

*Original Article*

## Reimbursement and economic factors influencing dialysis modality choice around the world

Paul M. Just<sup>1</sup>, Frank Th. de Charro<sup>2</sup>, Elizabeth A. Tschosik<sup>3</sup>, Les L. Noe<sup>3</sup>, Samir K. Bhattacharyya<sup>1</sup> and Miguel C. Riella<sup>4</sup>

<sup>1</sup>Baxter Healthcare Corporation, 1620 Waukegan Road, MPGR-A2E, McGaw Park, IL 60085, USA, <sup>2</sup>Erasmus University Rotterdam, Postbus 1738, 3000 DR Rotterdam, The Netherlands, <sup>3</sup>ICON Lifecycle Sciences Group, 150 S. Saunders Road, Suite 100, Lake Forest, IL 60045, USA and <sup>4</sup>Catholic University of Parana, Curitiba, Brazil, 2689 Iguassu Ave, Curitiba 80240 030, Brazil

### Abstract

The worldwide incidence of kidney failure is on the rise and treatment is costly; thus, the global burden of illness is growing. Kidney failure patients require either a kidney transplant or dialysis to maintain life. This review focuses on the economics of dialysis. Alternative dialysis modalities are haemodialysis (HD) and peritoneal dialysis (PD). Important economic factors influencing dialysis modality selection include financing, reimbursement and resource availability. In general, where there is little or no facility or physician reimbursement or payment for PD, the share of PD is very low. Regarding resource availability, when centre HD capacity is high, there is an incentive to use that capacity rather than place patients on home dialysis. In certain countries, there is interest in revising the reimbursement structure to favour home-based therapies, including PD and home HD. Modality selection is influenced by employment status, with an association between being employed and PD as the modality choice. Cost drivers differ for PD and HD. PD is driven mainly by variable costs such as solutions and tubing, while HD is driven mainly by fixed costs of facility space and staff. Many cost comparisons of dialysis modalities have been conducted. A key factor to consider in reviewing cost comparisons is the perspective of the analysis because different costs are relevant for different perspectives. In developed countries, HD is generally more expensive than PD to the payer. Additional research is needed in the developing world before conclusive statements may be made regarding the relative costs of HD and PD.

**Keywords:** cost; economics; haemodialysis; peritoneal dialysis; reimbursement

### Introduction

Patients suffering from chronic kidney disease can be classified according to kidney function along a continuum from mild renal dysfunction to irreversible kidney failure. Patients with kidney failure require renal replacement therapy (RRT), either a kidney transplant or dialysis, to maintain life. Worldwide, at the end of 2004, ~1 800 000 patients were receiving RRT [1]. Of those patients 77% were on dialysis and 23% were living with a functioning kidney transplant. The global average prevalence for dialysis was 215 patients per million population, although significant regional variations existed. By the year 2010, it is expected that the number of dialysis patients will approach two million [1].

Because the worldwide incidence of kidney failure continues to rise and treatment is costly, the global burden of illness is growing. Thus, the resources to be allocated to RRT are increasing. This review focuses on the economics of dialysis. While kidney transplantation has important economic implications, it is beyond the scope of this review. A large volume of literature exists on the topic of kidney transplantation and its economic impact. Readers are referred to other review articles for more information [2–4].

For patients treated with dialysis, alternative modalities are haemodialysis (HD) and peritoneal dialysis (PD). In the United States, the incidence of HD has increased sevenfold since 1978, while the incidence of PD peaked in 1995 and has since declined. In 2005, there were over 97 000 incident HD patients and ~7000 incident PD patients. The prevalent population of HD patients was over 314 000 and the prevalent population of PD patients approached 26 000. In other parts of the world, the utilization of dialysis modalities varies. Among large nations, the highest utilization of PD around the world is in Mexico, where it is estimated that 72% of prevalent dialysis patients were on PD in 2005 (based on data from the state of Jalisco). In contrast, in Luxembourg, no prevalent dialysis patients are reported to receive PD. Among large nations, PD is used in fewer than 4% of patients receiving dialysis in Japan [5,6]. Worldwide,

*Correspondence and offprint requests to:* Paul M. Just, Global Health Economics and Reimbursement, Renal Division, Baxter Healthcare Corporation, 1620 Waukegan Road, MPGR-A2E, McGaw Park, IL 60085, USA. Tel: +1-847-473-6127; Fax: +1-847-785-6959; E-mail: paul\_just@baxter.com

at the end of 2004, HD was used to treat 89% of dialysis patients while 11% were treated by PD [1].

Economic factors play a vital role in the sequence of events that lead to the choice between HD and PD and, thus, are the starting point for our review. We then examine the relationship between dialysis modality and employment status because kidney disease often affects the working population. We also identify and discuss the costs of dialysis and key cost drivers for HD and PD, followed by an overview of the relative costs of dialysis modalities in different regions of the world.

#### *Economic factors influencing dialysis modality selection*

Important economic factors influencing dialysis modality selection include financing, reimbursement and resource availability [6,7]. When asked in surveys, physicians respond that financial considerations (i.e. profit status or facility reimbursement) are not among the primary considerations used in guiding patients to a particular modality [8–11]. However, literature reveals evidence to the contrary. In fact, reimbursement structure has been called ‘the ultimate controlling force in the establishment and maintenance of home dialysis’ [12]. Financial and reimbursement issues have been identified as the most important non-medical factors in dialysis modality selection in countries around the globe [6,7,13]. In general, where there is no facility reimbursement for PD, or where there is little or no physician reimbursement for PD, utilization is very low [6,14]. In contrast, in countries with equal or higher reimbursement or payment for PD, utilization is much higher. For example, Mexico is unique in the developing world in that the utilization of PD is ~70%. An important reason for the higher utilization of PD in Mexico is that it has been the modality with the best financial support from the social security system and the public health institutions [15]. Over the last few years a trend can be observed in a number of countries to increase the funding of HD services, especially satellite HD centres, which are smaller and often located closer to a patient’s home. The recent decrease in utilization of PD noted in Mexico may be related to this trend [5]. Additionally, in the growing sector of private-care dialysis, physicians receive direct payments for HD but not for PD.

