


# BMJ Open Prevalence of peritonitis and mortality in patients with ESKD treated with chronic peritoneal dialysis in Africa: a systematic review

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## ABSTRACT

**Objective** The aim of this study was to report the prevalence of peritonitis and mortality in patients with end-stage kidney disease (ESKD) treated with chronic peritoneal dialysis (PD) in Africa.

**Design** Systematic review.

**Setting** Africa.

**Participants** Patients with ESKD in Africa.

**Interventions** PD in its varied forms.

**Primary and secondary outcomes** PD-related peritonitis rate (primary outcome), time-to-discontinuation of PD, mortality.

**Data sources** Four databases, including PubMed, Embase, Web of Science and Africa Journal Online were systematically searched from 1 January 1980 to 31 December 2019.

**Eligibility criteria** Studies conducted in Africa reporting peritonitis rate and mortality in patients treated with PD.

**Data extraction and synthesis** Two reviewers extracted and synthesised the data using Microsoft Excel. The quality of included data was also assessed.

**Results** We included 17 studies from seven African countries representing 1894 patients treated with PD. The overall median age was 41.4 years (IQR: 38.2–44.7) with a median time on PD of 18.0 months (17.0–22.6). An overall median peritonitis rate of 0.75 (0.56–2.20) episodes per patient-year (PPY) was observed and had declined with time; peritonitis rate was higher in paediatric studies than adult studies (1.78 (1.26–2.25) vs 0.63 (0.55–1.87) episodes PPY). The overall median proportion of deaths was 21.1% (16.2–25.8). Culture negative peritonitis was common in paediatric studies and studies that reported combined outcomes of continuous ambulatory PD and automated PD. Both 1-year and 2-year technique survival were low in all studies (83.6% and 53.0%, respectively) and were responsible for a high proportion of modality switch.

**Conclusions** Our study identifies that there is still high but declining peritonitis rates as well as low technique and patient survival in PD studies conducted in Africa. Sustained efforts should continue to mitigate factors associated with peritonitis in patients with ESKD treated with PD in Africa.

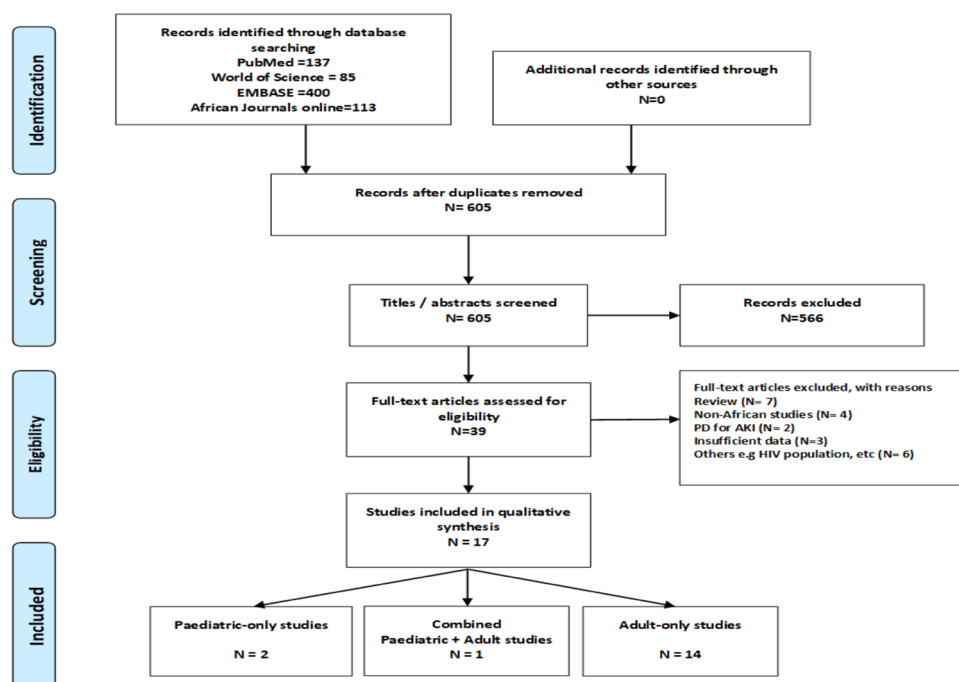
**PROSPERO registration number** CRD42017072966.

## Strengths and limitations of this study

- Extensive literature search of Medline, Embase, Web of Science and Africa Journal online with independent screening of all abstracts and eligible full-text publications by two investigators.
- Assessment of study quality and extensive data extraction on peritonitis rate, proportion of deaths, technique and patient survival from each study.
- Significant heterogeneity in populations, peritonitis rates and proportion of deaths precluded the use of meta-analysis to further summarise the data.
- Reported deaths were not usually linked to infectious peritonitis but included all deaths occurring in patients treated with peritoneal dialysis.
- There was only one prospective study and quality of reporting of outcomes was not optimal across studies.

