Global Trends in Rates of Peritoneal Dialysis

Arsh K. Jain,*† Peter Blake,* Peter Cordy,* and Amit X. Garg*†

*Division of Nephrology and †Department of Epidemiology and Biostatistics, University of Western Ontario, London, Canada

ABSTRACT

Although there is a perception that the use of peritoneal dialysis is declining worldwide, compilations of global data are unavailable to test this hypothesis. We assessed longitudinal trends in the use of peritoneal dialysis from 1997 to 2008 in 130 countries. The preferred data sources were renal registries, followed by nephrology societies, health ministries, academic centers, national experts, and industry affiliates. In 2008, there were approximately 196,000 peritoneal dialysis patients worldwide, representing 11% of the dialysis population. In total, 59% were treated in developing countries and 41% in developed countries. Over 12 years, the number of peritoneal dialysis patients increased in developing countries by 24.9 patients per million population and in developed countries by 21.8 per million population. The proportion of all dialysis patients treated with peritoneal dialysis did not change in developing countries but significantly declined in developed countries by 5.3%. The use of automated peritoneal dialysis increased by 14.5% in developing countries and by 30.3% in developed countries. In summary, the number of patients treated with peritoneal dialysis rose worldwide from 1997 to 2008, with a 2.5-fold increase in the prevalence of peritoneal dialysis patients in developing countries. The proportion of all dialysis patients treated with this modality continues to decline in developed countries.


Chronic dialysis is a life-sustaining treatment for patients with ESRD. Access to dialysis remains limited in several regions of the world due to a lack of financial and clinical resources.1–9 As countries look to develop dialysis programs to manage the growing burden of ESRD, it is important to place patterns of peritoneal dialysis (PD) use in the global context. This information is particularly helpful to individuals in member nations responsible for health care delivery to evaluate their PD programs through comparisons with countries of similar socioeconomic structure.

A comprehensive global assessment of PD use to date has been lacking. One study suggested that 11% of chronic dialysis patients around the world are treated with PD.10 Several renal registries report PD use at a national and regional level,11–14 but not on a global scale. There is a perception that PD use is declining worldwide. However, studies that showed declining PD use in the developed world are limited by the number of countries considered and the length of time examined.3,15–17 No study has examined the global use of different PD modalities over a significant period of time, including continuous ambulatory PD (CAPD) and automated PD (APD). For these reasons, we assessed PD use worldwide by compiling data from multiple sources over a 12-year period. We examined the trends in PD use across developing and developed nations, focusing on crude numbers, prevalence per million population, and the proportion of dialysis patients who received PD. We hypothesized an increasing PD prevalence in the developing world and a decreasing prevalence in the developed world.
Figure 1. Current number of peritoneal dialysis patients. Crude number of prevalent patients treated with peritoneal dialysis in (A) developing countries and (B) developed countries.
RESULTS

We obtained data from 113 of the 122 countries (93%) in which dialysis is provided, per Grassmann et al.18 Seventeen additional countries reported PD use resulting in a total of 130 countries in our analysis. Our primary sources of data were renal registries (n=68), nephrology societies (n=39), academic centers (n=10), national representatives (n=6), Ministry of Health departments (n=5), industry affiliates (n=1), and other (n=1) (Supplemental Table 1). We collected data from 1997 to 2008, with 73 countries (56%) reporting most recent data to 2008 (most recent data available from remaining countries included 44 countries for 2007, 11 countries for 2006, and 2 countries for 2004 and 2005) (Supplemental Table 2).

According to most recent data, 195,555 patients were treated with PD across the 130 countries. Fifty-eight percent of PD patients were treated in developing countries (n=114,221), and the remaining 42% in developed countries (n=81,334). Using a weighted average by world regions to impute missing data, we estimate that approximately 197,000 patients are treated with PD worldwide, with 59% of patients receiving treatment in developing countries and 41% in developed countries. In comparison, approximately 1,550,000 patients were treated with hemodialysis (HD) across the 130 countries, with 38% receiving treatment in developing countries and 62% in developed countries (Supplemental Figure 1). Overall, the proportion of all dialysis patients treated with PD worldwide was 11%.

