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ECONOMIC EVALUATION

Illustrating the impact of including future costs in economic evaluations: an application to end-stage renal disease care

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Summary

There are strong theoretical arguments for including future costs for related and unrelated medical care and non-medical expenditures within economic evaluations. Nevertheless, there is limited data on how inclusion of such costs affects the cost effectiveness of medical interventions in practice. For a low-cost intervention that improves survival in end-stage renal disease (ESRD) patients, we sought to determine how the inclusion of future costs for related medical care (i.e. dialysis and transplantation) and for unrelated medical care and non-medical expenditure would affect the magnitude of the cost per QALY ratio. We performed a cost-utility analysis comparing hemodialysis using a synthetic dialyser (the current treatment of choice in Canada) with the historical gold-standard treatment (use of a cellulose dialyser). We contrasted the results of the analysis including and excluding various measures of future costs. While the inclusion of future costs for unrelated medical care and non-medical expenditures had a significant impact on the cost per QALY ratio, the size of the cost per QALY ratio was most sensitive to inclusion of future costs for related medical care. Our analysis shows that even relatively inexpensive interventions that extend survival of dialysis patients may not be cost-effective since, by extending survival, the extra outpatient dialysis costs that are incurred are large. Inclusion of such costs (which, in and of itself, is methodologically correct) in economic evaluations in this area may mitigate against the acceptance of interventions that are relatively inexpensive themselves but which improve patient survival. Copyright © 2003 John Wiley & Sons, Ltd.

Keywords economic evaluation; kidney failure; hemodialysis; future costs; end-stage renal disease

Introduction

Treatment of patients with end-stage renal disease (ESRD) using hemodialysis is expensive, and is associated with a high cost per quality-adjusted life year (QALY) gained [1,2]. This highlights the need to identify interventions to improve the cost effectiveness of caring for patients with ESRD, but also creates methodological challenges for evaluating such interventions. In this paper, we investigate three such methodological challenges, the first being how the high cost of ongoing dialysis affects the cost per QALY ratio, the second being whether to include the 'future' costs of unrelated medical care and non-medical expenditures (defined as 'consumption – earnings'), and the third being whether QALYs represent an adequate measure of benefit in the area of ESRD.

Within health economics in general, it remains controversial whether to include future costs for

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unrelated illnesses and non-medical expenditures within economic evaluations [3], and if so, whether such an inclusion will significantly affect the cost per QALY ratio [4–7]. Meltzer has used economic models to suggest that such future costs be included in economic evaluations, arguing that their inclusion may substantially alter the cost effectiveness of many medical interventions, particularly ones that increase length of life more than quality of life (QOL) [4].

In the context of evaluating interventions for patients with ESRD, we sought to determine the impact on cost per QALY of the inclusion of different types of future costs. These future costs were for (1) related medical care (i.e. ongoing dialysis three times per week and/or transplantation) and (2) unrelated medical care and non-medical expenditures. We hypothesised that interventions with a small incremental cost that improve survival in ESRD patients would result in substantial costs in the form of continued hemodialysis and, given the types of patients who have ESRD (i.e. elderly patients with many comorbid diseases [8]), other health service costs such as hospitalisations.

The above issues are addressed in the context of an economic evaluation of the switch from cellulose to synthetic hemodialysers that took place in hemodialysis treatment in North America in the early 1990s [9], largely due to the results of several studies suggesting that patients dialysing with cellulose dialysers were at an increased risk of mortality [9–16]. The switch to synthetic hemodialysers was made at a time when health programmes tended to focus on the clinical effects of a treatment and to ignore cost as a consideration, so that the greater cost of synthetic vs cellulose dialysers was not a matter of much attention. Although this comparison may be of limited practical significance within North America now (since very few centres currently use cellulose dialysers [9]), it serves as a useful example to illustrate important methodological points that must be considered in future economic evaluations within this area.

Methods

Hemodialysis is one form of dialysis used to treat patients with end-stage renal disease. It is performed three times per week, generally in a hospital setting though patients can be trained to perform hemodialysis at home. During hemodialysis, blood is cleansed by passing through an artificial kidney (termed a 'dialyser'). Being a consumable item, a new dialyser is required for each dialysis session.