## INTRODUCTION

Despite having several advantages over haemodialysis (HD) including cost, preservation of residual renal function, improved quality of life, greater independence and better initial survival, the utilisation of peritoneal dialysis (PD) as a modality for kidney replacement therapy (KRT) in Africa is limited.<sup>1</sup> Data from the South African Renal Registry show that of the 10 744 patients who have received KRT in South Africa in 2017, only 11.2% were on PD while 71.5% were on HD and 17.3% were kidney transplant recipients.<sup>2</sup> Due to several reasons, including the high cost or unavailability of PD fluids, unavailability of PD catheters, patient unwillingness, reimbursement of physicians and high rates of peritonitis and other PD catheter-related infections, chronic PD is unavailable in many countries in Africa.<sup>1 3</sup> A number of studies from Africa report that low socioeconomic status,<sup>4</sup> low level of education,<sup>4 5</sup> dwelling in informal housing<sup>6</sup> and lack of electricity and water



**Figure 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram. AKI, acute kidney injury; PD, peritoneal dialysis.

supply to households<sup>47</sup> are associated with increased rates of peritonitis; this is thought to influence the reduced utilisation of PD in the continent. For these reasons, PD is frequently offered to highly motivated, educated and financially stable patients with acceptable levels of personal hygiene,<sup>3,8,9</sup> such as in the South African public sector where KRT is still rationed. The International Society of Peritoneal Dialysis (ISPD) recommends for peritonitis rates to be under 0.5 episodes per year at risk,<sup>10</sup> however, studies from Africa often show much higher peritonitis rates leading to an increased change in KRT modality, technique failure and mortality. We conducted this systematic review to estimate the prevalence of peritonitis and mortality in African patients with end-stage kidney disease (ESKD) treated with PD. Although this study is not designed to assess measures to prevent peritonitis, we hope it will show that peritonitis rates have been reducing in Africa with time and the PD can be an option for KRT in the continent.

## METHODS

### Selection of eligible studies, types of studies and sources of information

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis 2009 guidelines<sup>11</sup> was the framework for reporting this review (see online supplemental table 1 and figure 1). The study protocol was registered in the International Prospective Register of systematic reviews and has been published.<sup>12</sup> We searched PubMed, Embase, Web of Science and Africa Journal Online for relevant studies on peritonitis related to the treatment of patients with ESKD treated with PD. The searches were

limited to studies performed in Africa and published from 1 January 1980 to 31 December 2019. Key search terms were: ‘peritoneal dialysis’, ‘peritonitis’, ‘Africa’ with a filter to include all African countries (PubMed, Embase and Web of Science search strategies are shown in online supplemental tables 2–4). Further, we used controlled vocabularies synonyms to identify related terms. Individual country names for all African countries were also included in the search.

### Search strategy/identification of studies

Two authors (MWM and JJN) independently assessed all abstracts for eligibility. In situations of disagreements between the two reviewers, a third reviewer (IGO) arbitrated for eligibility. JJN assessed all the abstracts in French. Studies included were observational studies (cross-sectional studies, prospective observational studies and cohort studies) reporting data on the prevalence of peritonitis and mortality among children and/or adults with ESKD treated with PD in Africa. There were no restrictions to studies based on age, language, sample size or type of PD used (continuous ambulatory PD (CAPD), automated PD (APD) or nightly intermittent PD (NIPD)). However, the following exclusion criteria were applied: (1) case reports, case-control studies and review articles, (2) studies conducted among populations of African origin residing outside of Africa, (3) duplicates or similar data from the same centre and by the same authors which included data from the excluded study (eg, Abu-Aisha *et al.*<sup>13</sup> and Jellouli *et al.*), (4) studies from which the prevalence of PD-related peritonitis cannot be determined and whose full data could not be accessed even after request from the authors, (5) studies describing PD outcomes in



**Figure 2** African countries with number of studies included in this study.

a specific ESKD population (eg, HIV, diabetics and so on) or focusing on specific organisms or types of peritonitis (eg, fungal peritonitis, encapsulating peritoneal sclerosis and so on), (6) studies on other types of infections in patients treated with PD (eg, exit site infection, tunnel infection and so on) and (7) studies of PD outcomes for acute kidney injury (AKI).

