Gaining Efficiencies: Resources and Demand for Dialysis around the Globe

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ABSTRACT

Objectives: End-stage renal disease (ESRD) is a debilitating condition resulting in death unless treated. Treatment options are transplantation and dialysis. Alternative dialysis modalities are peritoneal dialysis (PD) and hemodialysis (HD), each of which has been shown to produce similar outcomes and survival. Nevertheless, the financial implications of each modality are different and these differences vary by country, especially in the developing world. Changes in clinically appropriate dialysis delivery leading to more efficient use of resources would increase the resources available to treat ESRD or other disabling conditions. This article outlines the relative advantages of HD and PD and uses budget impact analysis to estimate the country-specific, 5-year financial implications on total dialysis costs assuming utilization shifts from HD to PD in two high-income (UK, Singapore), three upper-middle-income (Mexico, Chile, Romania), and three lower-middle-income (Thailand, China, Colombia) countries.

Results: Peritoneal dialysis is a clinically effective dialysis option that can be significantly cost-saving compared to HD, even in developing countries.

Conclusions: The magnitude of costs associated with treating ESRD patients globally is large and growing. PD is a clinically effective dialysis option that can be used by a majority of ESRD patients and can also be significantly cost-saving compared to HD therapy. Increasing clinically appropriate PD use would substantially reduce health-care costs and help health-care systems meet ever-tightening budget constraints.

Keywords: chronic kidney disease, dialysis, economics, end-stage renal disease, hemodialysis, modality selection, peritoneal dialysis.

Introduction

The global incidence of chronic kidney disease (CKD) continues to rise. At the end of 1990 there were approximately 426,000 maintenance dialysis patients worldwide [1]. By the end of 2004 this number had climbed to nearly 1.4 million [2]. There are five stages of CKD, each representing worsening degrees of kidney failure. The fifth and final stage is a debilitating complete, or near complete failure of kidney function. Treatment options for patients with CKD stage 5, also called end-stage renal disease (ESRD), are transplant and dialysis. In the absence of kidney transplantation and without dialysis these patients would die of uremia, many within a matter of weeks. Kidney transplantation is generally recognized as the most clinically effective and cost-efficient treatment [3]. Nevertheless, not all patients are medically suitable for transplantation and the demand for kidneys far exceeds the supply, often rendering this option unavailable. In light of this, dialysis remains the most commonly employed treatment option for patients with ESRD. At the end of 2004, only about 23% of ESRD patients worldwide were living with a functioning kidney transplant and the remaining 77% were on dialysis [2].

The 2004 global average prevalence for ESRD patients on dialysis was 280 patients per million population, although there were significant regional variations. Prevalence was higher in Japan (380 per million), the Middle East (190 per million), Africa (70 per million) or Asia (70 per million, excluding Japan) [2]. By the year 2010 it is predicted that the global maintenance dialysis population will approach or exceed two million [1,2]. The costs of dialysis services to support this population are expected to amount to $1.1 trillion for the decade 2001 to 2010 [1]. In the USA alone, Medicare costs for dialysis in 2004 were $16.3 billion [4].

Clearly, both the burden of illness and the resources needed for treatment of patients on dialysis have been escalating despite increasing pressures on health-care budgets. This, along with worldwide increases in the prevalence of diabetes, hypertension, and obesity, speaks to high—and growing—demand for dialysis treatment on every health-care system in the world. The purpose of this article is to outline the potential benefits of changing the relative use of HD and PD and to consider the extent to which the mix of dialysis modalities employed to serve ESRD patients might reduce the financial burden of caring for this expanding population and maximize the level of dialysis services that a fixed health-care budget is able to support.

Current Dialysis Options

Alternative dialysis modalities are hemodialysis (HD) and peritoneal dialysis (PD). HD may, in some cases, be performed at home, but is most commonly performed in a dialysis center three times per week, requiring the patient to travel to treatments lasting on average 3 to 5 hours. In contrast, PD is usually performed daily at home, and provides considerable flexibility for work and travel. Primary types of PD include continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD).
Comparative Outcomes of Dialysis

Although many factors influence the selection of one dialysis modality over another [5–9], absolute medical contraindications for the use of either modality are few [10]. The effect of dialysis modality on survival is a controversy that has been debated in the literature for well over a decade [11–21]. Nevertheless, several careful reviews of the literature have unveiled some common themes, among them that utilization of PD as the initial dialysis modality seems to offer a survival advantage compared to HD early in therapy [12–18,20]. Eventually, though, the advantage for PD levels off and mortality rates become roughly equivalent with HD for several years. In the USA, 5-year survival for incident PD patients may have begun to exceed that for incident HD patients as of the year 2000 [22,23].

