Pediatric Nephrology (2023) 38:4111–4118
https://doi.org/10.1007/s00467-023-05995-x

ORIGINAL ARTICLE

Pediatric peritoneal dialysis training program and its relationship to peritonitis: a study of the International Pediatric Peritoneal Dialysis Network

Nivedita Kamath[1] · Dagmara Borzych-Dużałka[2,3] · Amrit Kaur[4] · Gisela Neto[5] · Klaus Arbeiter[6] · Yok Chin Yap[7] · Annie Lahoche[8] · Loai Eid[9] · Nakysa Hooman[10] · Troy Richardson[11] · Franz Schaefer[3] · Bradley A. Warady[12] · on behalf of the IPPN participants

Received: 11 January 2023 / Revised: 17 April 2023 / Accepted: 17 April 2023 / Published online: 5 July 2023

Abstract

Background The guidelines for training of patients and caregivers to perform home peritoneal dialysis (PD) uniformly include recommendations pertaining to the prevention of peritonitis. The objective of this study conducted by the International Pediatric Peritoneal Dialysis Network (IPPN) was to investigate the training practices for pediatric PD and to evaluate the impact of these practices on the peritonitis and exit-site infection (ESI) rate.

Methods A questionnaire regarding details of the PD program and training practices was distributed to IPPN member centers, while peritonitis and ESI rates were either derived from the IPPN registry or obtained directly from the centers. Poisson univariate and multivariate regression was used to determine the training-related peritonitis and ESI risk factors.

Results Sixty-two of 137 centers responded. Information on peritonitis and ESI rates were available from fifty centers. Training was conducted by a PD nurse in 93.5% of centers, most commonly (50%) as an in-hospital program. The median total training time was 24 hours, with a formal assessment conducted in 88.7% and skills demonstration in 71% of centers. Home visits were performed by 58% of centers. Shorter (< 20 hours) training duration and lower number of training tools (both $p < 0.02$) were associated with higher peritonitis rate, after adjustment for proportion of treated infants and income of country of residence.

Conclusions An association between training duration and the number of training tools represent potentially modifiable risk factors to reduce peritonitis rates within the pediatric PD population.

Keywords Pediatric peritoneal dialysis · Training · Peritonitis rate · Exit-site infection rate

✉ Nivedita Kamath
nkamath25@yahoo.com

1 St John's Medical College Hospital, Bangalore, India

2 Department of Pediatrics, Nephrology and Hypertension, Medical University of Gdańsk, Gdańsk, Poland

3 Division of Pediatric Nephrology, Center for Pediatrics and Adolescent Medicine, Heidelberg, Germany

4 Royal Manchester Children's Hospital, Manchester, UK

5 Pediatric Nephrology Unit, Dona Estefania Hospital, Lisbon, Portugal

6 Medical University Vienna, Vienna, Austria

7 Women and Children Hospital Kuala Lumpur, Kuala Lumpur, Malaysia

8 Hospital Jeanne de Flandre CHRU, Lille, France

9 Dubai Hospital, Dubai, United Arab Emirates

10 Ali Asghar Clinical Research Development Center, Department of Pediatrics, Iran University of Medical Science, Tehran, Iran

11 Children's Hospital Association, Lenexa, KS, USA

12 Division of Pediatric Nephrology, Children's Mercy Kansas City, Kansas City, USA

Introduction

Peritoneal dialysis (PD) is a frequently used long-term kidney replacement therapy (KRT) in children, especially in the pre-adolescent age group [1, 2]. Peritonitis is the most significant complication of the therapy, as the infection is associated with an increased risk for technique failure, hospitalization, severe morbidity and mortality [3–5].

Improvements in PD connectology along with greater clinical experience have led to a significant decline in peritonitis rates globally. The International Society for Peritoneal Dialysis (ISPD) has published evidence and opinion-based guidelines designed to reduce the risk of peritonitis in infants, children, and adolescents [6]. Implementation of standardized care programs has also contributed significantly to the development of strategies to further reduce infectious complications [5, 7]. Despite these resources, there remains wide variation in the frequency of peritonitis in children reported from centers around the globe [8].

The ISPD training guidelines of 2006 laid the foundation for an effective home PD training program by emphasizing the need for a one-on-one trainer-patient ratio, as well as a comprehensive training protocol [9]. The updated guidelines published in 2016 further emphasized the importance of re-training and home visits as key components of training. The importance of assessing the knowledge of the patient and/or caregiver at the conclusion of training was also emphasized [10, 11]. The ISPD position statements on prevention of peritonitis in adults [12] and children [13] have endorsed these training elements.