We noted substantial variation in PD use across countries. Mexico (n=41,089), the United States (n=26,517), and China (n=16,000) reported the absolute largest number of patients receiving PD (Figure 1; median 158 PD patients per country; interquartile range [IQR], 14–952). In contrast, PD was not offered as a treatment modality in 24 countries in recent years. Hong Kong had the highest prevalence of PD (489 pmp), followed by Mexico (378 pmp) and El Salvador (324 pmp) (Figure 2; median 23.8 pmp; IQR, 1.6–65.3 pmp). The proportion of dialysis patients treated with PD varied around the world, ranging from 79% in Hong Kong to 0.02% in Egypt (Figure 3; median 8.2% of dialysis patients per country treated with PD; IQR, 2.3%–16.3%). PD was used by a majority of dialysis patients in four countries: Hong Kong, El Salvador, Mexico, and Guatemala.

We obtained sufficient data from 67 developing countries and 30 developed countries to examine trends in the proportion of dialysis patients treated with PD from 1997 to 2008 (Figure 4). There were significant differences between developing and developed countries (P<0.001). Over the study period, there was a nonsignificant decrease in the proportion of dialysis patients treated with PD in developing countries (from 13.8% to 12.4%, absolute change −1.35% [95%
Figure 2. Current peritoneal dialysis prevalence. Peritoneal dialysis prevalence per million population in (A) developing countries and (B) developed countries.
In developed countries, there was a significant decline in the proportion of dialysis patients treated with PD (from 20.6% to 15.3%, absolute change 5.3%; [95% CI, −6.7%, −3.8%]). We analyzed trends in the prevalence of PD per million population over the study period using data from 70 developing countries and 30 developed countries (Supplemental Figure 5). The crude total number of patients receiving PD increased over time (Supplemental Material). The prevalence of PD grew in both developing and developed countries, with no significant difference between the two groups of countries (developing countries: from 10.0 pmp to 34.9 pmp, increasing 24.9 pmp; [95% CI, 19.2 pmp, 30.6 pmp]); developed countries: from 69.7 pmp to 91.5 pmp, increasing 21.8 pmp; [95% CI, 16.0, 27.6 pmp]; \(P=0.45\) for comparison of groups of countries).

Trends in HD prevalence per million population over time were examined using data reported from 51 developing countries and 30 developed countries (Supplemental Figure 2). As with PD, the crude number of patients receiving HD increased over time (Supplemental Material). HD prevalence increased in both developing and developed countries, with a greater increase in developed countries (developing countries: from 128.5 pmp to 309.2 pmp, increasing 180.7 pmp [95% CI, 158.9 pmp, 202.5 pmp]; developed countries: from 347.8 pmp to 605.8 pmp, increasing 258.0 pmp [95% CI 237.4 pmp, 278.6 pmp]; \(P<0.0001\) for comparison of groups of countries).

We noted substantial variation in the type of PD used across countries. The proportion of PD patients treated with APD is significantly lower in developing countries compared with developed countries (Figure 6) (APD use in developing countries: 15.8% [95% CI, 9.0%, 22.6%]; APD use in developed countries: 42.4% [95% CI, 34.4%, 50.5%]; difference between two groups of countries, \(P<0.00001\)). We obtained sufficient data from 23 developing countries and 24 developed countries to examine trends in APD use over time (Supplemental Figure 3). The proportion of PD patients treated with APD increased worldwide, with a greater increase in developed countries compared with developing countries (APD use in developing countries increased from 0.1% to 14.6%, increase of 14.5% [95% CI, 10.6%, 18.5%]; APD use in developed countries increased from 16.9% to 47.2%, increase of 30.3% [95% CI 26.8%, 33.7%]; difference between the two groups of countries, \(P<0.001\)).