We performed a cost-utility analysis comparing dialysis using synthetic vs cellulose dialysers. We evaluated a simulated prevalent cohort of 60 year old male hemodialysis patients whose characteristics were representative of a 'typical' Canadian dialysis centre with regards to the presence of comorbid disease (40% with diabetes, 40% with ischemic heart disease) [8]. A Markov process [17] was used to model yearly transitions between the three possible clinical states, 'alive on hemodialysis', 'alive with a renal transplant' and 'dead'. In cycles subsequent to transplant, patients could die, return to hemodialysis, or continue with a functioning transplant. The analysis was continued until less than 5% of the cohort remained alive (19 year for the baseline analysis). The model outputs were QALYs and costs. QALYs were estimated by multiplying the number of cycles spent by the average patient in each clinical state by the utility associated with the state.

Costs and QALYs were both discounted at an annual rate of 5% as suggested by the Canadian Coordinating Office for Health Technology Assessment [18]. For this study, we used the arithmetic mean for costs and utilities since it is a more appropriate measure for decision analysis, which considers the effect of an intervention on an average patient. All analyses were performed using DATA software, version 3.5 (TreeAge Software, Inc., Williamstown, Massachusetts).

Clinical outcomes

The annual mortality of hemodialysis patients on synthetic dialysers (12.6 and 28.4% risk per year for 40 and 60 year old hemodialysis patients, respectively) was estimated using the average annual mortality risk reported for hemodialysis patients by the Canadian Organ Replacement Registry (CORR), stratified by age [8]. In order to determine the relative risk (RR) of mortality for patients being treated with cellulose dialysers, a standard fixed effects meta-analytic method [19] was used to combine the RR of mortality as reported in all relevant studies. Studies were identified through a comprehensive MEDLINE and EMBASE search, 1968-present, using the search terms 'dialyzer', 'hemodialysis' and 'mortality' as well as by hand searching the bibliography of all relevant identified articles. Included studies had to meet the following criteria: data not previously reported in a study already considered in the meta-analysis, prospective data collection, follow-up of $>70\%$ of patients, and adjustment of relative risk for age and the presence of diabetes, two factors likely to confound the risk of mortality. Only three of 59 screened studies met inclusion criteria [11,15,16].

The number of days spent in hospital per year for patients using synthetic dialysers (7.4 days per year, 95% CI 4.2–10.7) was estimated using results from a local study [20]. The RR of hospitalisation for patients being treated with cellulose dialysers was calculated as above for mortality. To be included in this meta-analysis, all studies had to meet the above-noted inclusion criteria and also had to report the RR of hospitalisation. Only two published studies [12,15] were found that reported the RR of hospitalisation for patients using cellulose vs synthetic dialysers.

The rate of transplantation for dialysis patients (8.35% per year) was estimated using data from CORR [8] while the mortality risk for transplant patients (3.8% per year) was estimated from a recent study [21]. Based on recent data looking at renal transplant graft survival in the 1990s in North America [22], the rate of transplant failure per year was estimated to be 4.0% per year.

The average utility score for patients treated with hemodialysis (0.621, 95% CI 0.574,0.668) or renal transplantation (0.816, 95% CI 0.626–1.0) was estimated from a local study of 192 patients using the Euroqol EQ-5D [23], which is very similar to the results of other recent studies [2,24]. The average utility score for hemodialysis patients treated with cellulose and synthetic dialysers was assumed to be equal since several studies have shown no difference in condition-specific QOL or intra-dialytic symptoms for patients treated with cellulose or synthetic dialysers [15,25,26]. The effect of this assumption was tested in sensitivity analyses.

Defining the cost categories considered

We considered the effect on the cost-per-QALY ratio of four different estimates of costs (Table 1): (1) inclusion of the *cost of the dialyser only*, excluding the cost of related medical care; (2) inclusion of the *cost of the dialyser and of related medical costs*, such as dialysis and transplantation, assuming that all patients are treated with in-centre hemodialysis; (3) inclusion of the *cost of the dialyser and both related and unrelated medical costs*; and (4) inclusion of the *cost of the dialyser and all related and unrelated medical costs and non-medical expenditures*. In sensitivity analysis, we also considered inclusion of only *related medical costs*, assuming that all patients are treated with the less-expensive home hemodialysis, rather than in-centre hemodialysis.