There is limited data from centers on the training practices for pediatric PD and the influence of these practices on peritonitis rate. There are, however, several possible barriers to providing effective training in a structured and uniform manner to all caregivers of children on dialysis which may serve as a potential influence on the rate of peritonitis. The lack of pediatric-specific training guidelines, variable educational level of caregivers, the lack of availability of trained pediatric PD nurses, and the absence of health-literate families in some centers all may compromise the efficacy of training. How widespread these training challenges are and how the presence or absence of training resources influence peritonitis rates in children is currently unknown. To further address the topic, the International Pediatric Peritoneal Dialysis Network (IPPN) developed and distributed a questionnaire to study the training practices for pediatric PD among its global members and to evaluate the impact of these training practices on peritonitis and exit-site infection (ESI) rate.

Methods

The questionnaire to assess PD training practices was developed using Microsoft Forms as a part of the IPPN collaborative and was distributed through email among 137 centers from 44 countries participating in the IPPN in early 2021. The email consisted of a detailed key pertaining to the questionnaire and informed the respondents that participation implied consent to share and publish center-aggregated data, as well as relevant details from the IPPN registry. Every center was requested to send a single response and the names of respondents along with the name of the center and country to prevent duplicate responses. The questionnaire (Supplementary file 1) consisted of 44 questions pertaining to PD training and peritonitis rates in accordance with the 2012 ISPD pediatric peritonitis guidelines [13]. Several questions addressed center details including the number and age range of patients on PD and the number of nurses participating in PD training. The centers were classified based on the number of patients per year (< 5, 5–10 and > 10 patients/year). There were 30 questions pertaining to training practices including care-giver assessment, indications for and frequency of re-training and the goals and process for home visits. In addition, eight questions, directed to centers with incomplete IPPN infection related data entry, pertained to the number of treated patients (separately, below 2 years and 2 years of age and above) and number of peritonitis and ESI episodes between 01.01.2019 and 31.12.2020. In centers with complete IPPN data entries, information about the number of patients and peritonitis/ESI episodes during the observation period was derived from the IPPN database.

While all participating centers ($n = 62$) were included in the descriptive analysis, 12 centers with incomplete data either on the number of treated patients or number of peritonitis episodes, were excluded from the analysis of factors associated with peritonitis rate.

The economic wealth of the countries of origin was classified based on gross domestic product (GDP) corrected for purchasing power parity as low GDP (per capita GDP < 10,000$) and high GDP (per capita GDP > 10,000$). The low GDP cut-off value was based on the IPNA KRT Registry Data analysis, showing that beyond this value access to KRT is limited (F, Schaefer, D. Borzych, personal communication International Pediatric Nephrology Association (IPNA) Congress Calgary 2022). The low GDP group included centers from Argentina, Colombia, India, Iran, Macedonia, Pakistan, Peru, Philippines, Tunisia, Turkey, and South Africa. The high-income centers were located in Austria, Belgium, Canada, Chile, China, Czech Republic, France, Germany, Greece, Israel, Italy, Korea, Lithuania, Malaysia, New Zealand, Poland, Portugal, Saudi Arabia, Slovenia, UAE, and USA.

Statistical analysis

Continuous variables were expressed as median and interquartile range. Differences in group means (log transformed in case of non-Gaussian distribution) were assessed using mixed linear models. Differences in proportions were assessed using the chi-squared test. The annualized rate of peritonitis was calculated as the number of episodes per patient year of dialysis. To assess training-related factors associated with peritonitis and ESI, we used a univariate and multivariable generalized linear model (GLM) approach assuming an underlying Poisson distribution and a log link function. To account for center-specific characteristics, we fit additional variables including gross domestic product of the country of residence (low vs. high) and the proportion of treated infants (%).The following training-related categorical variables were included: training duration below or above 20 h, regular reassessment vs. reassessment following peritonitis only, use of the VARK (visual, auditory, reading, and kinesthetic) tool, use of dummy patient/machine, home training, home visits, and remote monitoring. The continuous variables included the number of training tools used and the number of persons trained. As a formal training assessment was conducted in almost all (47/50) centers with available peritonitis/ESI data, this item was excluded from the analysis. Parameters with p value < 0.25 in univariate analysis were selected for a multivariate analysis. Differences in peritonitis rates were summarized by using adjusted rate ratios (RR) with 95% confidence intervals (CI). A p value of < 0.05 was considered significant. Statistical analyses were performed using SAS version 9.4.

Table 1 Summary of the results of the survey from all centers and from centers with data on peritonitis rates

Variable	All centers *N* (%)	Centers with peritonitis data *N* (%)
Number of centres	62	50
Number of children represented	1033	888
Number of children older than 2 years	778 (75%)	669 (75%)
Pediatric trained PD nurse	58 (94%)	48 (96%)
PD training location:		
In-hospital only	31 (50%)	22 (44%)
Out-patient only	6 (10%)	5 (10%)
Combined	25 (40%)	23 (46%)
Use of VARK tool	18 (29%)	15 (30%)
Training tools		
Posters	37 (60%)	32 (64%)
Videos	30 (48%)	23 (46%)
Dummy patients	43 (70%)	35 (70%)
Dummy machines	28 (45%)	21 (42%)
Simulation tools	23 (37%)	17 (34%)
Formal assessment of training	62 (89%)	46 (92%)
Re-assessment of training	24 (39%)	20 (40%)
Home visits	36 (54%)	26 (52%)