**DISCUSSION**

PD is currently used as a chronic life-sustaining treatment by approximately 197,000 ESRD patients, or 11% of the global dialysis population. The number of patients per million population treated with PD in both developing and developed countries has increased over the last decade, although the

<table>
<thead>
<tr>
<th>Developing Countries</th>
<th>PD Prevalence (pmp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>216.0</td>
</tr>
<tr>
<td>Taiwan</td>
<td>182.6</td>
</tr>
<tr>
<td>New Zealand</td>
<td>162.5</td>
</tr>
<tr>
<td>South Korea</td>
<td>158.3</td>
</tr>
<tr>
<td>Singapore</td>
<td>120.1</td>
</tr>
<tr>
<td>Canada</td>
<td>108.1</td>
</tr>
<tr>
<td>Denmark</td>
<td>105.0</td>
</tr>
<tr>
<td>Australia</td>
<td>92.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>87.1</td>
</tr>
<tr>
<td>USA</td>
<td>78.3</td>
</tr>
<tr>
<td>Italy</td>
<td>74.8</td>
</tr>
<tr>
<td>UK</td>
<td>73.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>71.9</td>
</tr>
<tr>
<td>Japan</td>
<td>69.6</td>
</tr>
<tr>
<td>Finland</td>
<td>68.0</td>
</tr>
<tr>
<td>Greece</td>
<td>65.9</td>
</tr>
<tr>
<td>Belgium (D)</td>
<td>53.7</td>
</tr>
<tr>
<td>Belgium (F)</td>
<td>51.7</td>
</tr>
<tr>
<td>Slovenia</td>
<td>49.4</td>
</tr>
<tr>
<td>Spain</td>
<td>48.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>44.3</td>
</tr>
<tr>
<td>Ireland</td>
<td>44.1</td>
</tr>
<tr>
<td>Iceland</td>
<td>43.5</td>
</tr>
<tr>
<td>Israel</td>
<td>43.3</td>
</tr>
<tr>
<td>Austria</td>
<td>43.0</td>
</tr>
<tr>
<td>France</td>
<td>39.6</td>
</tr>
<tr>
<td>Norway</td>
<td>38.8</td>
</tr>
<tr>
<td>Germany</td>
<td>35.6</td>
</tr>
<tr>
<td>Switzerland</td>
<td>4.7</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*Figure 2. Continued.*
**Figure 3.** Current proportion of total dialysis that is peritoneal dialysis. Proportion (%) of chronic dialysis patients treated with peritoneal dialysis in (A) developing countries and (B) developed countries.
Figure 3. Continued.
proportion of dialysis patients treated with PD is declining in developed countries.

Variability in the practice and rate of PD across countries provides insight into the ways to manage the growing demand for dialysis services. Countries with successful PD programs demonstrate the feasibility of developing and maintaining sizable PD populations and can serve as models for other countries. With knowledge of global rates, health policy makers can examine the use of PD within their countries and put them in context with other countries of similar socioeconomic structure.

We found that 59% of PD patients were from developing countries, a set of countries that are estimated to account for 80% of the world’s population. PD use is increasing dramatically in developing countries, with a 2.50-times increase in PD prevalence over 12 years. Growth in PD prevalence coincides with the growth of HD prevalence in developing countries. As a result of the similar growth pattern of these two modalities, there was no significant change in the proportion of dialysis patients using PD in the developing countries.

PD may have certain advantages over HD in the developing world, including simplicity of therapy, reduced need for trained medical staff, and minimal requirement for technical support and electricity. Patients living in remote and rural locations could use PD as a home-based treatment option. PD is sometimes thought to be more expensive than HD in the developing world because staffing costs for HD are low and the costs to import PD supplies are high. However, the economics of dialysis vary between countries, and a paucity of well conducted studies makes it difficult to determine if this perception is reality. Several avenues to circumvent financial barriers have been suggested and include increasing local production of PD solutions and promoting international trade agreements to help importing countries avoid expensive tariffs and transportation costs.