#### Data extraction and assessment of study quality

We grouped studies based on the type of PD used (CAPD only or CAPD+APD/NIPD or APD only) and based on the population studied (paediatric only, adult only or paediatric+adult). Two investigators (IGO and UE) independently extracted data; discrepancies between investigators were resolved through discussion until consensus was reached. Data extracted included first author name, year of publication, country of study origin, sample size of the study, gender proportions in the study population, mean age, mean duration of patients on PD, number of peritonitis episodes, peritonitis rate (reported as episodes/patient-year), number of deaths and types of organisms causing peritonitis. We also recorded the proportion of patients changing modality, transplanted, recovering kidney function as well as 1-year and 2-year technique and patient survival (if provided). Assessment of quality in individual studies was performed independently by two reviewers (IGO and UE), using an adapted quality assessment tool from a previous prevalence study<sup>14</sup> to evaluate the quality of individual studies by assessing selection bias, study design, data collection method, statistical analysis and withdrawals. The quality of individual studies was rated as high (8–10), medium (5–7) or low (<5) (see online supplemental tables 5 and 6).

#### Statistical analysis

Microsoft Excel (Redmond, Washington, USA) was used to compile extracted data. Due to heterogeneity of the study population and reporting, a meta-analysis was not carried out. However, we pooled the reported data and for each variable of interest, we calculated the median and IQR. The primary outcome was the peritonitis rate and the proportion of deaths reported from the studies during the study period. Secondary outcomes included proportion of modality switch to HD, patients who had transplants and reported 1-year and 2-year technique and patient survival. Studies were grouped into adult studies, paediatric studies, CAPD only studies, CAPD+APD/NIPD studies and APD-only studies. The results were presented as reported percentages, rates and as overall/group median (IQR).

#### Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

## RESULTS

### Demographic features of included studies

Seventeen studies were included in this review representing studies from seven countries (Cameroon,<sup>15</sup> Egypt,<sup>8</sup> Morocco,<sup>16</sup> Senegal,<sup>7 17</sup> South Africa,<sup>4 5 9 18–22</sup> Sudan<sup>23</sup> and Tunisia<sup>24–26</sup>) (figure 2). The overall sample size for the studies was 1894 with a median sample of 85 (IQR: 62–152). The median proportion of men in all the studies was 59% (IQR: 52–61) with an overall median age of 41.4 years (IQR: 38.2–44.7). The median time on PD was 18.0 months (IQR: 17.0–22.6); the median time on PD was shorter in paediatric studies compared with adult studies (12.6 months vs 18.0 months). There was only one (5.9%) study from South Africa that had a prospective design.<sup>20</sup> 14/17 (82.4%) studies were conducted in adults,<sup>4 5 7–9 15–21 24 26</sup> two studies were in paediatric patients<sup>22 25</sup> and one study from Sudan included combined data from paediatric and adult patients on PD.<sup>23</sup> The types of PD reported were: CAPD (nine studies),<sup>4 5 8 15 16 18–21</sup> CAPD+APD/NIPD (seven studies)<sup>7 9 17 22 23 25 26</sup> and APD (one study)<sup>24</sup> (tables 1 and 2).

### Peritonitis rates and organisms causing peritonitis

Over time (1980–2019), the reported peritonitis rate was observed to be declining. The highest peritonitis rate was 2.72 episodes per patient-year (PPY), the lowest was 0.33 episodes PPY with an overall median peritonitis rate of 0.75 (IQR: 0.56–2.20) episodes PPY for all studies. The median peritonitis rate for studies published in the 1980s and 1990s was 2.71 (IQR: 2.58–2.72) episodes PPY and had improved to a median of 0.60 (IQR: 0.55–0.82) episodes PPY for studies published in the 2000s. Other groups also showed improved peritonitis rates from 1980 to 2019. The median peritonitis rates in studies focused on adults and children were 0.63 (IQR: 0.55–1.87) and 1.78