The overall incidence of infection among PD patients is no greater than among HD patients and studies have shown the incidence of serious bloodstream infections to be lower in PD than in HD, at least in some parts of the world [24–28]. In the USA, the hospital admission rate because of dialysis-related infections is lower in PD than in HD [29]. Finally, the clinical and economic benefits of preserving RRF are well documented [30–37] and there is evidence that PD is associated with significant preservation of RRF compared to HD [32–34,38]. This may explain in part the early survival advantage observed for patients on PD.

Factors Influencing Modality Selection

A limited number of medical conditions constitute specific indications to select one dialysis modality over the other as the initial treatment modality [39]. Absolute medical contraindications for the use of PD in the USA include documented loss of peritoneal function or extensive abdominal adhesions that limit dialysate flow, and uncorrectable mechanical defects that prevent effective PD or increase the risk of infection, such as a surgically irreparable hernia or bladder exstrophy. Conversely, PD may be preferred in patients who cannot tolerate HD for medical reasons, such as congestive heart failure, ischemic heart disease, extensive vascular disease or problematic vascular access.

In practice, a number of nonmedical factors may also influence dialysis modality selection. Among these, financial and reimbursement issues have been identified as the most important in any given country [8,9,40]. A recent review of the literature in North America concluded that overall health-care costs for patients receiving HD are between 22% and 52% higher than the corresponding costs for patients receiving PD [41]. In general, studies in Western Europe are in agreement with the North American findings; a review of Western European literature found that in-center HD ranged from about twice the cost of PD in France to 30% more expensive than PD in Italy and the UK [41]. In Eastern Europe, PD costs have been shown to be similar or lower than HD costs [42,43]. In developing countries PD is often perceived to be more expensive than HD because of relatively low costs of labor and space and relatively high costs of imported supplies [41,44]. Nevertheless, although few economic evaluations of dialysis are available from developing countries, recently reported data from China, Mexico, and Chile suggest that PD is, in actuality, less expensive compared to HD [44–49].

Physician preferences can also influence modality selection. Recent studies conducted in Canada, the USA and the UK—countries with health systems very different from one another—report that practicing nephrologists estimate the optimal mix of HD to PD at about 65:35 (or 60:40, according to nephrologists in the UK), where “optimal” is defined as maximizing clinical outcomes [5,50,51]. Despite this, physicians and nurses in some nations, including developed ones, may not have had adequate training in the PD and thus may be more comfortable recommending HD [7,9].

Most studies suggest that PD offers similar quality of life compared to HD [6,52–58] and that PD is associated with equal or better treatment satisfaction compared to HD [59,60]. Several studies have shown patients who are objectively educated about dialysis modality options and given free choice more often choose PD or other self-care dialysis than do uneducated patients [61–66]. Social/cultural issues may influence utilization of dialysis modalities as well. In Germany and Hong Kong, for instance, many patients prefer in-center dialysis because of small living spaces and the desire to not involve other family members [8]. Increased distance from a dialysis center has been associated with increased use of PD in Canada, Latin America and the UK [8,64]. Culturally, most Japanese patients prefer to receive health care at clinics or hospitals rather than at home (which drives utilization of HD), but in Hong Kong, many patients are averse to needle puncture (which drives utilization of PD) [8].

Underutilization of PD in Many Countries

Despite its clinical and economic advantages, nephrologists’ opinions that 35% to 40% use of PD would produce optimal clinical outcomes and, in some cases, patient/social preference for PD, the modality remains underutilized in many countries around the world. The highest utilization of PD is in Mexico, where an estimated 70% of prevalent dialysis patients were treated with PD in 2004. New Zealand has the next highest PD utilization rate at 43% [67]. Utilization of PD in most other countries is well below these levels: worldwide at the end of 2004 an estimated 89% of dialysis patients were treated with HD and only 11% were treated with PD [2].

Increasingly across the globe, financial concerns and the availability of key clinical resources influence the delivery of all aspects of medical care, including dialysis treatment for ESRD. Growing financial pressures obligate governments and other decision-makers to grapple with how best to allocate health-care resources for everyone in their charge, while at the same time balancing the competing objectives of clinical need and cost containment [68]. Slowing the progression of CKD to ESRD is one strategy to save lives and reduce the cost of treatment for dialysis. A complementary approach is to maximize the cost-efficiency of renal replacement therapy wherever possible.