The first analysis examines the impact of the use of the more effective, and marginally more expensive, synthetic dialyser (see below). The second and third analyses are used to examine whether, because hemodialysis and other required medical care is costly and required indefinitely, the improved survival among ESRD patients can lead to substantial increases in the cost per QALY gained from the use of a synthetic dialyser. The fourth analysis illustrates the impact on the cost per QALY of including a broader range of future costs and allows comparison of the incremental impact of their inclusion *vis-à-vis* those of future (related and unrelated) medical costs.

Measuring and valuing costs

In this analysis, we used the perspective of the health-care payer and of society, depending on the costs considered. Costs were converted to 1999 Canadian dollars using the consumer price index for health-care goods for Canada [31]. All cost estimates, including the unit costs of the different dialysers, are shown in Table 1.

The cost of the synthetic dialyser was based on a local contract that included a cost reduction due to a volume-based discount. Similarly, the cost for the cellulose dialyser was estimated from a potential local contract that also took account of a volume-based discount. The cost of related health care (including the cost of dialysis supplies, salaries for dialysis staff, outpatient clinic visits, physician claims and hospital admissions for kidney-failure related reasons (i.e. vascular access related)) was estimated from a Canadian study [27]. The cost of outpatient dialysis care (i.e. the cost of related health care) varies based on whether the patient is treated with in-centre or home

Table 1. Cost estimates

Variable	Baseline estimate	Range	Data source
Cost of intervention			
Cost of synthetic hemodialyser/run	$18	$16–20	[a]
Cost of cellulose dialyser/run	$15	$8–18	[b]
Related medical costs			
Yearly cost of outpatient in-centre hemodialysis[c]	$60 819	± 20%	[27]
Yearly cost of outpatient home hemodialysis[c]	$23 978	± 20%	[27]
Yearly cost of transplantation[d]			
Year 1	$66 290	± 20%	[25]
Years 2 and on	$27 875/year	± 20%	
Unrelated medical costs			
Yearly costs of hospitalisation (per average 60 year old patient treated with synthetic single- use) not	$7309 (60 year old)	$4035–11 387	[21]
directly related to kidney failure (i.e. excludes dialysis access-related admissions)	$5308 (for 40 year old)	$2960–8460	[21]
Yearly cost of medications (excluding kidney-failure related medications such as erythropoietin)	$4252		
Non-medical costs per year (i.e. net resource use equal to consumption[e] – earnings[f])	$20 164 (> 65 year old male)		[28–30]
	$16 079 (60 year old male)		
	$6880 (40 year old male)		

[a] Pricing based on local volume-based discount rate for synthetic dialyser (high efficiency (surface area 1.8 m^2), low flux polysulphone membrane).
[b] Estimate based on potential contract including a volume-based discount rate for cellulose dialyser (high efficiency (surface area 1.7 m^2), low flux cellulose acetate membrane).
[c] Includes nursing salary, physician charges, overhead, cost of kidney failure-related admissions and the cost of erythropoietin (excludes the cost of the dialyser and annual hospitalisation costs for non-kidney failure-related admissions).
[d] Assumed equal for both strategies.
[e] Future consumption = Annual consumption of non-medical goods ($19 702 per year [28]) + annual consumption of medical goods ($462 per year [29]).
[f] Future earnings [30] adjusted for patient age [8] and labour force participation.

hemodialysis (Table 1) [20]. In-centre and home hemodialysis differ only with respect to the requirement for nursing care (patients on home hemodialysis are trained to do their own dialysis). As such, for patients who are eligible for treatment with either in-centre or home hemodialysis, the health outcomes associated with each type of dialysis should be, for practical purposes, identical. For the baseline analysis, we considered the cost of in-centre hemodialysis. The cost of renal transplantation was taken from a Canadian study [24]. The cost of unrelated health care (including the annual cost of non-kidney failure-related medications and the annual mean cost of non-kidney failure related hospitalisation) for hemodialysis patients using synthetic dialysers was estimated from a local study [21] (Table 1).