Whereas PD prevalence increased in developed countries, the proportion of all dialysis patients using PD declined. This decline in PD use has been noted by others and may be explained by a few factors. Several economic influences, including health care financing and delivery, physician

Figure 4. Trends in peritoneal dialysis as a proportion of total dialysis. Trends in the proportion (%) of dialysis patients treated with peritoneal dialysis from 1997 to 2008 in (A) developing countries and (B) developed countries.
reimbursement, and resource availability, have been suggested to affect trends in use.\(^3\) For example, countries with private dialysis providers generally use PD for a smaller proportion of dialysis patients than countries in which public providers dominate.\(^{23-27}\) The proliferation of HD units in some countries has increased the availability of HD, creating an incentive to use that capacity rather than home dialysis modalities.\(^{23,28}\) Some have raised concerns that nephrology training programs are deficient in PD and do not adequately prepare young nephrologists to provide care for PD patients.\(^{29,30}\) Declining use seems unexpected because PD has been reported to be less expensive than HD in many developed countries.\(^{7-9}\)

APD use is on the rise in both developing and developed countries. The data presented here suggest that APD expansion is also possible in the developing world where the potential for growth was previously thought to be limited.\(^{31}\) Some researchers have suggested that this indicates that individuals in developing countries are willing to invest in more expensive technology that is considered to be more advanced.\(^{17,32}\) The increasing use serves as a call to action to conduct trials to address the paucity of data demonstrating the benefits of this increasingly popular modality.

**Strengths and Limitations**

Our study has several strengths. We took a comprehensive approach and compiled data from 130 countries over a 12-year period. This extends the work of previous studies that considered between 9 and 42 countries for a period of time of 1–5 years.\(^{11-13,15,33,34}\) We reviewed all data on two occasions for accuracy, and we sent preliminary data tables and graphs to country representatives to verify data and for final confirmation. When necessary, we translated all information into English. Some of the data we compiled for this report are not easily accessible elsewhere.

The limitations of our approach merit consideration. Similarly to all studies that draw from multiple databases and nonvalidated data sources, the accuracy of the results is largely dependent on the quality of captured data. Because many countries struggle to establish and maintain reputable renal registries, data were not always complete or representative; thus, inaccurate reporting may be an issue for some countries.\(^4\)

---

**Figure 5.** Trends in peritoneal dialysis prevalence. Trends in the prevalence of peritoneal dialysis per million population from 1997 to 2008 in (A) developing countries and (B) developed countries.
For example, some national registries, including France, Italy, Spain, and Mexico, cover select regions rather than the entire country. Some populous countries, including India and China, were not maintaining national registries at the time of this study. Rather, national representatives, tertiary care centers, and industry reports provided the data we used to represent these countries. In some cases, data reported by different sources were discrepant. Although we present the best data available, it remains difficult to determine which source most accurately represents dialysis use within a country. Previous studies evaluating global dialysis trends have been limited to countries that report validated data. Because this was not a criterion for inclusion in our study, we were able to present trends for a larger pool of developing and developed countries. To minimize information biases, we reconciled the accuracy of data using multiple sources whenever possible.

As the prevalence of ESRD increases worldwide, it is important to evaluate the role of PD as a treatment option. Using data from multiple international sources, we found that the number of patients per million population treated with PD in both the developing and developed worlds has increased, although developed countries seemed to be turning to PD less often. Future research will help to better understand global dialysis practices and characterize barriers to PD in developing and developed nations. Communication and collaboration between countries will allow PD use to be evaluated in an international context, improving the efficiency of global dialysis practices for current and future patients who suffer from ESRD.