**Table 1** Demographic and descriptive features of included studies

Year of publication	Country	Author and reference	Study period	Study design	Study population	Dialysis type	Sample size	Males (%)	Mean age (yrs)	Mean time on PD (months)	Duration of treatment (person-months)
1984	South Africa	Parsoo <i>et al</i> <sup>18</sup>	1979–1983	Retrospective	Adult	CAPD	88	61.4	43.8	12.2	1054
1989	Cameroon	Yumbissi <i>et al</i> <sup>15</sup>	–	Retrospective	Adult	CAPD	13	69.2	41±7.2	–	216
1993	South Africa	Naiker <i>et al</i> <sup>19</sup>	1979–1988	Retrospective	Adult	CAPD	278	–	–	–	–
1994	South Africa	Zent <i>et al</i> <sup>4</sup>	1987–1991	Retrospective	Adult	CAPD	132	43.9	41.8	17.3	2283.6
2001	South Africa	Katz <i>et al</i> <sup>20</sup>	1998–1999	Prospective	Adult	CAPD	84	65.5	39	17±12	–
2007	Sudan	Elhassan <i>et al</i> <sup>23</sup>	2005–2007	Retrospective	Paediatric+Adult	CAPD+APD	111	–	56 (1–75)	–	893
2007	Tunisia	Karoui <i>et al</i> <sup>24</sup>	1997–2003	Retrospective	Adult	APD	78	59.0	38.6±14.5	25.5	1998
2007	South Africa	Naidoo <i>et al</i> <sup>21</sup>	2000–2005	Retrospective	Adult	CAPD	263	63	41.8	–	719
2010	Egypt	Mahmoud <i>et al</i> <sup>8</sup>	1997–2008	Retrospective	Adult	CAPD	33	33	31.7	18 (2–76)	–
2010	South Africa	Raaijmakers <i>et al</i> <sup>22</sup>	2000–2008	Retrospective	Paediatric	CAPD+NIPD	67	52.2	10.1 (1.2–17.4)	7.0 (0.4–36.8)	544
2012	Senegal	Cisse <i>et al</i> <sup>17</sup>	2004–2007	Retrospective	Adult	CAPD+APD	31	54.8	49±5	–	–
2012	Morocco	Bekaoui <i>et al</i> <sup>16</sup>	2006–2011	Retrospective	Adult	CAPD	36	60.2	49.1±16.8	22.6±14.1	–
2014	Senegal	Niang <i>et al</i> <sup>7</sup>	2004–2010	Retrospective	Adult	CAPD+APD	62	54.8	47±13	–	–
2014	South Africa	Isla <i>et al</i> <sup>6</sup>	2007–2012	Retrospective	Adult	CAPD	152	52	36.8±11.4	21.0±17.8	–
2016	Tunisia	Jellouli <i>et al</i> <sup>25</sup>	2004–2013	Retrospective	Paediatric	CAPD+APD	85	60.0	9.3±5.7	18.1±12	–
2018	South Africa	Davidson <i>et al</i> <sup>9</sup>	2008–2014	Retrospective	Adult	CAPD+APD	199	49.8	39.7±10.4	17.0	–
2019	Tunisia	Lasfar <i>et al</i> <sup>26</sup>	2006–2016	Retrospective	Adult	CAPD+APD	182	59.3	43.9±16.9	27.8±26.2	5068.5

– Unavailable/unreported data.

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NIPD, nightly intermittent peritoneal dialysis; PD, peritoneal dialysis.

**Table 2** Summary of study characteristics by study age group and type of peritoneal dialysis used

	All studies	Adult studies*	Paediatric studies†	CAPD only‡	CAPD+APD/NIPD**§	APD only¶
Peritonitis rate (episodes PPY)						
1980–2019	0.75 (0.56–2.20)	0.63 (0.55–1.87)	1.78 (1.26–2.29)	0.82 (0.58–2.70)	0.75 (0.58–0.87)	0.33
1980–1999	2.71 (2.58–2.72)	2.71 (2.58–2.72)	–	0.75 (0.56–2.20)	–	–
2000–2019	0.60 (0.55–0.82)	0.57 (0.47–0.64)	1.78 (1.26–2.29)	0.58 (0.56–0.65)	0.75 (0.58–0.87)	0.33
Peritonitis (organisms) (%)						
Gram positives	37.0 (25.6–51.6)	47.5 (28.5–52.3)	32.1 (31.2–33.1)	52.1 (37.0–54.6)	31.6 (22.6–33.8)	40.0
Gram negatives	18.2 (12.2–23.0)	15.4 (10.2–22.1)	23.5 (23.4–23.6)	14.7 (10.2–21.5)	21.5 (15.2–23.0)	22.2
Fungal	2.6 (0.95–5.2)	3.4 (2.1–6.0)	0.9 (0.85–0.95)	2.8 (1.7–5.4)	2.0 (0.9–4.5)	–
Culture negatives	28.7 (19.5–49.0)	25.5 (18.8–47.5)	35.0 (31.9–38.2)	24.6 (15.5–37.7)	42.2 (31.9–49.0)	–
Others	1.5 (0.0–5.7)	1.5 (0.0–3.8)	5.1 (2.5–7.6)	2.9 (2.9–6.6)	–	–
Proportion of deaths (%)	21.1 (16.2–25.8)	21.1 (17.9–30.3)	11.2 (5.6–16.8)	21.1 (12.5–38.4)	21.1 (17.9–22.8)	19.2
Other outcomes (%)						
Modality switch	19.3 (16.4–26.0)	20.4 (15.7–25.9)	41.2 (28.8–53.6)	16.7 (14.0–21.5)	26.0 (18.7–28.7)	28.2
Patients who had transplants	5.7 (0.0–11.0)	6.8 (0.0–10.6)	39.6 (19.8–59.3)	7.1 (0.0–10.6)	2.3 (0.0–10.1)	1.3
Recovery of kidney function	0.0 (0.0–1.1)	0.0 (0.0–1.5)	0	0.0 (0.0–3.0)	0.0 (0.0–0.5)	0
1-Year technique survival	83.6 (67.0–91.9)	85.0 (75.1–93.1)	61.8 (50.9–72.7)	83.3 (75.2–87.6)	83.6 (62.0–85.0)	94.3
2-Year technique survival	53.0 (47.5–73.5)	62.4 (50.8–74.3)	32.0	53.0 (51.5–62.4)	60.1 (41.8–78.9)	–
1-Year patient survival	92.3 (83.3–94.8)	91.3 (79.9–93.9)	100.0	86.7 (79.9–90.6)	93.7 (84.2–97.1)	93.3
2-Year patient survival	79.6 (72.4–86.6)	79.2 (69.2–79.9)	100.0	78.7 (72.4–79.4)	86.4 (70.2–94.9)	–

All values are presented as median (IQR).