Non-medical expenditures were estimated by calculating lifetime total net resource use for patients by adding age-specific estimates of average consumption [28,29] net of earnings [6,30]. Average consumption by age was estimated with data from the Canadian Survey of Household Spending and included the annual consumption of non-medical and medical goods. Average earnings by age were estimated from 1998 Canadian data [30]. Given that our analysis takes the societal perspective when including these indirect costs, we used gross wages to estimate earnings. Because labour force participation rates are reduced among persons on dialysis, we determined the earnings of those on dialysis by multiplying the age-related average income by the rate of labour force participation as determined using local data [32] for persons treated with dialysis (25, 33.9, 10.4, and 0% for hemodialysis patients aged < 24, 25–55, 55–65, and > 65). In baseline analyses, the estimates considered for each of the above variables were for 60-year-old men.

Approximating the effect of future costs on the cost-per-QALY ratio using the Meltzer formula

The correct way to estimate the effect of including future costs on the cost per QALY ratio is to directly include them in the analysis. For studies that have not done this, Meltzer has developed a formula for estimating the effect on the cost-per-QALY ratio of inclusion of future costs (for unrelated medical costs and non-medical expenditure) [4]. Since we were able to estimate the impact on the cost per QALY using both methods, we have taken the opportunity to test the predictive ability of the Meltzer formula, which has previously only been tested in one study of intensive therapy for Type 1 Diabetes for young adults [6].

The portion of the formula that approximates the effect of inclusion of future costs on the cost per QALY is as follows:

$$C \times \left(\frac{\Delta\text{LIFEEXPECTANCY}}{\Delta\text{QALYs}}\right)$$

where C is the average annual net resource use over the remainder of a person's life after treatment [4]. In our study, C was calculated from our decision model by totalling the annual net resource use (consisting of the 'future costs' of unrelated medical care and non-medical expenditure) for an average patient (discounted at 5% per year) and dividing by the life expectancy of an average patient (also discounted at 5% per year). In the absence of the decision model, C could have been estimated by totalling the sum of unrelated medical costs and non-medical expenditure per year (Table 1), though only given the assumption that these costs were constant in future years.

Results

Risk of mortality and hospitalisation

Although based on a small number of studies, each with its own methodological drawbacks, we noted a statistically significant increase in the relative risk of mortality (RR 1.27, 95% CI 1.04,1.56) as well as a trend towards an increase in hospitalisation (RR 1.14. 95% CI 0.9,1.49) in patients treated with cellulose dialysers compared with synthetic dialysers.

Cost-utility analysis

Over a 19-year time horizon, synthetic dialysers lead to, on average, an extra 0.38 QALYs per patient compared with cellulose dialysers. Use of synthetic dialysers was also the more expensive strategy, though only a small portion (i.e. 6%) of the extra cost for this strategy was related to an increased expenditure on synthetic dialysers themselves (Table 2).

The cost per QALY gained by synthetic over cellulose dialysers ranged from \$5036, when only the cost of the intervention was considered (i.e. exclusion of the cost of related and unrelated medical care and non-medical expenditures), to \$83 501, when the cost of the intervention and related medical care costs were included, to \$121 124 when all future costs were included. The magnitude of the increase in the cost per QALY ratio was mostly due to the high cost of future related medical care (i.e. dialysis and transplantation) (Table 2). Inclusion of the cost of future unrelated medical care and non-medical expenditures also had a significant, though less large impact on the total costs of each strategy and on the size of the cost per QALY ratio (Table 2).