In certain countries, there is interest in revising the reimbursement structure in a way to provide incentives for home-based as well as more frequent therapies, including PD and home HD. In the Canadian province of Ontario, reimbursement for dialysis changed in 1998. Prior to that time, reimbursement was based on a fee-for-service system, with rates for in-centre HD that were sevenfold higher than those for home or community-based HD or PD. After 1998, a modality-independent weekly capitation fee was adopted. This change in reimbursement structure arguably contributed to a stabilization of an ongoing reduced utilization of PD and non-hospital-based HD in Ontario, while the utilization of PD continued to decline in other parts of Canada [16]. In Hong Kong, the government long ago removed the upper age limit of 55 years for subsidizing home dialysis consumables and continues with a ‘PD First’ policy [7]. In Japan, reimbursement for HD is being decreased, and the Japanese Ministry of Health and Welfare is promoting

home healthcare. A similar situation is present in Taiwan where the Bureau of National Health Insurance (BNHI) has reduced points for HD but maintained those for PD in an effort to increase PD utilization.

Historically, home dialysis was more common in the United Kingdom (UK) than it is today. This had been related to resource constraints and reduced access to HD services in some communities. Thus, a stimulus for preferential use of home continuous ambulatory peritoneal dialysis (CAPD) had existed, as access to HD services was limited in some regions. Renal clinicians were able to transfer a significant portion of the resource responsibility for CAPD patients to general practitioners who could, at that time, prescribe CAPD therapy. However, since April 1995, general practitioners have not been permitted to prescribe CAPD fluids [17]. More significantly, over the last several years, following publication in 2002 of a National Institute for Clinical Excellence (NICE) guideline [18], there has been a significant expansion of access to HD services as a result of a capital development programme in which £60 million were to be invested between 2000 and 2006 by the government for expansion of access to, in particular, satellite HD services. During this period, a National Service Framework was published to define standards of dialysis care and establish good practice markers and support balanced access to all dialysis modalities in England [19].

Medicare policy in the United States provides incentives to private insurers, dialysis facilities, patients and physicians for home dialysis options. These include waiver of the 90-day Medicare coverage waiting period, additional additions to the capitated, or composite, rate for home training, home training supervision fees for physicians, the availability of a training exception rate and an alternative reimbursement option referred to as Method II reimbursement [20]. Unlike patients using the much more common Method I reimbursement, Method II patients do not receive their home supplies and equipment from their dialysis provider directly. Rather, they receive them from an independent supplier who bills Medicare for actual supplies used on a reasonable charge basis using local prevailing rates up to a capitated maximum that varies by modality. More recently, the Centers for Medicare and Medicaid Services (CMS) modified the physician monthly capitated payment system to improve care quality in a manner that they believe provides an incentive for home dialysis therapy. Physicians are required to personally evaluate in-centre HD patients at least once each month but receive payment based on three tiers of patient contact, one visit, two or three visits or four visits per month. They may use physician extenders, such as a physician’s assistant, clinical nurse specialist or nurse practitioner, to evaluate patients for the second through fourth visits. CMS believes that the incentive for home dialysis is provided by not requiring a monthly evaluation visit for home patients, not specifying a required visit frequency and fixing the physician payment rate for home dialysis patients at ~2% below the rate paid for two to three evaluation visits for in-centre HD patients [21].

Unfortunately, evidence published both prior to and after implementation of this policy does not support the supposition that increased dialysis patient visit frequency results in improved clinical outcomes [22–24]. Just prior to

implementation of the new policy, Plantinga and colleagues reported results of a prospective cohort study that found that the frequency of patient–physician contact was not associated with improvements in patient survival, hospitalization rate, quality-of-life or patient-rated care [22]. Following implementation of the new policy, Mentari and associates compared outcomes in over 2000 patients between 12 months prior to implementation of the policy to 7 months after implementation. Despite a doubling of patient–physician contact, from 1.52 before to 3.14 visits per month after policy implementation, they found no associated change in hospital admissions or days, quality-of-life, patient satisfaction or numerous markers of quality outcomes [23]. Anecdotally, some suggest that the lower maximum monthly reimbursement opportunity for physicians caring for home dialysis patients compared to in-centre HD patients does not align with published evidence suggesting that patients receiving home dialysis, either PD or HD, have superior outcomes as measured by survival, quality-of-life and patient satisfaction.

Resource availability also influences dialysis modality selection [6]. When centre HD capacity is high, there is a strong incentive to use the capacity rather than place the patient on an alternative dialysis therapy that does not use it. More recent approaches that lease or place the HD hardware and sell the supplies at a premium, thus integrating the hardware cost into the supply cost, are increasingly common. Such an approach may be noted in environments with distinctly separate budgets for capital investment and supplies or therapy management services and in which there are specific constraints on expanded capital investment. The inverse may also be found. Finally, a current trend noted in many parts of the world is the growth of satellite HD centres. These centres are often self-care or limited care and are most frequently small units built in convenient locations closer to patient homes to allow easier access to HD.

#### *Dialysis modality and employment status*

The impact of renal insufficiency on workplace productivity is substantial. There is a significant reduction in workforce participation among patients with renal dysfunction aged 18–64 years. A conservative estimate of lost productivity from workforce non-participation associated with renal dysfunction in 1994 was ~\$665 million [25].

A number of cross-sectional analyses have examined the relationship between dialysis modality and employment status. Most studies have found that PD patients are more likely to be employed than HD patients. However, because of the cross-sectional nature of the research, it is difficult to conclude whether dialysis modality influenced employment status, or whether employment status had an influence on the choice of dialysis modality [26–29].