\*References 4 5 7–9 15–21 24 26.

†References 22 25.

‡References 4 5 8 15 16 19–21.

§References 7 9 17 22 23 25 26.

¶References 24.

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NIPD, nightly intermittent peritoneal dialysis; PPY, per patient-year.



(IQR: 1.26–2.25) episodes PPY, respectively. The median peritonitis rate was also higher in studies reporting use of CAPD (0.82 (IQR: 0.58–2.7)) than in those reporting the outcomes of patients on CAPD combined with APD/NIPD (0.68 (IQR: 0.52–0.87) episodes PPY, [tables 2 and 3](#)). In the lone study that described patient outcomes when treated with APD only, the peritonitis rate was 0.33 episodes PPY.

Gram-positive bacteria (GPB) were the most common cause of peritonitis with an overall median of 37.0% (IQR: 25.6–51.6); the prospective study from South Africa had the highest reporting of GPB as the cause of peritonitis (85.3%).<sup>20</sup> Culture-negative peritonitis was highest in paediatric studies (35.0% (IQR: 31.9–38.2)) and studies that combined CAPD with APD/NIPD (42.2% (IQR: 31.9–49.0)). In three studies, more than half of the reported cultures yielded no growth (culture-negative). ([tables 2 and 4](#)).

### Mortality, technique and patient survival

Two studies reported no deaths for the duration of their studies. In studies reporting deaths, the lowest was 8.3% and the highest 39.2%. The median proportion of deaths from all the studies was 21.1% (IQR: 16.2–25.8). The median proportion of deaths was lower in the two paediatric studies (11.2% (IQR: 5.6–16.8)) compared with the studies in adults (21.1% (IQR: 17.9–30.3)). Nine studies provided information on technique survival; overall median 1-year and 2-year techniques survival was 83.6% (IQR: 67.0–91.9) and 53.0% (47.5–73.5), respectively. The lowest technique survival was from a paediatric study (1-year—40.0% and 2-year—32.0%). For studies providing data on patient survival, median 1-year and 2-year patient survival was 92.3% (IQR: 83.3–94.8) and 79.6% (IQR: 72.4–86.6), respectively. Only one study showed 100% patient survival during their study duration ([tables 2 and 3](#)).

### Other outcomes—modality switch, transplants and recovered kidney function

Modality switch to HD and proportion of patients who had transplants were highest in the paediatric studies with median values of 41.2% (IQR: 28.8–53.6) and 39.6% (IQR: 19.8–59.3), respectively. Patients treated only with CAPD had the lowest proportion of modality switch to HD (16.7% (IQR: 14.0–21.5)). The overall proportion of patients who had transplants was 5.7% (IQR: 0.0–11.0) and three studies reported 0% transplant due to unavailability at their centre.<sup>5 7 17</sup> For studies that reported recovery of kidney function, this ranged from as low as 0.6%<sup>26</sup> to 9.5%<sup>20</sup> ([tables 2 and 5](#)).

## DISCUSSION

This systematic review has used published data from 17 studies, over a period spanning four decades, to report on some important observations on peritonitis rates, mortality and other outcomes such as modality switch and

survival in patients treated with PD in Africa. Our study has demonstrated the lack of utilisation of chronic PD as a KRT modality in the African continent. Eight of the 17 studies (47.1%) that met inclusion were from South Africa with six studies (35.3%) from North African countries, two (11.8%) from West Africa and one (5.9%) from Central Africa. The significance of this becomes even more apparent when consideration is given to reports from the South African Renal Registry that shows that chronic PD represents only 11.2% of all KRT in that country.<sup>2</sup> Although PD may be more cost-effective than HD,<sup>27</sup> various factors have accounted for low PD utilisation in Africa, including poor infrastructure, lack of PD fluids, unavailability of catheters and high peritonitis rates often leading to modality switch to HD.<sup>3 4 7</sup>