PD peritoneal dialysis, *VARK* visual, auditory, reading, kinaesthetic

Results

We obtained responses from 62 of the 137 centers (45.2%) who received the questionnaire. The responding centers were distributed across 32 countries and managed 1033 children on PD over the 2-year period of observation. The regional distribution of centers that participated in the study is described in Fig. 1. A summary of the results of

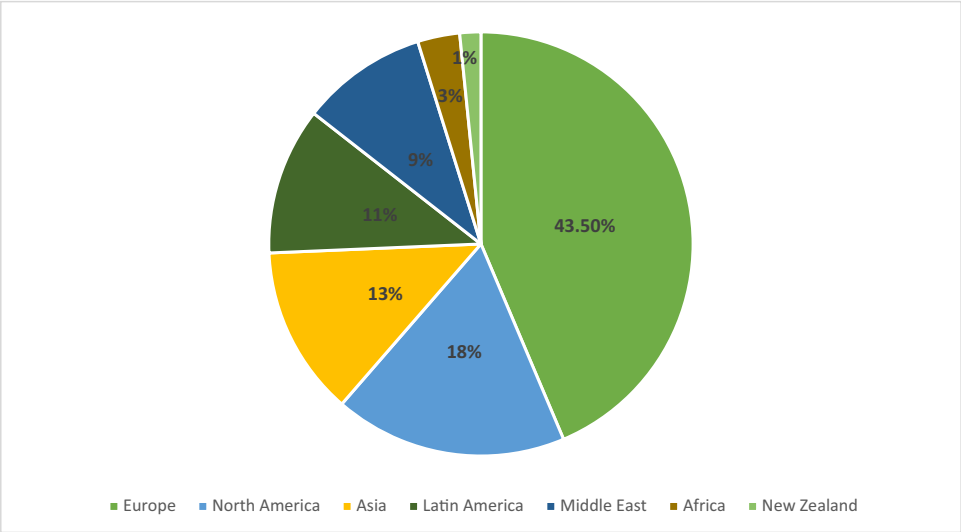

Fig. 1 The geographic distribution of centers participating in the study

the survey of all centers and the centers with peritonitis data is included in Table 1.

The majority of children (778/1033, 75.3%) were 2 years of age and older. In 6 centers (5 of these from "low income" countries), there were no children < 2 years of age (infants) during the observation period. Of the 1033 children, 834 (80.7%) were receiving automated peritoneal dialysis (APD) and the remainder were on continuous ambulatory peritoneal dialysis (CAPD). In all centers except one, the PD programs were managed by pediatric nephrologists. There were 22 centers treating less than 5 patients/year, 18 centers with 5–10 patients/year, and 22 centers with > 10 patients/year.

PD training was conducted by an experienced pediatric PD nurse in the majority (58/62, 93.5%) of centers. The centers had a median (IQR) of 2 (2,4) nurses conducting the training. The nurse: trainee(s) ratio was 1:1 in all centers. The training was conducted only as an in-hospital program in 31 (50.0%) centers, as a combined in-hospital and out-patient program in 25 centers (40.3%) and only in the out-patient setting in 6 (9.7%) centers. Additional training in the home environment was provided in 9 (14.5%) centers. Training was conducted for a median (IQR) of 10 (7.14) days and for about 24 (18,30) hours per trainee.

Forty-five centers (72.5%) trained more than one person and a median (IQR) of 2 (1,2) caregivers were trained per patient. All centers trained mothers and 15 (24.2%) centers trained both parents. Children older than 12 years were trained in 21 (33.9%) centers. Eighteen centers (29.0%) used the VARK tool to assess the trainees' preferred method of learning prior to the training. The median number of tools used for training were 4 (2,5). All centers except one used written material for training the caregivers. Posters and videos were used as educational material in 37 (59.7%) and 30 (48.4%) centers, respectively. Dummy patients were used in 43 (69.3%) centers, dummy machines in 28 (45.2%) centers and simulation in 23 (37.1%) centers (Fig. 2). Take-away learning material was distributed in 54 (87.1%) centers.

A formal assessment of the caregivers at the end of training was conducted in 55 of the 62 centers (88.7%). Demonstration of skills was incorporated into the assessment in 39 (70.9%) of these centers. The remaining centers used a combination of verbal and written assessments. Remote monitoring facilities were available in 44 (71%) centers.

Re-assessment of training principles was conducted regularly in 24 (38.7%) centers, whereas in 34 (54.8%) centers, it was done only after an episode of peritonitis or ESI. Re-assessment of training incorporated demonstration of skills in 28 centers (45.2%).

