006.07.073.
31 Bart BA, Boyle A, Bank AJ, et al. Ultrafiltration versus usual care for hospitalized patients with heart failure: the Relief for Acutely Fluid-Overloaded Patients With Decompensated Congestive Heart Failure (RAPID-CHF) trial. *J Am Coll Cardiol* 2005; **46:** 2043–46. https://doi.org/10.1016/j.jacc.2005.05.098.
32 Bart BA, Goldsmith SR, Lee KL, et al. Ultrafiltration in decompensated heart failure with cardiorenal syndrome. *N Engl J Med* 2012; **367:** 2296–304. https://doi.org/10.1056/NEJMoa1210357.
33 Grossekettler L, Schmack B, Meyer K, et al. Peritoneal dialysis as therapeutic option in heart failure patients. *ESC Heart Fail* 2019; **6:** 271–79. https://doi.org/10.1002/ehf2.12411.
34 Schwenger V, Remppis BA, Westenfeld R, et al. Dialyse- und Ultrafiltrationsverfahren bei kardiorenalem Syndrom. *Kardiologe* 2014; **8:** 26–35. https://doi.org/10.1007/s12181-013-0549-5.
35 Bonenkamp AA, Reijnders TDY, van Eck Sluijs A, et al. Key elements in selection of pre-dialysis patients for home dialysis. *Perit Dial Int* 2021; **41:** 494–501. https://doi.org/10.1177/08968608211023263.
36 Schaubel DE, Blake PG, Fenton SS. Effect of renal center characteristics on mortality and technique failure on peritoneal dialysis. *Kidney Int* 2001; **60:** 1517–24. https://doi.org/10.1046/j.1523-1755.2001.00969.x.
37 Huisman RM, Nieuwenhuizen MGM, Th de Charro F. Patient-related and centre-related factors influencing technique survival of peritoneal dialysis in The Netherlands. *Nephrol Dial Transplant* 2002; **17:** 1655–60. https://doi.org/10.1093/ndt/17.9.1655.

38 Jaar BG, Plantinga LC, Crews DC, et al. Timing, causes, predictors and prognosis of switching from peritoneal dialysis to hemodialysis: a prospective study. *BMC Nephrol* 2009; **10:** 3. https://doi.org/10.1186/1471-2369-10-3.

39 Evans D, Lobbedez T, Verger C, Flahault A. Would increasing centre volumes improve patient outcomes in peritoneal dialysis? A registry-based cohort and Monte Carlo simulation study. *BMJ Open* 2013; **3. https://doi.org/**10.1136/bmjopen-2013-003092.

40 Hingwala J, Diamond J, Tangri N, et al. Underutilization of peritoneal dialysis: the role of the nephrologist's referral pattern. *Nephrol Dial Transplant* 2013; **28:** 732–40. https://doi.org/10.1093/ndt/gfs323.

41 Scholten N, Ohnhaeuser T, Schellartz I, et al. Multidimensional analysis of factors responsible for the low prevalence of ambulatory peritoneal dialysis in Germany (MAU-PD): a cross-sectional Mixed-Methods Study Protocol. *BMJ Open* 2019; **9:** e025451. https://doi.org/10.1136/bmjopen-2018-025451.

42 Fluck RJ, Fouque D, Lockridge RS. Nephrologists' perspectives on dialysis treatment: results of an international survey. *BMC Nephrol* 2014; **15:** 16. https://doi.org/10.1186/1471-2369-15-16.

43 Jung B, Blake PG, Mehta RL, Mendelssohn DC. Attitudes of Canadian nephrologists toward dialysis modality selection. *Perit Dial Int* 1999; **19:** 263–68.

44 Mendelssohn DC, Mullaney SR, Jung B, Blake PG, Mehta RL. What do American nephologists think about dialysis modality selection? *Am J Kidney Dis* 2001; **37:** 22–29. https://doi.org/10.1053/ajkd.2001.20635.

45 Jassal SV, Krishna G, Mallick NP, Mendelssohn DC. Attitudes of British Isles nephrologists towards dialysis modality selection: a questionnaire study. *Nephrol Dial Transplant* 2002; **17:** 474–77. https://doi.org/10.1093/ndt/17.3.474.

46 van Biesen W, Veys N, Lameire N, Vanholder R. Why less success of the peritoneal dialysis programmes in Europe? *Nephrol Dial Transplant* 2008; **23:** 1478–81. https://doi.org/10.1093/ndt/gfn123.

47 Krediet RT, Abrahams AC, Fijter CWH de, et al. The truth on current peritoneal dialysis: state of the art. *Neth J Med* 2017; **75:** 179–89.

48 Li PK-T, Chow KM. Peritoneal dialysis patient selection: characteristics for success. *Adv Chronic Kidney Dis* 2009; **16:** 160–68. https://doi.org/10.1053/j.ackd.2009.02.001.

49 Institut für Qualitätssicherung und Transparenz im Gesundheitswesen. Jahresbericht 2019 zur Qualität in der Dialyse. Anlage 2 zum Beschluss. https://www.g-ba.de/downloads/39-261-4568/2020-11-20_QSD-RL_IQTIG-Jahresbericht-2019.pdf (accessed May 25, 2023).