Even though we showed that peritonitis rates in PD in Africa has been on the decline since the 1980s, it nevertheless remains higher than current recommendations of the ISPD.<sup>10</sup> Results from the Peritoneal Dialysis Outcomes and Practice Patterns Study (PDOPPS) involving 7051 adult patients treated with PD across seven developed countries showed crude peritonitis rate to be 0.28 episodes PPY.<sup>28</sup> Lower peritonitis rate was reported if the centres used more APD, used antibiotics at catheter insertion, had longer PD training duration or used topical exit-site mupirocin or aminoglycoside ointment.<sup>28</sup> Although it is unclear what the practice patterns of the centres are in the studies included in this research, however, the one study that reported outcomes in patients treated with APD demonstrated the lowest peritonitis rate.<sup>24</sup> Sociodemographic factors were highlighted in several of the studies included in our research and appear to play a major role in peritonitis rates in Africa. The reduction in peritonitis rate with time may possibly be related to use of the Y-set and twin bag connection systems<sup>7 29</sup> and improved selection of patients with housing, electricity, running water and other amenities to PD.<sup>9</sup>

The bacteriology of peritonitis in this study is comparable to findings from other studies that have shown a predominance of Gram-positive organisms. The PDOPPS study reported similar microbiology of peritonitis across all countries, except in Thailand, where Gram-negative and culture-negative peritonitis were more common. Culture-negative peritonitis was very high in many studies that were included in our research and represented over 50% of culture reports from three studies. This may be suggestive of poor sampling and culture methods and could lead to inappropriate treatment with antibiotics. A better understanding of PD effluent culture sampling and adherence to international recommendations on diagnostic methods may reduce rates of culture-negative peritonitis.

Peritonitis has also been demonstrated to be associated with technique failure, all-cause, cardiovascular and infection-related mortality in patients treated with PD.<sup>30 31</sup> This relationship between peritonitis and mortality can explain the reduction in the proportion of deaths seen in our study which followed the same decline as peritonitis

**Table 3** Prevalence of peritonitis and proportion of deaths from individual studies

Year of publication	Country	Author and reference	Study population	Dialysis type	No. of patients	No. of peritonitis episodes	Peritonitis rate (episodes/patient-year)	Number of deaths	Proportion of deaths (%)
1984	South Africa	Parsoo <i>et al</i> <sup>18</sup>	Adult	CAPD	88	239	2.72	28	31.8
1989	Cameroon	Yumbissi <i>et al</i> <sup>15</sup>	Adult	CAPD	13	40	2.2	5	38.4
1993	South Africa	Naiker <i>et al</i> <sup>19</sup>	Adult	CAPD	278	–	2.72	109	39.2
1994	South Africa	Zent <i>et al</i> <sup>4</sup>	Adult	CAPD	132	–	2.7	23	17.5
2001	South Africa	Katz <i>et al</i> <sup>20</sup>	Adult	CAPD	84	34	0.43	7	8.3
2007	Sudan	Elhassan <i>et al</i> <sup>23</sup>	Paediatric+Adult	CAPD+APD	111	60	0.87	18	16.2
2007	Tunisia	Karoui <i>et al</i> <sup>24</sup>	Adult	APD	78	45	0.33	15	19.2
2007	South Africa	Naidoo <i>et al</i> <sup>21</sup>	Adult	CAPD	263	291	0.58	102	38.7
2010	Egypt	Mahmoud <i>et al</i> <sup>8</sup>	Adult	CAPD	33	65	0.56	4	12.5
2010	South Africa	Raaijmakers <i>et al</i> <sup>22</sup>	Paediatric	CAPD+NIPD	67	129	2.8	0	0
2011	Senegal	Cisse <i>et al</i> <sup>17</sup>	Adult	CAPD+APD	31	33	0.55	6	19.5
2012	Morocco	Bekaoui <i>et al</i> <sup>16</sup>	Adult	CAPD	36	76	0.65	0	0
2014	Senegal	Niang <i>et al</i> <sup>7</sup>	Adult	CAPD+APD	62	45	0.60	16	25.8
2014	South Africa	Isla <i>et al</i> <sup>5</sup>	Adult	CAPD	152	210	0.82	32	21.1
2016	Tunisia	Jellouli <i>et al</i> <sup>25</sup>	Paediatric	CAPD+APD	85	97	0.75	19	22.4
2018	South Africa	Davidson <i>et al</i> <sup>9</sup>	Adult	CAPD+APD	199	–	0.87	42	21.1
2019	Tunisia	Lasfar <i>et al</i> <sup>26</sup>	Adult	CAPD+APD	182	186	0.44	42	23.1

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NIPD, nightly intermittent peritoneal dialysis.