Wherever the systems cost of providing PD is lower than HD, an increased use of PD would provide an opportunity to lower overall ESRD treatment costs. We conducted an analysis to explore the extent to which increased use of PD would lower overall ESRD treatment costs in eight countries across the globe and, in turn, maximize the level of dialysis services that a fixed health-care budget is able to support.

Methods

We used budget impact analysis to estimate how changes in the mix of dialysis modalities would impact the trajectory of total spending for dialysis services in eight countries. Budget impact analyses are commonly used to estimate the financial stream of consequences related to the uptake and diffusion of health technologies to assess their affordability [69]. Increasingly, budget impact analyses are sought out by those who manage and plan health-care budgets, such as administrators of national or regional health-care programs or private insurance plans.
A Microsoft Excel-based model was developed to assess the cumulative budget impact (payer’s perspective) of a shift in the dialysis treatment modality mix. The model begins with point-prevalent patient years at risk (acknowledging that the average point-prevalent patient may receive fewer than 12 months of dialysis treatment per year) in the baseline year and performs a simple arithmetic forecast of current and future spending for patients on dialysis up to a maximum of 5 years from baseline, assuming that the mix of dialysis modality use shifts toward greater use of PD over time. We used the model to estimate impacts for two high-income (UK, Singapore), three upper-middle-income (Mexico, Chile, Romania), and three lower-middle-income countries (Thailand, China, Colombia) as defined by the World Bank. According to World Bank definitions, lower-middle and upper-middle-income countries are all considered to be developing countries.

Primary model inputs were derived from a variety of sources as indicated in Tables 1 and 2. Cost data, in particular, were drawn from published research conducted over different time periods and using very different methodologies; as such, direct comparisons of results between countries in this analysis are inappropriate. Instead, the model estimates the potential magnitude of country-specific savings assuming shifts toward greater PD use in eight separate nations.

For the UK, total costs of dialysis, including drugs and transportation, were obtained from a study of dialysis costs in the Cardiff and Vale National Health Services Trust and six other UK hospitals [70]. Using semi-structured interviews with nephrologists, head nurses, and business managers, these researchers identified the steps involved in delivering each modality and estimated the costs associated with each step using published figures or suppliers’ published price lists. For Singapore, cost data represent average charges for outpatient HD and PD, estimated the costs associated with any hospitalization event for patients on PD and HD.

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For Mexico, estimates include costs associated with any hospitalization event for patients on PD and HD.

For Romania, estimates represent government reimbursement for patients on PD and HD.

For Colombia, estimates include lifetime costs of palliative care, set-up costs for PD (e.g., peritoneal catheter implantation for PD, arteriovenous graft for HD), annual maintenance costs, and costs of treating comorbidities and complications, as well as direct and indirect nonhealth-care costs (e.g., travel, time away from work) paid by patients [75].

Reference costs for China were estimated using data from dialysis centers in four hospitals (in Beijing, Shanghai, and Changsa) in combination with detailed survey data collected from 1061 ESRD patients. These estimates include direct medical (dialysis, drug treatment for complications, laboratory, hospitalizations), direct nonmedical (nutrition, home care, transportation), and indirect costs [45]. Finally, the cost basis used for Colombia relies on hospitalizations only; these estimates were derived from the 2005 monthly clinical report from Renal Therapy Services, a network of renal clinics in Colombia and include costs associated with any hospitalization event for patients on PD and HD.

**Results**

Modeled results show projected modality use and budget impacts (payer perspective) for each country (Table 3). These results should be read together with the country-specific estimates provided in Tables 1 and 2. Taking a detailed look at the UK as one example, we see that, as of June 2007, there were an estimated 25,628 patients on dialysis in the UK and the ratio of HD : PD utilization was 79:21 (Table 1). The assumption is that this population would grow by 5% annually and that the average point-prevalent patient would receive 12 months of dialysis annually (Table 1). If over 5 years there were to be a shift in dialysis modality use to 30% PD and 70% HD (Table 3) and assuming costs are as estimated in Table 2, the model projects that the cumulative national savings for dialysis services would be about £1.33 million (2007 £). These savings would create an opportunity to provide an additional 4495 patient-years of dialysis treatment within a fixed national budget for dialysis treatment (Table 3).