Two studies address the limitations of these cross-sectional analyses. A multi-centre, prospective study in The Netherlands followed 359 patients for 12 months. No relationship between treatment modality (HD or PD) and employment status was observed. The authors concluded that many patients become unemployed before starting dialysis. They also concluded that most patients who have a job at the start of dialysis keep working. Finally, the

authors suggested that treatment modality does not influence the ability to maintain employment, but employment may influence the choice between HD and PD [30].

Another study utilized a simultaneous probit model to account for the potential endogeneity between treatment choice and employment [31]. Data were analysed from Wave II of the United States Renal Data System's Dialysis Morbidity and Mortality Study. The authors concluded that PD has a causal effect on dialysis patients' ability to participate in the labour force; however, the magnitude of the effect is small in absolute terms and much smaller than the effect implied by previous cross-sectional research, in which endogeneity was ignored. In a naive model ignoring endogeneity, PD patients were ~60% more likely to be employed than HD patients; however, in a two-stage model accounting for endogeneity, the relative increase in the probability of working for PD patients compared to HD patients was only 14.7%. The authors further stated that most of the effect of PD on employment arises from endogenous selection of PD by patients who wish to maintain employment, rather than from the ability of PD to ease work scheduling [31].

A summary of the literature referenced above is provided in Table 1.

#### **The costs of dialysis**

Recent analyses in the United States have reported the Medicare payments to compensate for a year's treatment of a dialysis patient to be about \$67 000. Employer group health insurance payment is much higher at \$180 000 per year. Medicare expenditures for end-stage renal disease (ESRD) claims increased 11.2% in 2004, to ~\$19 billion. Employer group health plan expenditures for ESRD increased to \$390 million in 2004, representing a 56% increase compared to the previous year [5]. In Europe, although dialysis patients make up less than 0.1% of the population, their dialysis treatment accounts for around one to two percent of total healthcare costs [32]. From 1990 to 2010, treatment costs for the global maintenance dialysis population are expected to rise from less than \$200 billion to \$1.1 trillion [33].

The costs of dialysis around the world can vary widely according to many local market conditions, including local production and distribution factors, import duties, the presence or absence of local suppliers and purchasing power. HD cost is driven largely by the fixed costs of facility space and staff. HD machines typically cost ~\$18 000 to \$30 000 each, but the machines have a 5- to 10-year life cycle, and, in a weekly schedule, three to six patients can be treated on one machine. The cost of dialyzers for HD ranges from \$1000 to \$5000 per year. Other items that factor into the cost of HD are additional facility costs such as maintenance and utilities, and the costs of transportation to and from the HD facility [26].

In contrast, the economics of PD are driven primarily by variable, or 'disposable', costs, such as the costs of solutions and dialysis tubing, and PD exhibits a near constant economy of scale [26,34]. A review of the literature determined that the cost of PD materials ranges from \$5000 to \$25 000 annually. The use of automated cyclers generally adds to

**Table 1.** Dialysis modality and employment status

Reference	Baseline employment (%)		Time on dialysis	On dialysis employment (%)		Statistical significance
	HD	PD		HD	PD	
Rubin <i>et al.</i> [28]	–	–	7 weeks	11.3	28.1	$P < 0.001$
Blake <i>et al.</i> [26]	–	–	$\geq 3$ months	41	43	NS
Wolcott and Nissenson [29]	–	–	$\geq 6$ months	12 <sup>a</sup>	45 <sup>a</sup>	Not reported
Julius <i>et al.</i> [27]	–	–	Not available	9.6	27.4	$P < 0.05$
van Manen <i>et al.</i> [30]	31	48	1 year	25	40	NS <sup>b</sup>
Hirth <i>et al.</i> [31]	–	–	60 days	32.2 <sup>c</sup>	51.3 <sup>c</sup>	$P < 0.01$
Hirth <i>et al.</i> [31]	–	–	60 days	40.6 <sup>d</sup>	46.6 <sup>d</sup>	$P < 0.01$

<sup>a</sup>Includes patients currently employed or in school or who routinely perform household tasks.

<sup>b</sup>No association between treatment modality and loss of employment when adjusted for demographic, clinical variables and SF-36 summary scores.

<sup>c</sup>Relative probability of employment when dialysis modality is treated as an exogenous variable in a model that does not account for endogeneity.

<sup>d</sup>Relative probability of employment when dialysis modality is treated as an exogenous variable in a model that accounts for endogeneity.

the cost of PD. The machines cost \$3000 to \$10 000 each when purchased outright. However, they may be leased or provided, in which case their actual cost is bundled into the cost of solutions and materials purchased through the same company. Comparison of supply costs alone may result in inaccurate assessment of the absolute cost of the various dialysis therapies.

That said, supply-related issues do impact provider costs of both dialysis modalities. For HD, provider costs can be affected by the choice of the dialyzer membrane prescribed and whether or not the dialyzer is used only one time or is reused. A key issue influencing the apparent daily cost of PD is that some new dialysate solutions are priced at a premium relative to the standard glucose solutions. When comparing dialysis treatment costs on a procurement basis only, misleading conclusions may be reached. For example, when one standard bag of dialysate is replaced with the newer solution icodextrin, the net daily cost for that patient's dialysis treatment might appear to increase in some countries. However, such an increase in daily therapy cost may be more than offset if the alternative would have been transfer to and maintenance with a more expensive dialysis treatment, such as HD, as documented later in this manuscript. Budget impact models and Markov analysis have reported that such extension of time on PD therapy lowers the total costs of care over time by deferring the need for HD, which is generally found to be a more expensive treatment alternative [26,35,36]. Such analyses underscore the need to evaluate dialysis treatment costs as a total therapy rather than simply thinking of dialysis costs as the procurement expense of the supplies. Additionally, this example demonstrates the value of considering the cumulative costs of dialysis over a patient's therapy lifetime rather than for a limited discrete segment of time.