**Table 4** Organisms causing peritonitis from individual studies

Year of publication	Country	Author and reference	Dialysis type	Gram (+) organisms (%)	Gram (-) organisms (%)	Fungal (%)	Culture negative (%)	Others (%)
1984	South Africa	Parsoo <i>et al</i> <sup>18</sup>	CAPD	50.0	15.4	3.4	24.6	6.6
1989	Cameroon	Youmbissi <i>et al</i> <sup>15</sup>	CAPD	52.5	27.5	7.5	12.5	0
1993	South Africa	Naiker <i>et al</i> <sup>19</sup>	CAPD	–	–	–	–	–
1994	South Africa	Zent <i>et al</i> <sup>4</sup>	CAPD	–	–	–	–	–
2001	South Africa	Katz <i>et al</i> <sup>20</sup>	CAPD	85.3	11.8	0	0	2.9
2007	Sudan	Elhassan <i>et al</i> <sup>23</sup>	CAPD+APD	6.7	13.3	0	53.3	–
2007	Tunisia	Karoui <i>et al</i> <sup>24</sup>	APD	40.0	22.2	–	–	–
2007	South Africa	Naidoo <i>et al</i> <sup>21</sup>	CAPD	52.1	8.6	2.1	18.5	18.8
2010	Egypt	Mahmoud <i>et al</i> <sup>8</sup>	CAPD	24.0	8.0	6.0	49.0	–
2010	South Africa	Raaijmakers <i>et al</i> <sup>22</sup>	CAPD+NIPD	30.2	23.3	0.8	28.7	10.1
2011	Senegal	Cisse <i>et al</i> <sup>17</sup>	CAPD+APD	33.0	21.0	3.0	43.0	0
2012	Morocco	Bekaoui <i>et al</i> <sup>16</sup>	CAPD	56.6	37.7	–	26.3	–
2014	Senegal	Niang <i>et al</i> <sup>7</sup>	CAPD+APD	20.0	22.0	7.0	51.0	0
2014	South Africa	Isla <i>et al</i> <sup>5</sup>	CAPD	19.6	14.7	1.5	62.3	2.9
2016	Tunisia	Jellouli <i>et al</i> <sup>25</sup>	CAPD+APD	34.0	23.7	1.0	41.3	0
2018	South Africa	Davidson <i>et al</i> <sup>9</sup>	CAPD+APD	47.5	4.0	5.0	19.5	0
2019	Tunisia	Lasfar <i>et al</i> <sup>26</sup>	CAPD+APD	–	–	–	–	–

– Unreported data.

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NIPD, nightly intermittent peritoneal dialysis.

rate over the study period. A number of other factors such as increasing age, presence of comorbidities such as diabetes and underlying cardiovascular disease, early pre-dialysis care and use of icodextrin have been shown to influence mortality in patients treated with PD.<sup>6 31–33</sup> One study from a predominantly rural population in South Africa showed a near fivefold increase in all-cause mortality in diabetic patients treated with PD than non-diabetic patients treated with HD in the same centre.<sup>6</sup> However, we think that the high proportion of deaths and low technique and patient survival may be related to high peritonitis rates as in many centres, the selection process for KRT usually excludes those with comorbidities.<sup>3 9</sup> Although icodextrin use has been reported to be associated with reduction in mortality,<sup>32</sup> there is limited availability of icodextrin for PD in Africa given the overall shortage of all PD fluids<sup>3</sup> and very limited use of icodextrin was reported in only 3 of the 17 studies.<sup>7 9 26</sup> Although cost is a major reason for the limited use of icodextrin, there still needs to be significant financial support to make locally produced PD fluids available as these have shown comparable efficacies with commercially produced fluids in patients with AKI treated with PD in Africa.<sup>34 35</sup>

The outcome of children with ESKD in Africa is similar to those in adults given that the same prevalent sociodemographic factors are also applicable.<sup>36</sup> Children with ESKD treated with PD may face several added challenges such as schooling, logistics of accessing treatment, underlying developmental problems, emotional and psychological

issues.<sup>37</sup> The peritonitis rates seen in children in our study were much higher than for adults and this could be the reason for the higher modality switch to HD in children than in adults. However, the proportion of deaths in children was not as high as in adults. The reason for this could be the higher proportion of children than adults who received a kidney transplant during the study period (39.6% (19.8–59.3) and 6.8% (0.0–10.6)), respectively.

Our study findings show that more still needs to be done to reduce the peritonitis rates from centres across the African continent. Improved patient and care provider education, increased implementation of ISPD guidelines regarding catheter insertion, collection of specimens for microbiology and appropriate use of antibiotics need to be strictly adhered to. Skills gained from the saving young lives programme,<sup>34</sup> a partnership of four organisations: International Society of Nephrology, International Paediatric Nephrology Association (IPNA), ISPD and the Sustainable Kidney Care Foundation on acute PD in Africa, can be leveraged and transferred to chronic PD. These efforts may improve PD outcomes in the continent and increase utilisation of PD as a KRT modality in Africa. However, strong support from various national and regional governments is needed to sustain these efforts.