Home visits were conducted by 36 (58.1%) centers and nearly two-thirds of these centers (22/36, 61.1%) carried out an initial home visit prior to the initiation of PD. A single home visit before PD initiation was performed by 11 centers, a visit following PD initiation by six centers, one visit before and one after PD start by 2 centers, and regular home visits every 3 to 12 months by nine centers. Eight centers performed home visits by indication only. In all except 4 centers, a PD nurse was the primary person conducting the home visit. In 24 (66.6%) of the 36 centers, the PD nurse observed dialysis being performed during the home visit.

Comparing the PD modality and training practices between countries based on GDP, we found that CAPD was used more frequently (69.3% vs. 14.5%, $p < 0.0001$) and the proportion of centers providing PD in children younger than 2 years was significantly lower (68.7% vs. 97.8%, $p < 0.0001$) in centers located in countries with a

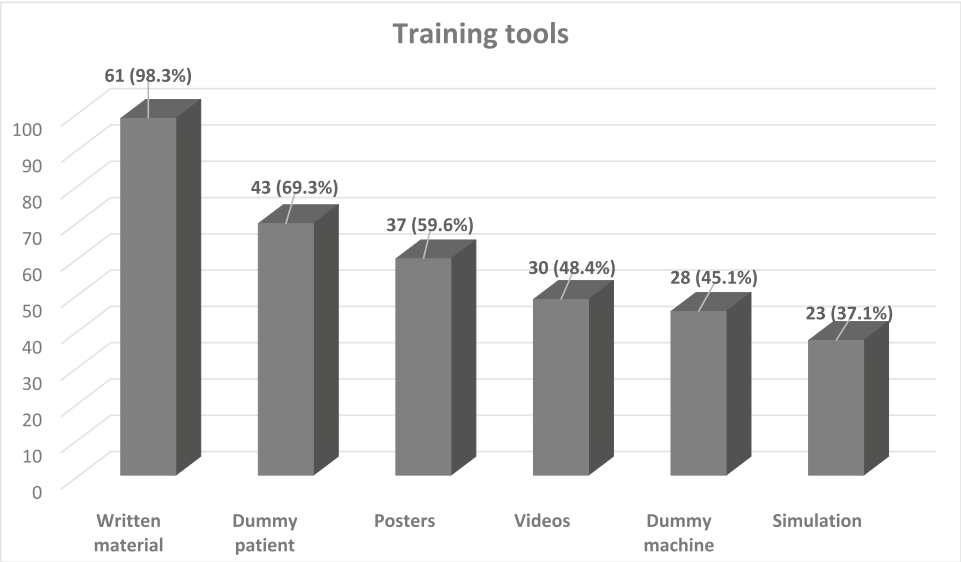

Fig. 2 Tools used for training families in long-term peritoneal dialysis

low GDP. Home training (3.4% vs. 24.2%, $p = 0.029$) and home visits (41.3% vs. 72.7%, $p = 0.02$) were conducted less often in countries with a low GDP when compared to those countries with a high GDP.

Peritonitis and ESI rates were calculated in 50 centers (888 patients) with complete data. There were 405 episodes of peritonitis in 989 patient years of dialysis, resulting in an annualized peritonitis rate of 0.41. Of these, 186 (45.9%) episodes were caused by gram-positive organisms, 107 (26.4%) by gram-negative organisms, 101 (24%) episodes were culture negative and 11 (2.7%) were caused by fungal organisms.

In the univariate analysis (Table 2), the risk of peritonitis was positively associated with the percentage of infants treated (RR 1.012, 95% CI 1.005–1.016), $p = 0.0006$). In terms of the relationship with training characteristics, the overall peritonitis rate was significantly higher in centers with a shorter training duration (< 20 h) ($p = 0.01$) and lower dummy patient/machine use ($p = 0.02$). The latter finding could not be explained by either an association with GDP or with the percentage of treated infants.

The number of care-givers trained, use of VARK tool, regular re-assessment, and availability of remote monitoring were not associated with the rate of peritonitis.

In the multivariable linear Poisson regression analysis, peritonitis rate was independently predicted by training duration below 20 h and inversely by the number of training tools used after adjustment for the percentage of treated infants and GDP.

One hundred and forty-four ESIs were recorded during the 2 years, corresponding to an ESI rate of 0.15 episodes per patient year. No associations between training practices and ESI rates were found.

Discussion

This study of training practices in pediatric PD centers participating in the IPPN found that while there were many differences in training practices, the majority of centers had experienced nurses as trainers, used a variety of training tools and conducted formal assessments after completion of the training program. Regular re-assessments, re-training and home visits were conducted in fewer centers. Countries with a low GDP had fewer infants on dialysis, higher use of CAPD and a lower prevalence of home training and home visits. Most importantly, when adjusting for GDP and the proportion of infants on dialysis, peritonitis was independently and inversely associated with the duration of training and the number of tools used for training.

The first ISPD recommendations for PD training published in 2006 provided some basic recommendations to nurses about the nurse to trainee ratio, duration of training, protocols for training, training tools and emphasized the importance of re-training and home visits [9]. However, these recommendations were based on limited evidence that was available in the area of PD education. A more recent set of recommendations proposed a syllabus for training, emphasized the importance of tailoring the training program to individual patient requirements and highlighted the value of follow-up assessments [11].