Additional costs associated with dialysis are physician fees, medications, laboratory and other diagnostic investigations and hospitalizations. For example, in the United States in 2004, Medicare spending for erythropoiesis-stimulating agents was ~10% of total Medicare spending for all ESRD care services [5]. Medication costs with PD are typically less than those with HD. Less erythropoietin is required because anaemia is less severe. More inexpensive forms of Vitamin D tend to be used (oral or subcutaneous versus intravenous), and less parental iron is required be-

cause patients are less likely to have treatment-related blood losses [26].

Hospitalization costs contribute substantially to total expenditures for dialysis patients [26]. Room costs and inpatient dialysis costs account for nearly half of the cost of hospitalizations for dialysis patients. Some evidence suggests that hospitalization costs are lower for PD than for HD due to a reduced number of hospital days per year [37,38]; however, a comprehensive literature review indicates that hospitalization costs are similar for HD and PD, although the reasons for hospital admission differ. The primary causes of hospital admission in patients receiving PD are peritonitis and cardiovascular disease [39–44]. Conversely, in patients receiving HD, the primary causes for hospitalization are access issues, thrombosis and infections [26]. Rates and duration of hospitalization by modality may vary in different regions of the world, so caution should be used in generalizing research results.

The cost of treating patients with chronic kidney disease who ultimately progress to ESRD begins to increase in the last 6 months immediately prior to starting dialysis, peaks in the first month of dialysis, and generally reaches a plateau by month 6 of dialysis. One reason for this is that mortality is high during the first 6 months of dialysis, and patient treatment is more expensive in the period immediately prior to a terminal event [5,45]. Also, start-up costs occur with all dialysis modalities and result in higher costs for the first year of dialysis compared to subsequent years. Start-up costs include surgical implantation of an access. A peritoneal catheter must be inserted for PD and a vascular access, fistula, graft or temporary catheter must be established for HD. Finally, start-up costs for CAPD and home HD include patient training and so also contribute to the cost of modality switches because they are incurred with each change in modality [46]. When considering a patient lifetime approach, it has been shown that total payer expense over a 3-year period is lowest when patients are started on PD and maintained on it for at least year 1 of the 3-year period [47].

A key factor influencing the cost of dialysis care is the timing of referral to a nephrologist. When patients are either referred late to a nephrologist's care or must urgently initiate dialysis without a planned access, they are generally sicker, require longer hospitalization and are nearly always started

on HD. Early referral and planned start result in cost savings and improved survival. Patients who are referred earlier to a nephrologist have an extended time prior to starting RRT during which access may be planned and placed, and patients may be objectively educated about their treatment choices. This approach has usually been found to result in fewer inpatient hospital days [48]. Patients who have been exposed to pre-dialysis modality education are more likely to choose PD over HD [49–51] and therefore contribute to lower societal and payer dialysis expense in most countries, as discussed below.

### **Economic evaluations of dialysis treatment modalities**

The growing kidney failure population and high cost of RRT have led to early economic evaluations of the medical technology. Some propose that few other medical technologies have had their costs and outcomes assessed so regularly and widely [4]. However, the research varies greatly in quality.

One factor to consider in reviewing the economic assessments of dialysis modalities is the perspective taken for the analysis. Relevant perspectives include patient, dialysis facility or provider, physician, payer, dialysis manufacturing industry, government and society as a whole. The costs to payers, facilities and physicians are most likely to affect practice patterns such as modality selection. Costs to society and patients or families are less likely to influence practices [26]. Depending on the perspective of the analysis, different costs or expenses may be relevant. A previous analysis found that many dialysis economic evaluations fail to include costs that are relevant for the stated perspective [52].

Costs are generally described in four categories: direct medical costs, direct non-medical costs, indirect costs and intangible costs. Direct medical costs of dialysis include staffing costs, physician fees or salary, costs of dialyzers and tubing in HD, costs of solutions and tubing in PD, costs associated with radiology, laboratory and medications, capital costs of HD machines and PD cyclers, costs of hospitalizations and costs of outpatient consultations from other specialties [26].

Direct non-medical costs may vary widely in different parts of the world but tend to be highest in more developed economies. Direct non-medical costs include building costs, facility utilities and other overhead costs. These costs are difficult to estimate but are important elements of an economic evaluation of dialysis modalities. Additionally, an activity-based cost analysis is the most appropriate cost approach to apply when comparing modality expenses between home and centre-based therapies. Activity-based cost analysis apportion costs according to the proportional share of a particular cost element used by patients on different modalities. However, in practice it appears that this method is not applied by a number of dialysis centre managers.

Intangible costs are the costs associated with pain, suffering and impairment in quality of life (QOL), as well as the value of extending life. These costs are often omitted from economic evaluations. Likewise, indirect costs, or productivity losses for patients and their families or

caretakers, rarely have been assessed and incorporated in dialysis economic evaluations. While it is true that the mean age of the kidney failure population is increasing and that many patients are past the age of retirement when they start dialysis, indirect costs still represent a potentially important element of dialysis economic evaluations [26]. This is particularly true if health systems are dependent upon employee and employer contributions to fund medical care. When patients do not continue to work, both sources of contribution cease. Additionally, such a social system generally will pay a disability income to non-working patients in addition to their medical care payment or reimbursement.