Analogously, model results for Singapore, a relatively small country with a baseline prevalent dialysis population of fewer than 4000 individuals in 2006, project that a shift in PD use from the current 21% to 40% over a period of 5 years would create the opportunity to provide an additional 919 patient-years of dialysis treatment. Similarly, increasing PD use in Chile from its current 6% to 25% over 5 years would provide some 901 additional patient-years of dialysis treatment within a fixed national

### Table 1  Dialysis demand and baseline modality use

<table>
<thead>
<tr>
<th>Country</th>
<th>HD : PD</th>
<th>Patient-years at risk</th>
<th>Baseline modality use</th>
<th>Prevalent dialysis population</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>79:21</td>
<td>1.00</td>
<td>25,628</td>
<td>29:71</td>
</tr>
<tr>
<td>Singapore</td>
<td>79:21</td>
<td>0.72</td>
<td>3,953</td>
<td>79:21</td>
</tr>
<tr>
<td>Mexico</td>
<td>79:21</td>
<td>0.72</td>
<td>47,483</td>
<td>24:76</td>
</tr>
<tr>
<td>Chile</td>
<td>79:21</td>
<td>0.72</td>
<td>11,361</td>
<td>94:6</td>
</tr>
<tr>
<td>Romania</td>
<td>79:21</td>
<td>0.72</td>
<td>7,060</td>
<td>82:18</td>
</tr>
<tr>
<td>Thailand</td>
<td>79:21</td>
<td>0.72</td>
<td>12,900</td>
<td>93:7</td>
</tr>
<tr>
<td>China</td>
<td>79:21</td>
<td>0.72</td>
<td>74,137</td>
<td>89:11</td>
</tr>
<tr>
<td>Colombia</td>
<td>79:21</td>
<td>0.72</td>
<td>7,441</td>
<td>57:43</td>
</tr>
</tbody>
</table>

Source citation(s):

[78].
[71–73].
[10,48,79–82].
[4,83,84].
[85].
[4,75,86].
[4,5,87].
[83,88–90].

HD, hemodialysis; PD, peritoneal dialysis.
dialysis budget. A seven percentage point increase in PD utilization over 5 years in Romania (from 18% to 25%) would enable the country’s current dialysis budget to cover an additional 741 patient life-years of treatment, and parallel nine percentage point increase in PD utilization in Thailand (from 11% to 20%) would allow funding for an additional 677 patient-years of dialysis without an increase in current national spending.

In Mexico and China, where the baseline prevalent dialysis populations exceed 47,000 and 74,000 individuals, respectively, even relatively modest increases in PD use (from 76% to 81% in Mexico and from 11% to 21% in China) would yield substantial savings, enough to support nearly 3500 (Mexico) and 3900 (China) additional patient-years of treatment within each country’s baseline dialysis budget.

Modeled results in Colombia reflect the cost of hospitalizations only. As of 2005 there were an estimated 7441 patients on dialysis in Colombia, 43% of which were on PD (80% CAPD). The number of patients on dialysis was growing at 8% per year. Costs per hospitalization event were $2144, $884, and $775 for patients on HD, APD, and CAPD, respectively (2006 $). If over 5 years PD use were to increase by 5% (to 48% PD), hospitalization costs would decrease by $2.3 million, or the equivalent of 1546 patient-years of hospital events.

Sensitivity Analyses

A variety of one-way sensitivity analyses were conducted to explore model forecasts under varying assumptions about ESRD growth rates and years to reach targeted proportions of dialysis modality use. In general, results of these analyses demonstrate that modeled cumulative 5-year savings are sensitive to time; specifically, that savings will be greater as the shift toward greater PD use is accomplished sooner. The model is sensitive to assumptions about projected growth in ESRD populations; higher growth rates will result in greater cumulative savings as PD use increases, although the savings may still be substantial in a given country even if growth in ESRD populations is lower than anticipated. The model also projects greater savings as expenditures for PD decrease relative to HD. In general, countries with large prevalent dialysis populations, high ESRD growth rates and/or low baseline utilization of PD stand to gain the most from increasing clinically appropriate use of PD. Conversely, the model predicts that cumulative 5-year spending for dialysis in any given country will increase as time to reach projected PD modality use increases, as the costs associated with PD increase relative to HD and as PD utilization declines.