Studies in adult patients on PD have revealed conflicting results regarding the impact of PD training practices on patient outcomes [14]. A recent large analysis from the PDOPPS study showed that in adult patients on PD, there was a marked variation in training practices across centers globally. No training related factors were associated with peritonitis [15]. Other adult studies have also failed to show any relationship between peritonitis rates and either

Table 2 Univariate and Multivariate Poisson regression analysis of factors predicting peritonitis rate

Variable	Univariate		Multivariable	
	RR (95%CI)	*p* value	RR (95%CI)	*P* value
Infants on PD (%)	1.011 (1.004–1.016)	0.0006	1.013 (1.007–1.019)	0.0001
GDP below 10.000$	1.211 (0.970–1.511)	0.08	1.428 (1.097–1.858)	0.009
Training time < 20 h	1.331 (1.070–1.655)	0.01	1.318 (1.043–1.666)	0.02
Number of training tools	0.959 (0.896–1.027)	0.23	0.896 (0.813–0.988)	0.02
Use of dummy patient/machine	1.313 (1.032–1.671)	0.02	1.385 (0.991–1.936)	0.05
Home training	1.438 (0.776–2.664)	0.24	1.085 (0.732–1.608)	0.67
Home visits	1.154 (0.941–1.415)	0.16	1.149 (0.913–1.445)	0.23
Number of caregivers trained	0.951 (0.822–1.101)	0.49	–	–
Regular reassessment	1.097 (0.893–1.349)	0.36	–	–
Use of VARK tool	1.01 (0.824–1.246)	0.89	–	–
Remote monitoring	0.936 (0.732–1.197)	0.59	–	–

PD peritoneal dialysis, *GDP* gross domestic product; VARK tool: visual, auditory, reading, and kinesthetic tool

post-training test scores or length of clinical/teaching experience of the trainers [16, 17]. In contrast, some additional studies have found that post training scores [18], pre-dialysis training, home visits and re-training [19] were associated with lower rates of peritonitis. Importantly, non-compliance with key steps of the PD process and an associated decline over time in the patient's knowledge and skills has been revealed during home visits [20, 21]. Studies in adults on PD, despite variable results, have shown that PD training is a key aspect of a PD program and is believed to be an important tool for the prevention of peritonitis [22].

PD in children is different from that performed in adults as it is most often performed by the children's parents/caregivers and this, in addition to other aspects of CKD care, certainly contribute to caregiver burden and potential burnout [23]. Here too, training is seen as an essential step to decrease the risk of infectious complications. However, limited data pertaining to the training of pediatric caregivers for home PD have been published to help inform providers on the optimal composition of training in the pediatric setting, and the presence of any relationship between training content and the rate of infection. In the largest study to date which addressed the training of pediatric PD caregivers, Holloway et al. demonstrated that centers training larger numbers of patients and training programs with longer training time dedicated to theory and practical skills experienced lower peritonitis rates [24]. Home visits or training in the home environment did not influence the rate of peritonitis. Based on this study, the ISPD advisory committee recommended an extended duration of training with an adequate emphasis on theoretical and practical aspects of care as measures to reduce peritonitis [11].

Our questionnaire demonstrated that most of the training programs for pediatric PD conformed to the recommendations of the ISPD [11]. The participating centers had trained pediatric PD nurses, used a 1:1 trainer to trainee ratio and made use of a variety of training tools to cater to different learning preferences. Different studies have used different sets of training tools [14] and there is little evidence to suggest that one set of training tools is superior to another. The use of structured training programs [25, 26], and simulation tools [27] have also been found to be useful for training.

The majority of centers in this analysis conducted training in the hospital setting, and some centers had additional training in the home environment as well. Centers from countries with a low GDP had a lower prevalence of home training and this may reflect a lack of resources and logistical challenges in these settings.

While various studies in adults and children have found an association between individual components of training and the rate of peritonitis, we found that several factors influenced the peritonitis rate. The duration of training < 20 h emerged as an important risk factor for peritonitis in the current analysis. This finding confirms the study results from Holloway et al. which, as noted above, also emphasised the important influence of training duration on the rate of peritonitis [24]. Our findings are quantitatively in keeping with the ISPD recommendation that training be conducted for 10 days with 2 h of training each day [11].

As recommended by the ISPD, the majority of centers from the IPPN in this study conducted a post training assessment which included the demonstration of skills necessary to perform PD. The relationship between post training scores and the risk of developing peritonitis is variable [18]. A previously published study demonstrated that the scores on an objective, structured assessment at the end of training correlated with the rate of peritonitis [25]. However, since the vast majority of the centers in our study conducted a post training assessment, its influence on the rate of peritonitis could not be determined.