The majority of studies that compare dialysis modalities have focused solely on costs, rather than cost-effectiveness or cost-utility [26,52]. In part, this may be because survival and QOL outcomes for HD and PD are generally considered to be similar [26]. However, without large, randomized, prospective clinical trials comparing patient survival and other outcomes between the various dialysis modalities, quality cost-effectiveness or cost-utility evaluations are not possible. In the clinical literature, a number of observational studies provide conflicting survival results, with some demonstrating a survival advantage for HD [53–55], others finding a survival advantage for PD [56–59] and still others showing equal or mixed survival outcomes between modalities [60–62]. To a great extent, these disparate findings are explained by differences in study methods. When evaluated according to modern evaluation and statistical standards, only comparisons of incident patients are appropriate and adjustments must be applied for comorbid conditions. The most recent survival assessments of patients from four of the world's leading dialysis registries, Canada, Denmark, the Netherlands and the United States, find that overall survival is similar between the modalities but that there may be differences in select patient subgroups [63].

In the QOL literature, most research indicates that PD and HD patients have similar QOL, regardless of whether QOL is measured by a generic or disease specific measure or whether it is measured by a health profile or health preference instrument [64–67]. However, some evidence suggests that PD may offer an advantage in QOL over HD [68–71], while other research has found that HD may be superior to PD in certain QOL domains [71,72]. Differences in patient characteristics and research methods may explain some of these conflicting results.

A North American literature review concluded that PD is less expensive than HD and that the difference in cost is dramatic when the PD program is relatively large and well run. Annual costs for HD patients ranged from ~\$48 000 to ~\$69 000, while annual costs for PD patients ranged from ~\$34 000 to ~\$47 000. The cost ratio of HD to PD varied from 1.22 to 1.52 [26].

In general, reports from Western Europe are in agreement with the North American findings. A review of the literature found that in-centre HD was about twice the cost of CAPD in France and 30% more expensive than CAPD in Italy and the UK [26]. Another review of the Western European literature also concluded that, with the exception of home HD, PD is less costly than HD. However, that review noted that the magnitude of the cost difference between dialysis

modalities is difficult to determine due to deficiencies in the available evidence. Many publications fail to adequately describe their methodology or to include all relevant cost components [52].

Very little research exists on the economics of dialysis in developed Asian countries. A multi-national survey of Asian nephrologists conducted in 2001 suggests that HD is generally more expensive than PD in the developed Asian economies of Hong Kong, Singapore, Taiwan and Japan. However, the extent of cost savings with PD varies by region. According to the survey results, the ratio of costs for HD compared to PD ranged from a low of 0.99–1.09 in Japan to a high of 1.42–2.39 in Hong Kong [73].

The economics of dialysis in the developing world differ from advanced nations. CAPD requires less technology than HD, so it would seem particularly well suited for developing nations [15,74]. In poorer countries, though, labour is relatively inexpensive, while the cost of imported equipment and solutions is high. Costs are often considered as related only to supplies rather than assessed as a total therapy. Therefore, there is often a perception that PD is more expensive than HD in developing countries [26,75]. To reduce costs, patients may be placed on outdated straight-line systems and sometimes transfer sets may be reused. However, high peritonitis rates increase the cost of PD treatment even further, and dropout rates are high [15,74]. The lack of well-conducted economic evaluations in developing countries makes it difficult to accurately understand the true economic environment for dialysis care. A systematic review of the world literature on reports of dialysis economics and cost-effectiveness was recently published [76].

## Comments

Kidney failure is a disease with high resource demands on every health care system in the world. The literature supports a perception that the driving forces of patient modality selection are intricately linked to payment and reimbursement mechanisms in any society. As such, it is critical that any analysis of economics related to dialysis therapy must start with a clear understanding of the perspective from which the analysis is conducted and, therefore, interpreted. All relevant costs for a given perspective must be included in the analysis whenever possible, and may include expenses both directly and indirectly related to the provision of the dialysis service. Examples include facility, hardware (dialysis machine and water treatment), medical and non-medical personnel, hospitalization and complication management, access creation and management, disposable material, pharmaceutical, diagnostic, transportation and social costs. Additionally, indirect costs and intangible costs may have a greater contribution in some countries.

There are many complex and interrelated direct flows of money between participants in the care chain, including the patient, the physician, the provider of the dialysis service and any hospital facility supporting the patient's extended care needs plus health care product suppliers and medical distributors. Indirectly, kidney failure causes a societal burden in that patients otherwise able to work and

contribute to society become disabled, thus reducing societal tax income and increasing disability disbursements once working-age patients are no longer able to continue working. The impact of kidney failure on workplace productivity is substantial, with many patients becoming unemployed even before starting dialysis. Patients who are employed have a greater tendency to select PD rather than HD; however, the choice of dialysis modality has not been proven to independently affect a patient's ability to maintain employment.

When considered from the perspective of society or a payer, such as a health care funding authority or a principal insurer, the resource demands of a kidney failure patient are best considered over the course of that patient's cumulative remaining lifetime. Consideration of the cost-effectiveness of equivalent treatment alternatives as measured by effectiveness, safety and quality may then be balanced with their respective budget impact to the primary payers. A lower cost treatment alternative will extend available resources to allow improved treatment for more patients and will lower the lifetime treatment cost burden of an individual patient and the diseased population to society. In practical terms, this suggests that home dialysis alternatives should be preferentially selected when clinically and socially appropriate for the individual patient. Such an approach has been advocated [13] and the funding benefits have been documented using an analysis of US Medicare data [47].

Unfortunately, in a majority of health care systems, this approach is not followed, particularly in the case of private-care services [7,32]. From the perspective of society, health care should be aligned for greatest efficiency as measured by the ability to provide the highest quality care to the largest number of patients. When a treatment is equally effective and safe for patients, yet least costly to the principal payer, incentives that drive downstream care decision makers and providers to preferentially select that same therapy to be the initial treatment option are prudent.

Appropriate alignment of incentives throughout the downstream care system may not occur because cost drivers for PD and HD differ; PD is driven primarily by variable costs while HD is driven more by fixed costs. In developed nations, HD is generally more expensive than PD to the payer. In some developing and emerging economies, mainly due to inexpensive labour and high imported equipment and solution costs, PD is perceived to be more expensive than HD despite the lack of confirmatory prospective economic evaluations. However, the costs of dialysis differ by region and additional research is needed, particularly in the developing world.