One of the reasons for a higher prevalence of peritonitis in paediatric age groups may be due to the lack of paediatric nephrologists in several African countries, as children with kidney disease are often treated by general paediatricians, nephrologists who treat adults or nurses.<sup>38</sup>



**Table 5** Modality switch, technique survival and patient survival from individual studies

Year of publication	Country	Author and reference	Dialysis type	Modality switch (%)	Transplanted (%)	Recovered renal function (%)	1-Year technique survival (%)	2-Year technique survival (%)	1-Year patient survival (%)	2-Year patient survival (%)
1984	South Africa	Parsoo <i>et al</i> <sup>18</sup>	CAPD	18.2	6.8	0	67	53	73	66
1989	Cameroon	Youbissi <i>et al</i> <sup>15</sup>	CAPD	15.4	–	0	–	–	–	–
1993	South Africa	Naiker <i>et al</i> <sup>19</sup>	CAPD	21.5	7.5	0	–	50	–	80
1994	South Africa	Zent <i>et al</i> <sup>4</sup>	CAPD	24.2	26.5	3.0	–	–	–	–
2001	South Africa	Katz <i>et al</i> <sup>20</sup>	CAPD	16.7	7.1	9.5	–	–	–	–
2007	Sudan	Elhassan <i>et al</i> <sup>23</sup>	CAPD+APD	18.0	4.5	0.9	–	–	–	–
2007	Tunisia	Karoui <i>et al</i> <sup>24</sup>	APD	28.2	1.3	0	94.3	76.8*	93.3	76.8*
2007	South Africa	Naidoo <i>et al</i> <sup>21</sup>	CAPD	14.0	10.6	1.5	–	–	–	–
2010	Egypt	Mahmoud <i>et al</i> <sup>8</sup>	CAPD	13	15.1	0	91.9	–	94.4	–
2010	South Africa	Raaijmakers <i>et al</i> <sup>22</sup>	CAPD+NIPD	16.4	79.1	0	83.6	–	100	100
2011	Senegal	Cisse <i>et al</i> <sup>17</sup>	CAPD+APD	26.0	0	0	62.0	45	63.0	42.0
2012	Morocco	Bekaoui <i>et al</i> <sup>16</sup>	CAPD	7.9	–	0	–	–	–	–
2014	Senegal	Niang <i>et al</i> <sup>7</sup>	CAPD+APD	19.3	0	0	–	–	–	–
2014	South Africa	Isla <i>et al</i> <sup>5</sup>	CAPD	25.7	0	3.9	83.3	71.7	86.7	78.7
2016	Tunisia	Jellouli <i>et al</i> <sup>25</sup>	CAPD+APD	66.0	–	0	40.0	32.0	–	–
2018	South Africa	Davidson <i>et al</i> <sup>9</sup>	CAPD+APD	26.6	–	–	85.0	75.2	91.3	79.6
2019	Tunisia	Lastar <i>et al</i> <sup>26</sup>	CAPD+APD	30.7	12.0	0.6	96.7	90.0	96.1	93.2

–Unavailable/not reported data.

\*3-Year survival.

APD, automated peritoneal dialysis; CAPD, continuous ambulatory peritoneal dialysis; NIPD, nightly intermittent peritoneal dialysis.



One survey conducted by the IPNA showed that 100% of respondents from Africa reported mild to severe shortages (72% reported severe shortages) of paediatric nephrologists compared with 42% of respondents in Europe and 72% of respondents in Asia.<sup>39</sup> Although the implications of such shortages on peritonitis rates in children have not been studied, it is possible that there is an association. Strategies to improve paediatric nephrology workforce in the continent should be further addressed.

Our study has some limitations. Most of the studies included had either a low or medium methodological quality. Some reasons for this include the low sample size and poor characterisation of sociodemographic features of patients included in the studies. Also, important clinical characteristics and outcomes were not reported appropriately and similarly across studies. For instance, although all studies reported peritonitis rate, not all provided the number of peritonitis episodes or the duration of treatment with PD. Furthermore, even though the proportion of deaths were reported, causes of death were not always provided to enable us to assess the relationship between infectious peritonitis and reported proportions of death. The Standardised Outcome in Nephrology Peritoneal Dialysis group recently recommended that inclusion of PD-related infection, cardiovascular disease, mortality, technique survival and life participation as the core outcome domains for PD.<sup>40</sup> Finally, although we had intended to carry out a meta-analysis of our data, the heterogeneity across studies precluded it. Despite these limitations, our study has been able to show that peritonitis rates in PD, although still high, has been declining and reported on other important outcomes in patients treated with PD in Africa.

## CONCLUSION

Our study shows high peritonitis rate, high proportion of mortality and low 1–2 year technique and patient survival in PD studies conducted in Africa over the past four decades. Although the peritonitis rates have been on a decline since the 1980s, they remain inappropriately higher than reports from other regions and what guidelines recommend. This suggests a need to sustain and improve ongoing efforts such as patient and staff education, improved selection of patients to PD, increase access to APD in selected patients, adherence to guidelines for sampling and treatment of peritonitis in order to mitigate factors associated with poor outcomes in patients with ESKD treated with chronic PD in Africa.

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