Regular re-assessment and re-training were performed only in about a third of centers. Prior studies have shown an attrition of knowledge and skills necessary to perform PD and emphasized the need for periodic re-assessment and re-training in adult patients on PD [20]. Regular re-assessment of skills as part of a follow-up care bundle practiced by the SCOPE collaborative in children has previously been shown to be associated with a decreased frequency of peritonitis [5]. The lack of influence of the re-assessment of skills on the peritonitis rates in our cohort may be confounded by the small number of centers incorporating this practice. On the other hand, re-training was conducted in the majority of centers following an episode of peritonitis. This approach does permit targeted education if the cause for the infection can be determined.

Home visits have been shown in various studies to be useful to directly observe skills, investigate non-compliance and to be associated with a reduction in the rate of peritonitis [28]. Home visits were performed only in about half the centers in our cohort and there was a significantly lower prevalence of home visits in centers residing in countries with a low GDP. Lack of resources and manpower, logistic and financial constraints and distance from the hospital are possible reasons that visits to a patient's home were limited.

Infants are a unique group of patients who are well recognized to be at higher risk for peritonitis. Data from the SCOPE collaborative has also revealed that infancy is associated with a high risk of peritonitis, with stomas and surgical interventions being important associated risk factors for this group of patients [29]. In our study as well, we found that the proportion of infants cared for in a center independently predicted the peritonitis rate. Future studies focussing on potentially modifiable risk factors for infection in this group of patients may result in the inclusion of specific training components that should be particularly emphasized for caregivers of infants on PD.

Centers from countries with a low GDP experienced a higher frequency of peritonitis, as well as a higher use of CAPD, and a lower use of home training and home visits. However, none of these factors independently influenced peritonitis rates. Another study from the IPPN found that the rate of culture negative peritonitis was higher in low-income countries as well, but other factors related to peritonitis were not different [30].

There are limitations in this study. The almost universal use of many training features precluded the evaluation of their association with peritonitis or ESIs. Also, since our survey of training practices included only centers participating voluntarily in the IPPN registry, it may not completely reflect variations in global practices. In addition, since the study focussed on center-based training practices, it is limited by its inability to capture patient-specific data (number of children with stomas, socioeconomic and educational level of caregivers, etc.) which may independently influence peritonitis rates.

However, a substantial strength of our study is the pediatric specific focus of the study and the inclusion of an objective outcome parameter (i.e., peritonitis rate) collected from a large number of pediatric PD patients and centers, which adds an important dimension to the interpretation of the data obtained from the questionnaire.

In conclusion, this study demonstrated that the training practices in pediatric PD are commensurate with the recommendations of the ISPD. The questionnaire results and the accompanying data pertaining to peritonitis calls attention to a number of training characteristics (e.g., duration of training, use of training tools) that influence the rate of peritonitis and need to be taken into account in the development or modification of training practices for pediatric PD. Ongoing assessment of this important aspect of PD management in children should further inform interventions designed to further decrease the rate of infection and enhance the duration of PD as a viable kidney replacement therapy for children.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00467-023-05995-x.