## Conclusions

When reviewing dialysis economic evaluations, key factors that significantly influence their interpretation include the perspective taken for the analysis and the cost components included in the comparison. All relevant costs for a given perspective must be included whenever possible. These include expenses both directly and indirectly related to the provision of the dialysis service as previously described.

Additionally, indirect costs and intangible costs may have a more or less significant contribution to economic evaluations in different economies.

In most regions of the world, an analysis of total therapy expenses reveals that home dialysis is a lower cost option than in-centre dialysis and PD is a lower cost modality than HD, particularly when comparing CAPD to in-centre HD. The actual cost of each modality may be affected by supply expenses, such as dialyzers for HD and solutions for PD, but the absolute impact of such elements can only be discovered by economic analysis that would concurrently evaluate the influence of those supply factors on overall patient outcomes. Unfortunately, cost-effectiveness and cost-utility studies based on randomized prospective clinical trials comparing home to in-centre dialysis modalities are unavailable and are unlikely to take place, as most patients do not wish to leave their modality choice to chance.

As health system budgets continue to shrink, even in developed countries, resource-intensive therapies such as treatments for patients with kidney failure will need to find new efficiencies. Renal transplantation, while the most clinically and financially effective approach for kidney failure patients [77], is unlikely to become significantly more available in the near future in most countries.

Healthcare systems have historically supported resource intensive treatments because the previously more common fee-for-service approach rewarded utilization of expensive services such as dialysis in general and HD in particular. Today, the approach to healthcare reimbursement is changing in many parts of the world to either a capitated system or one using a global budget. As these become more routine, incentives should be optimized to better support efficient treatment option alignment. When dialysis modalities are selected, economic factors such as financing, reimbursement and resource availability do not appear to be wholly independent from clinical considerations when modality selection recommendations are discussed with patients. The rate of PD utilization appears to be positively associated with equal or higher reimbursement or payment for PD. When centre HD capacity is high, there is a perceived and actual incentive to utilize that capacity, rather than to place patients on alternative modalities such as a home dialysis treatment option.

Further research is needed to allow direct comparison of the complete expenses of the various dialysis modalities applied in a given region. Combined with a population risk-factor-adjusted prospective selection of the best outcome modality treatment and practice alternatives, future dialysis resources application may become more efficient.

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## References

- Grassmann A, Gioberge S, Moeller S *et al*. ESRD patients in 2004: global overview of patient numbers, treatment modalities and associated trends. *Nephrol Dial Transplant* 2005; 20: 2587–2593
- Abecassis MM. Financial outcomes in transplantation—a provider's perspective. *Am J Transplant* 2006; 6: 1257–1263
- Clarke KS, Klarenbach S, Vlaicu S *et al*. The direct and indirect economic costs incurred by living kidney donors—a systematic review. *Nephrol Dial Transplant* 2006; 21: 1952–1960
- Winkelmayer WC, Weinstein MC, Mittleman MA *et al*. Health economic evaluations: the special case of end-stage renal disease treatment. *Med Decis Making* 2002; 22: 417–430
- USRDS. Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, 2007
- Nissenson AR, Prichard SS, Cheng IK *et al*. Non-medical factors that impact on ESRD modality selection. *Kidney Int Suppl* 1993; 40: S120–S127
- Nissenson AR, Prichard SS, Cheng IK *et al*. ESRD modality selection into the 21st century: the importance of non medical factors. *Asaio J* 1997; 43: 143–150
- Jassal SV, Krishna G, Mallick NP *et al*. Attitudes of British Isles nephrologists towards dialysis modality selection: a questionnaire study. *Nephrol Dial Transplant* 2002; 17: 474–477
- Jung B, Blake PG, Mehta RL *et al*. Attitudes of Canadian nephrologists toward dialysis modality selection. *Perit Dial Int* 1999; 19: 263–268
- Mendelssohn DC, Mullaney SR, Jung B *et al*. What do American nephrologists think about dialysis modality selection? *Am J Kidney Dis* 2001; 37: 22–29
- Thamer M, Hwang W, Fink NE *et al*. US nephrologists' recommendation of dialysis modality: results of a national survey. *Am J Kidney Dis* 2000; 36: 1155–1165
- Diaz-Buxo JA, Crawford-Bonadio TL, St Pierre D *et al*. Establishing a successful home dialysis program. *Blood Purif* 2006; 24: 22–27
- Lameire N, Peeters P, Vanholder R *et al*. Peritoneal dialysis in Europe: an analysis of its rise and fall. *Blood Purif* 2006; 24: 107–114
- Durand PY, Verger C. The state of peritoneal dialysis in France. *Perit Dial Int* 2006; 26: 654–657
- Correa-Rotter R. The cost barrier to renal replacement therapy and peritoneal dialysis in the developing world. *Perit Dial Int* 2001; 21(Suppl 3): S314–S317
- Mendelssohn DC, Langlois N, Blake PG. Peritoneal dialysis in Ontario: a natural experiment in physician reimbursement methodology. *Perit Dial Int* 2004; 24: 531–537
- Haycox A, Jones D. The cost effectiveness of renal provision in the UK. *J Manag Med* 1996; 10: 6–15
- NICE. Guidance on home compared with hospital haemodialysis for patients with end-stage renal failure. *Technology appraisal guidance no. 48* ([http://www.nice.org.uk/nicemedia/pdf/HvH\\_full\\_guidance.pdf](http://www.nice.org.uk/nicemedia/pdf/HvH_full_guidance.pdf), accessed 23 November 2007)
- Part 1: Dialysis and Transplantation. *The National Service Framework for Renal Services*. ([http://www.dh.gov.uk/en/Publicationsandstatistics/PublicationsPolicyAndGuidance/DH\\_4070359](http://www.dh.gov.uk/en/Publicationsandstatistics/PublicationsPolicyAndGuidance/DH_4070359), accessed 23 November 2007), 2004
- Fox MP. Facility reimbursement: a critical comparison between hemodialysis and peritoneal dialysis *Am J Kidney Dis* 1993; 22: 32–34
- CMS. Centers for Medicare and Medicaid Services. <http://www.cms.hhs.gov/home/medicare.asp> (accessed 23 November 2007)
- Plantinga LC, Fink NE, Sadler JH *et al*. Frequency of patient-physician contact and patient outcomes in hemodialysis care. *J Am Soc Nephrol* 2004; 15: 210–218
- Mentari EK, DeOreo PB, O'Connor AS *et al*. Changes in Medicare reimbursement and patient-nephrologist visits, quality of care, and health-related quality of life. *Am J Kidney Dis* 2005; 46: 621–627