Discussion

Worldwide, the systems costs of treating ESRD patients are of a large magnitude. Financial and reimbursement issues have been identified as the most important nonmedical factors in dialysis modality selection in any given country, and the growing ESRD population underscores the importance of these issues [8,9,40]. It is in the best interest of governments and health-care decision-makers to direct spending toward the most cost-efficient method of dialysis treatment for ESRD. Research reports from Eastern and Western Europe suggest that PD costs are similar to, or lower than HD costs [41–43,70,76]. And although PD is often perceived to be more expensive than HD in developing countries because of relatively low costs of labor and space compared with high costs of imported supplies, several published analyses disavow this perception, showing that PD treatment is, in fact, often less expensive than HD in the developing world [41,44,46,74,77]. Further, whereas delivery of HD is largely
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Table 3  Projected modality use and budget impacts

<table>
<thead>
<tr>
<th>Projected modality use</th>
<th>HD : PD</th>
<th>Budget impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>Cumulative 5-year savings</td>
<td></td>
<td>£133 million</td>
</tr>
<tr>
<td>Equivalent patient-years of treatment</td>
<td>4495</td>
<td>1220</td>
</tr>
</tbody>
</table>

HD, hemodialysis; PD, peritoneal dialysis.

dependent on the availability of trained nurses and other dialysis personnel, PD is a home-based therapy that is performed independently by the patient—an especially important consideration in areas where trained HD workers are in short supply. In addition, PD requires very little in terms of physical resources compared to HD, such as building space, water purification, electricity, and the purchase and maintenance of expensive HD equipment. Yet global utilization of PD relative to HD remains low, despite its clinical and economic advantages.

We used a budget impact model to consider the extent to which shifting the mix of dialysis modalities toward greater use of clinically-appropriate PD might reduce the financial burden of caring for an expanding ESRD population and/or maximize the level of dialysis services that a fixed health-care budget is able to support. The results suggest that, in countries where the systems cost of providing PD is lower than HD, an increased use of clinically appropriate PD provides an opportunity to substantially lower overall ESRD treatment costs. These savings could be applied to reduce health-care costs in the dialysis population or to treat additional patients with ESRD or other debilitating conditions.

Our analysis has a number of limitations. Although our budget impact model presents financial streams over time, it does not include inflation or discounting. Costs are assumed to remain constant over the time horizon of each analysis, and do not include costs associated with transplantation, physical facilities and equipment, training, or patients’ switching from one mode of dialysis to another. Indeed, the initial investment necessary to achieve increased use of PD would likely vary by country, because infrastructures differ widely and barriers to PD use may be, in part, socially determined. Projected shifts in the use of PD relative to HD are assumed in the model to occur linearly over time; increased savings would result to the extent that the projected modality shift occurred sooner, rather than later over the modeled time horizon. The cost basis used in this analysis varies among countries, making between-country comparisons imprecise. Because some of the country-specific baseline inputs used in the model is only available as abstracts, the results must be interpreted with caution; additional research is needed to confirm these assumptions in other regions of the world. In addition, full economic evaluations assess costs and outcomes, where outcomes are measured in dollars (cost-benefit analysis), units of a desirable end point such as life-years saved (cost-effectiveness analysis), or years of life gained adjusted by a measure of life quality (cost-utility analysis). The majority of published studies comparing dialysis modalities have focused solely on costs, rather than cost-effectiveness or cost-utility [41,76]. In part this may be because survival and quality of life outcomes for HD and PD are generally considered to be similar [41]. Cost analyses are considered useful for macro-level fiscal planning. Nevertheless, it should be noted that, although PD and HD are complementary therapies, they are not perfect substitutes. Preferences for dialysis modalities may differ when outcomes are taken into consideration, rather than solely focusing on costs. Despite the simplicity of the model and its inherent limitations, it is an important starting point. The magnitude of the potential savings warrants further investigation and discussion of these important topics.

Conclusions

The systems costs of treating ESRD patients are large and increasing, and there is little doubt that the funding of treatment for the ESRD population already creates significant financial challenges across the globe. The growing ESRD population and the high cost of renal replacement therapies underscore the importance of these issues. Nations should look more closely at modes of dialysis that are both clinically effective and cost-saving. There is evidence suggesting that PD therapy is significantly cost-saving compared to HD therapy, even in developing countries. In countries where the systems cost of providing PD is lower than HD, an increased use of clinically appropriate PD provides an opportunity to substantially lower overall ESRD treatment costs. The considerable cumulative savings that would stem from increased use of PD over time could be used to offset part of the financial burden of ESRD care and help nations respond to ever-tightening health-care budget constraints. The sheer magnitude of the potential savings warrants a more in-depth, country-specific evaluation of these issues. At the very least, nations should take care to prevent any negative incentives to using more cost-efficient methods of treating a costly and increasingly prevalent chronic disease.

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References