List of all contributors Gurinder Kumar, Sheikh Khalifa Medical City, Abu Dhabi, UAE; Sevcan A. Bakkaloglu, Gazi University School of Medicine, Ankara, Turkey; Maria Mila, Aglaia Kyriakou Children's Hospital, Athens, Greece; William Wong, Starship Hospital, Auckland, New Zealand; Alicia Neu, John Hopkins Hospital, Baltimore, Maryland, USA; Xuhui Zhong, Peking University First Hospital, Beijing, China; Julia Thumfart, Charite Universitatsmedizin, Berlin, Germany; Sahar Fathallah-Shaykh, University of Alabama, Birmingham, Alabama, USA; Brigitte Adams, HUBERF, Brussel, Belgium; Paula Alejandra Coccia, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina; Peter Nourse, Red Cross War Memorial Children's Hospital, Cape Town, South Africa; Hiren Patel, Nationwide Children's Hospital, Columbus, Ohio, USA; Ilona Zagożdzon, Medical University of Gdańsk, Gdańsk, Poland; Enrico Eugenio Verrina, IRCCS Instituto Giannina Gaslini, Genoa, Italy; Bassanese Giulia, University of Heidelberg, Heidelberg, Germany; Alex R Constantinescu, Joe DiMaggio Children's Hospital, Hollywood, Florida, USA; Zeynep Yuruk Yildirim, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey; Biswanath Basu, NRS Medical College, Kolkata, India; Dorota Drożdz, Jagiellonian University Medical College, Kraków, Poland; Reyner loza, Cayetano Heredia Hospital, Lima, Peru; Rukshana Shroff, Great Ormond Street Hospital for Children, London, UK; Shazia Adalat, Evelina London Children's Hospital, London, UK; Mark Hanudel, Univeristy of California Los Angeles, Los Angeles, California, USA; Gregor Novljan, University Medical Center Lubljana, Lubljana, Slovenia; Pamela Slack, Royal Manchester Children's Hospital, Manchester, UK; Richard Baquero Rodriguez, Hospital Universitario San Vicente Fundacion, Medellin, Colombia; Luisa Fernanda Rojas, RTS, Medellin, Colombia; Iliana Principi, Hospital Notti, Mendoza, Argentina; Silvia Consolo, IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; Marc Fila, Center Hospitalier Universitaire, Arnaud de Villeneuve, Montpellier, France; Vikki Emmet, Great North Children's Hospital, Newcastle Upon Tyne, UK; Roy Connel, Nottingham Children's Hospital, Nottingham, UK; Germana Longo, Dialysis and Transplantation unit, Padova, Italy; Daniel Landau, Schneider Children's Medical Center, Petach Tikva, Israel; Anjali Nayak, Phoenix Children's Hospital, Phoenix, USA; Karel Vondrak, Department of Pediatrics, Dialysis Center, Prague, Czech Republic Jyoti Sharma, King Edward Memorial Hospital, Pune, India; Zenaida L. Antonio, National Kidney & Transplant Institute, Quezon City, Philippines; Khawla A. Rahim, Children's Specialised Hospital, King Fahad Medical City, Riyadh, Saudi Arabia; Lavjay Butani, University of California Davis, Sacramento, California, USA; Macarena Gajardo Zurita, Hospital Roberto del Río, Santiago, Chile; Francisco Cano, Luis Calvo MacKenna Children's Hospital, Santiago, Chile; Raj Munshi, Seattle Children's Hospital, Seattle, USA; Yo Han Ahn, Seoul National University Hospital, Seoul, Republic of Korea; Emilija Sahpazova, University Pediatric Clinic, Skopje, N. Macedonia; Elizabeth Harvey, Hospital for Sick Children, Toronto, Canada; Mabrouk Sameh, University of Sahloul, Sousse, Tunisia: Enrico Vidal, Department of Medicine (DAME), University of Udine, Udine, Italy; Augustina Jankauskiene, Vilnius University Hospital, Santaros Klinikos, Vilnius, Lithuania; Kristen Pederson, Winnipeg Children's Hospital, Winnipeg, Manitoba, Canada; Maria Szczepańska, Dialysis Division for Children, Zabrze, Poland.

Declarations

Conflict of interest The authors declare no competing interests.

References

1. Annual Data Report | USRDS. https://adr.usrds.org/2021/end-stage-renal-disease/8-esrd-among-children-and-adolescents Accessed 30 Dec 2022
2. Annual Report of the North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS). 2008
3. Chadha V, Schaefer FS, Warady BA (2010) Dialysis-associated peritonitis in children. Pediatr Nephrol 25:425–440
4. Redpath Mahon A, Neu AM (2017) A contemporary approach to the prevention of peritoneal dialysis-related peritonitis in children: the role of improvement science. Pediatr Nephrol 32:1331–1341
5. Neu AM, Richardson T, Lawlor J, Stuart J, Newland J, McAfee N, Warady BA, SCOPE Collaborative Participants (2016) Implementation of standardized follow-up care significantly reduces peritonitis in children on chronic peritoneal dialysis. Kidney Int 89:1346–1354
6. Li PK, Szeto CC, Piraino B, de Arteaga J, Fan S, Figueiredo AE, Fish DN, Goffin E, Kim YL, Salzer W, Struijk DG, Teitelbaum I, Johnson DW (2016) ISPD Peritonitis Recommendations: 2016 Update on Prevention and Treatment. Perit Dial Int 36:481–508