24. Golper TA. Frequency of physician visits to patients on in-center maintenance hemodialysis: does one strategy fit all? *J Am Soc Nephrol* 2004; 15: 238–239
25. Klarenbach S, Stafinski T, Longobardi T et al. The effect of renal insufficiency on workforce participation in the United States: an analysis using National Health and Nutrition Examination Survey III data. *Am J Kidney Dis* 2002; 40: 1132–1137
26. Blake P, Just P. Economics of dialysis. In: Horl WH, Koch KM, Lindsay RM, Ronco C, Winchester JF (eds). *Replacement of Renal Function by Dialysis*, 5th edn. Dordrecht, The Netherlands: Kluwer, 2004
27. Julius M, Kneisley JD, Carpentier-Altling P et al. A comparison of employment rates of patients treated with continuous ambulatory peritoneal dialysis vs in-center hemodialysis (Michigan End-Stage Renal Disease Study). *Arch Intern Med* 1989; 149: 839–842
28. Rubin HR, Fink NE, Plantinga LC et al. Patient ratings of dialysis care with peritoneal dialysis vs hemodialysis. *JAMA* 2004; 291: 697–703
29. Wolcott DL, Nissenson AR. Quality of life in chronic dialysis patients: a critical comparison of continuous ambulatory peritoneal dialysis (CAPD) and hemodialysis. *Am J Kidney Dis* 1988; 11: 402–412
30. van Manen JG, Korevaar JC, Dekker FW et al. Changes in employment status in end-stage renal disease patients during their first year of dialysis. *Perit Dial Int* 2001; 21: 595–601
31. Hirth RA, Chernew ME, Turenne MN et al. Chronic illness, treatment choice and workforce participation. *Int J Health Care Finance Econ* 2003; 3: 167–181
32. De Vecchi AF, Dratwa M, Wiedemann ME. Healthcare systems and end-stage renal disease (ESRD) therapies—an international review: costs and reimbursement/funding of ESRD therapies. *Nephrol Dial Transplant* 1999; 14(Suppl 6): 31–41
33. Lysaght MJ. Maintenance dialysis population dynamics: current trends and long-term implications. *J Am Soc Nephrol* 2002; 13(Suppl 1): S37–S40
34. Dor A, Held PJ, Pauly MV. The Medicare cost of renal dialysis. Evidence from a statistical cost function. *Med Care* 1992; 30: 879–891
35. Johnson DW, Vincent K, Blizzard S et al. Cost savings from peritoneal dialysis therapy time extension using icodextrin. *Adv Perit Dial* 2003; 19: 81–85
36. Weijnen TJ, van Hamersvelt HW, Just PM et al. Economic impact of extended time on peritoneal dialysis as a result of using polyglucose: the application of a Markov chain model to forecast changes in the development of the ESRD programme over time. *Nephrol Dial Transplant* 2003; 18: 390–396
37. Bruns FJ, Seddon P, Saul M et al. The cost of caring for end-stage kidney disease patients: an analysis based on hospital financial transaction records. *J Am Soc Nephrol* 1998; 9: 884–890
38. McMurray SD, Miller J. Impact of capitation on free-standing dialysis facilities: can you survive? *Am J Kidney Dis* 1997; 30: 542–548
39. Murphy SW, Foley RN, Barrett BJ et al. Comparative hospitalization of hemodialysis and peritoneal dialysis patients in Canada. *Kidney Int* 2000; 57: 2557–2563
40. Zhang AH, Cheng LT, Zhu N et al. Comparison of quality of life and causes of hospitalization between hemodialysis and peritoneal dialysis patients in China. *Health Qual Life Outcomes* 2007; 5: 49
41. Trivedi HS, Tan SH, Prowant BF et al. Predictors of hospitalization in patients on peritoneal dialysis: the Missouri experience. *Am J Nephrol* 2007; 27: 483–487
42. Lecame M, Lobbedez T, Allard C et al. Hospitalization of peritoneal dialysis patients: the impact of peritonitis episodes on the hospitalization rate. *Nephrol Ther* 2006; 2: 82–86
43. Metcalfe W, Khan IH, Prescott GJ et al. Hospitalization in the first year of renal replacement therapy for end-stage renal disease. *QJ Med* 2003; 96: 899–909
44. Fried L, Abidi S, Bernardini J et al. Hospitalization in peritoneal dialysis patients. *Am J Kidney Dis* 1999; 33: 927–933
45. St Peter WL, Khan SS, Ebben JP et al. Chronic kidney disease: the distribution of health care dollars. *Kidney Int Suppl* 2004; 66: 313–321
46. Prichard SS. The costs of dialysis in Canada. *Nephrol Dial Transplant* 1997; 12(Suppl 1): 22–24
47. Shih YC, Guo A, Just PM et al. Impact of initial dialysis modality and modality switches on Medicare expenditures of end-stage renal disease patients. *Kidney Int* 2005; 68: 319–329
48. McLaughlin K, Manns B, Culleton B et al. An economic evaluation of early versus late referral of patients with progressive renal insufficiency. *Am J Kidney Dis* 2001; 38: 1122–1128
49. Gomez CG, Valido P, Celadilla O et al. Validity of a standard information protocol provided to end-stage renal disease patients and its effect on treatment selection. *Perit Dial Int* 1999; 19: 471–477
50. Little J, Irwin A, Marshall T et al. Predicting a patient's choice of dialysis modality: experience in a United Kingdom renal department. *Am J Kidney Dis* 2001; 37: 981–986
51. Marron B, Martinez Ocana JC, Salgueira M et al. Analysis of patient flow into dialysis: role of education in choice of dialysis modality. *Perit Dial Int* 2005; 25(Suppl 3): S56–S59
52. Peeters P, Rublee D, Just PM et al. Analysis and interpretation of cost data in dialysis: review of Western European literature. *Health Policy* 2000; 54: 209–227
53. Bloembergen WE, Port FK, Mauger EA et al. A comparison of mortality between patients treated with hemodialysis and peritoneal dialysis. *J Am Soc Nephrol* 1995; 6: 177–183
54. Ganesh SK, Hulbert-Shearon T, Port FK et al. Mortality differences by dialysis modality among incident ESRD patients with and without coronary artery disease. *J Am Soc Nephrol* 2003; 14: 415–424
55. Stack AG, Molony DA, Rahman NS et al. Impact of dialysis modality on survival of new ESRD patients with congestive heart failure in the United States. *Kidney Int* 2003; 64: 1071–1079
56. Collins AJ, Hao W, Xia H et al. Mortality risks of peritoneal dialysis and hemodialysis. *Am J Kidney Dis* 1999; 34: 1065–1074
57. Fenton SS, Schaubel DE, Desmeules M et al. Hemodialysis versus peritoneal dialysis: a comparison of adjusted mortality rates. *Am J Kidney Dis* 1997; 30: 334–342
58. Heaf JG, Lokkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. *Nephrol Dial Transplant* 2002; 17: 112–117
59. Schaubel DE, Morrison HI, Fenton SS. Comparing mortality rates on CAPD/CCPD and hemodialysis. The Canadian experience: fact or fiction? *Perit Dial Int* 1998; 18: 478–484
60. Termorshuizen F, Korevaar JC, Dekker FW et al. Hemodialysis and peritoneal dialysis: comparison of adjusted mortality rates according to the duration of dialysis: analysis of The Netherlands cooperative study on the adequacy of dialysis 2. *J Am Soc Nephrol* 2003; 14: 2851–2860
61. Vonesh EF, Moran J. Mortality in end-stage renal disease: a reassessment of differences between patients treated with hemodialysis and peritoneal dialysis. *J Am Soc Nephrol* 1999; 10: 354–365
62. Vonesh EF, Snyder JJ, Foley RN et al. The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. *Kidney Int* 2004; 66: 2389–2401
63. Vonesh EF, Snyder JJ, Foley RN et al. Mortality studies comparing peritoneal dialysis and hemodialysis: what do they tell us? *Kidney Int Suppl* 2006; 103: S3–S11
64. de Wit GA, Ramsteijn PG, de Charro FT. Economic evaluation of end stage renal disease treatment. *Health Policy* 1998; 44: 215–232
65. Harris SA, Lamping DL, Brown EA et al. Clinical outcomes and quality of life in elderly patients on peritoneal dialysis versus hemodialysis. *Perit Dial Int* 2002; 22: 463–470
66. Korevaar JC, Feith GW, Dekker FW et al. Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. *Kidney Int* 2003; 64: 2222–2228
67. Manns B, Johnson JA, Taub K et al. Quality of life in patients treated with hemodialysis or peritoneal dialysis: what are the important determinants? *Clin Nephrol* 2003; 60: 341–351
68. Cameron JJ, Whiteside C, Katz J et al. Differences in quality of life across renal replacement therapies: a meta-analytic comparison. *Am J Kidney Dis* 2000; 35: 629–637