CONCISE METHODS

Data of Interest
We used a list of 122 countries estimated to account for 99% of the global ESRD population as a reference for data collection. The methodology of our approach is described elsewhere. For each country, we attempted to contact a representative from a national renal or dialysis registry. When available, we collected the following data on an annual basis from 1997 to 2008:

![Figure 6. CAPD versus APD use. The types of peritoneal dialysis used in (A) developing countries and (B) developed countries.](https://www.jasn.org)
(1) the crude number of prevalent chronic PD patients, (2) the crude number of prevalent chronic HD patients (including home HD), and (3) a categorization of all PD use in which patients were subdivided into CAPD, APD, and other PD (other PD included intermittent peritoneal dialysis [IPD]). Data were the sum of the chronic dialysis population including pediatric patients. We cited the most recent registry report from which data were captured. We translated data obtained in seven different languages into English. When multiple sources supplied the desired data, we reviewed all options and selected the most complete dataset. For countries with no registry available, we collected data (in order of preference) from national nephrology societies, ministries of health, academic centers, national experts, and/or industry affiliates. Our approach to data from Mexico deserves mention. Unlike a previous report that used data from the state of Jalisco (in Mexico) to represent the entire country,12 we determined national-level statistics. We did this by reconciling data from the state registry with national-level data available from the Latin American Dialysis and Transplant Registry.11,38 We found PD prevalence rates and percentage of PD use to be very similar; thus, we were able to extrapolate national-level statistics.

Data Abstraction
We completed the data collection from May 2008 to September 2010. In some cases, contacts within renal or dialysis organizations were provided with blank data tables that they completed. We reviewed all data for accuracy on two occasions. In addition, we sent preliminary data tables and graphs to country representatives to verify data and for final confirmation.

Statistical Analyses
We classified countries as developing or developed according to International Monetary Fund guidelines.19 Nonmember nations of the International Monetary Fund were classified based on information available through the Central Intelligence Agency.39 We calculated annual PD and HD prevalence rates, measured in patients per million population, by dividing the crude number of patients by total midyear census population estimates from the US Census Bureau International Database.20 We calculated the proportion of all dialysis patients (HD and PD) treated with PD. To present a worldwide estimate of PD use, we used a simple weighted average by region (as defined by the World Health Organization)40 to impute the crude number of prevalent PD patients for countries reported to use PD but for which data were not available. We used the most recent data available (typically 2007 or 2008 data) for each country to generate current estimates of PD use.

We examined temporal trends of PD and HD use from 1997 to 2008 for countries that provided a minimum of 3 years of data. We used random intercept linear regression models to control for the within-country correlation and used an unstructured correlation matrix for all models. We calculated the 95% CIs for the best-fit lines using parameter estimates and the estimated covariance structure from each of the fitted models. We performed sensitivity analyses on countries that reported at least 4 or 5 years of data between 1997 and 2008 and the results were qualitatively similar. To compare the use of APD in the developing and developed worlds, we used an independent samples two-tailed t test and analyzed for a significance level of P<0.05. We performed statistical analyses with SAS software (version 9.2; SAS Institute, Cary, NC) and generated plots in R (version 2.10.1) and Excel 2007 software (Microsoft, Redmond, WA).

ACKNOWLEDGMENTS
We thank the representatives from 64 countries who provided or reviewed data for accuracy, Valerie Bloomfield for her dedication to this project, Heather ThiessenPhilbrook for providing statistical support, and Ms. Lucy Horvat for her help.

Grant support was provided by the Lawson Health Research Institute. A.J. was supported by a fellowship award, and A.X.G. was supported by a clinician scientist award, both from the Canadian Institutes of Health Research.

The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as official policy or interpretation of those programs or organizations cited within.

DISCLOSURES
A.J. and P.B. have received grant support and honoraria from Baxter Inc.

REFERENCES
10. Fresenius Medical Care: Fresenius Medical Care Annual Report 2008—Dialysis Market, Bad Homburg, Germany, Fresenius Medical Care, 2008
13. ERA-EDTA Registry: ERA-EDTA Registry 2008 Annual Report, Amsterdam, The Netherlands, Academic Medical Center, Department of Medical Informatics, 2010
35. ERA-EDTA Registry: ERA-EDTA Registry 2006 Annual Report, Amsterdam, The Netherlands, Academic Medical Center, Department of Medical Informatics, 2008

This article contains supplemental material online at http://jasn.asnjournals.org/lookup/suppl/doi:10.1681/ASN.2011060607/-/DCSupplemental.