7. Redpath Mahon AC, Richardson T, Neu AM, Warady BA (2019) Factors associated with high-cost hospitalization for peritonitis in children receiving chronic peritoneal dialysis in the United States. Pediatr Nephrol 34:1049–1055
8. Schaefer F, Feneberg R, Aksu N, Donmez O, Sadikoglu B, Alexander SR, Mir S, Ha IS, Fischbach M, Simkova E, Watson AR, Möller K, von Baum H, Warady BA (2007) Worldwide variation of dialysis-associated peritonitis in children. Kidney Int 72:1374–1379
9. Bernardini J, Price V, Figueiredo A (2006) Peritoneal dialysis patient training, 2006. Perit Dial Int 26:625–632
10. Hurst H (2016) A New Peritoneal Dialysis Training Guideline from the ISPD Nursing Committee. Perit Dial Int 36:585–586
11. Figueiredo AE, Bernardini J, Bowes E, Hiramatsu M, Price V, Su C, Walker R, Brunier G (2016) A syllabus for teaching peritoneal dialysis to patients and caregivers. Perit Dial Int 36:592–605
12. Li PK, Chow KM, Cho Y, Fan S, Figueiredo AE, Harris T, Kanjanabuch T, Kim YL, Madero M, Malyszko J, Mehrotra R, Okpechi IG, Perl J, Piraino B, Runnegar N, Teitelbaum I, Wong JK, Yu X, Johnson DW (2022) ISPD peritonitis guideline recommendations: 2022 update on prevention and treatment. Perit Dial Int 42:110–153
13. Warady BA, Bakkaloglu S, Newland J, Cantwell M, Verrina E, Neu A, Chadha V, Yap HK, Schaefer F (2012) Consensus guidelines for the prevention and treatment of catheter-related infections and peritonitis in pediatric patients receiving peritoneal dialysis: 2012 update. Perit Dial Int 32:32–86
14. Schaepe C, Bergjan M (2015) Educational interventions in peritoneal dialysis: A narrative review of the literature. Int J Nurs Stud 52:882–898
15. Cheetham MS, Zhao J, McCullough K, Fuller DS, Cho Y, Krishnasamy R, Boudville N, Figueiredo AE, Ito Y, Kanjanabuch T, Perl J, Piraino BM, Pisoni RL, Szeto CC, Teitelbaum I, Woodrow G, Johnson DW (2022) International peritoneal dialysis training practices and the risk of peritonitis. Nephrol Dial Transplant 37:937–949
16. Chen TW, Li SY, Chen JY, Yang WC (2008) Training of peritoneal dialysis patients—Taiwan's experiences. Perit Dial Int 28:72–75
17. Chow JS, Adams K, Cho Y, Choi P, Equinox KL, Figueiredo AE, Hawley CM, Howard K, Johnson DW, Jose MD, Lee A, Longergan M, Manera KE, Moodie JA, Paul-Brent PA, Pascoe EM, Reidlinger D, Steiner GZ, Tomlins M, Tong A, Voss D, Boudville NC (2020) Targeted education ApproaCH to improve peritoneal dialysis outcomes (TEACH-PD): A feasibility study. Perit Dial Int 40:153–163
18. Kazancioglu R, Ozturk S, Ekiz S, Yucel L, Dogan S (2008) Can using a questionnaire for assessment of home visits to peritoneal dialysis patients make a difference to the treatment outcome? J Ren Care 34:59–63
19. Bordin G, Casati M, Sicolo N, Zuccherato N, Eduati V (2007) Patient education in peritoneal dialysis: an observational study in Italy. J Ren Care 33:165–171
20. Russo R, Manili L, Tiraboschi G, Amar K, De Luca M, Alberghini E, Ghiringhelli P, De Vecchi A, Porri MT, Marinangeli G, Rocca R, Paris V, Ballerini L (2006) Patient re-training in peritoneal dialysis: why and when it is needed. Kidney Int Suppl 103:127–132
21. Ozturk S, Yucel L, Guvenc S, Ekiz S, Kazancioglu R (2009) Assessing and training patients on peritoneal dialysis in their own homes can influence better practice. J Ren Care 35:141–146
22. Bender FH, Bernardini J, Piraino B (2006) Prevention of infectious complications in peritoneal dialysis: best demonstrated practices. Kidney Int 70:44–54
23. Wightman A (2020) Caregiver burden in pediatric dialysis. Pediatr Nephrol 35:1575–1583
24. Holloway M, Mujais S, Kandert M, Warady BA (2001) Pediatric peritoneal dialysis training: characteristics and impact on peritonitis rates. Perit Dial Int 21:401–404
25. Gadola L, Poggi C, Poggio M, Sáez L, Ferrari A, Romero J, Fumero S, Ghelfi G, Chifflet L, Borges PL (2013) Using a multidisciplinary training program to reduce peritonitis in peritoneal dialysis patients. Perit Dial Int 33:38–45
26. Hall G, Bogan A, Dreis S, Duffy A, Greene S, Kelley K, Lizak H, Nabut J, Schinker V, Schwartz N (2004) New directions in peritoneal dialysis patient training. Nephrol Nurs J 31(149–54):159–163
27. Zgoura P, Hettich D, Natzel J, Özcan F, Kantzow B (2019) Virtual reality simulation in peritoneal dialysis training: the beginning of a new era. Blood Purif 47:265–269
28. Zhang L, Hawley CM, Johnson DW (2016) Focus on peritoneal dialysis training: working to decrease peritonitis rates. Nephrol Dial Transplant 31:214–222
29. Zaritsky JJ, Hanevold C, Quigley R, Richardson T, Wong C, Ehrlich J, Lawlor J, Rodean J, Neu A, Warady BA, SCOPE Investigators (2018) Epidemiology of peritonitis following maintenance peritoneal dialysis catheter placement during infancy: a report of the SCOPE collaborative. Pediatr Nephrol 33:713–722
30. Schaefer F, Borzych-Duzalka D, Azocar M, Munarriz RL, Sever L, Aksu N, Barbosa LS, Galan YS, Xu H, Coccia PA, Szabo A, Wong W, Salim R, Vidal E, Pottoore S, Warady BA, IPPN investigators (2012) Impact of global economic disparities on practices and outcomes of chronic peritoneal dialysis in children: Insights from the international pediatric peritoneal dialysis network registry. Perit Dial Int 32:399–409