69. Kutner NG, Zhang R, Barnhart H *et al.* Health status and quality of life reported by incident patients after 1 year on haemodialysis or peritoneal dialysis. *Nephrol Dial Transplant* 2005; 20: 2159–2167
70. Wu AW, Fink NE, Cagney KA *et al.* Developing a health-related quality-of-life measure for end-stage renal disease: the choice health experience questionnaire. *Am J Kidney Dis* 2001; 37: 11–21
71. Wu AW, Fink NE, Marsh-Manzi JV *et al.* Changes in quality of life during hemodialysis and peritoneal dialysis treatment: generic and disease specific measures. *J Am Soc Nephrol* 2004; 15: 743–753
72. Wasserfallen JB, Halabi G, Saudan P *et al.* Quality of life on chronic dialysis: comparison between haemodialysis and peritoneal dialysis. *Nephrol Dial Transplant* 2004; 19: 1594–1599
73. Li PK, Chow KM. The cost barrier to peritoneal dialysis in the developing world—an Asian perspective. *Perit Dial Int* 2001; 21(Suppl 3): S307–S313
74. Chugh KS, Jha V, Chugh S. Economics of dialysis and renal transplantation in the developing world. *Transplant Proc* 1999; 31: 3275–3277
75. Lo WK. What factors contribute to differences in the practice of peritoneal dialysis between Asian countries and the West? *Perit Dial Int* 2002; 22: 249–257
76. Just PM, Riella MC, Tschosik EA *et al.* Economic evaluations of dialysis treatment modalities. *Health Policy* 2008; 86: 163–180. Epub 2008 Feb 19
77. Magee CC, Pascual M. Update in renal transplantation. *Arch Intern Med* 2004; 164: 1373–1388

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