Sensitivity analysis

Sensitivity analysis was performed for the second scenario, which considered the cost of the dialyser and related medical care only. The results of this analysis were not sensitive to plausible changes in the utility scores, the cost of annual hospitalisation or renal transplantation or discount rates. Moreover, the cost per QALY ratio from choosing synthetic over cellulose dialysers remained between \$83 000 and 95 000 as the relative risk of mortality for cellulose over synthetic dialysers was varied between the 95% CI for the RR, 1.04–1.56. This was due to a constant relative increase in both QALYs gained by synthetic over cellulose and the added cost of dialysis for patients living longer. As noted above, the magnitude of the cost-utility ratio was most affected by the estimate considered for the ongoing cost of dialysis; for patients treated with the less expensive home hemodialysis, the use of synthetic over cellulose dialysers was associated with a more favourable cost-utility ratio (\$46 586 vs \$83 501) (Table 2).

We repeated the analysis using average 40-year-old hemodialysis patients (assuming a lower

Table 2. The effect of inclusion of different measures of 'future' costs for related and unrelated medical care and non-medical costs on expected per patient total cost, QALYs, and cost per QALY ratio

Annual costs estimated including:	Strategy	Average cost per patient (5% discount rate)	Average number of expected QALYs (5% discount rate)	Incremental cost–utility ratio (synthetic vs cellulose)
Cost of the intervention (dialyser) only (excluding the cost of dialysis and transplantation)	Synthetic Cellulose	\$6360 \$4430	2.61 2.23	\$5036
Cost of the intervention + related medical costs only (i.e. excludes 'future costs'[a])	Synthetic Cellulose	\$200 495 \$168 506	2.61 2.23	\$83 501
Cost of the intervention + related and unrelated medical costs	Synthetic Cellulose	\$243 733 \$207 545	2.61 2.23	\$94 461
Cost of the intervention + related and unrelated medical costs + non-medical costs (i.e. includes 'future costs'[a])	Synthetic Cellulose	\$309 461 \$263 059	2.61 2.23	\$121 124

[a] Cost of future care = cost of unrelated medical care + cost of non-medical consumption – income (adjusted for age and labour workforce participation).

annual mortality, 12.8%, and different estimates for the cost of unrelated medical care and non-medical expenditures (Table 1)). Considering only the cost of the dialyser and related medical costs, the cost per QALY gained by synthetic over cellulose dialysers was very similar, \$87 590. However, when we considered the cost of the dialyser, related and unrelated medical care and non-medical expenditures, the cost per QALY gained by synthetic over cellulose dialysers was \$105 349, less than the \$121 124 noted for average 60 year olds.

As expected, if we assumed that health-related QOL was lower for patients using cellulose compared to synthetic dialysers, then there was a reduction in the cost per QALY. Assuming a 10% reduction in the utility score for patients using cellulose dialysers, the cost per QALY ratio decreased from \$83 501 to \$63 892.

Use of the Meltzer equation to approximate the effect of future costs

The Meltzer formula predicts an increase in cost per QALY of \$42 936/QALY (= average annual future cost for unrelated medical care and non-medical expenditure, \$29 135 per life year X (0.56/0.38)) when future costs are included (Table 3). This is very similar to the increase that is obtained by directly incorporating future costs into the decision model (\$121 124 − 83 501 = \$37 623/QALY (Table 2)).

Discussion

Given the widespread use of synthetic dialysers, it is perhaps surprising that the cost per QALY gained of \$83 501 (considering only dialyser and related medical costs) is so high. Although we disagree with the following approach in principle, if one were to unthinkingly compare this number to the traditional value (\$50 000) that is often cited by decision makers as the critical value for 'cost-effective' care [33], then one might conclude that dialysis using synthetic dialysers is an inefficient use of resources. In comparison to the use of resources for other more cost-effective therapies, this may be correct but two additional aspects require consideration.

Table 3. The effect of including the cost of 'future' care (unrelated medical and nonmedical expenditures) on the cost per life year gained and the cost per QALY gained

	Cellulose dialyser[b]	Synthetic dialyser[b]	Difference (Synthetic−Cellulose)[b]
Cost of treatment excluding cost of future care[a]	\$168 506	\$200 495	\$31 989
Cost of treatment including cost of future care[a]	\$263 059	\$309 461	\$46 402
Expected life years	3.18	3.74	0.56
Expected QALYs	2.23	2.61	0.38
$\Delta C/\Delta$LY excluding cost of future care[a]			\$57 123
$\Delta C/\Delta$LY including cost of future care[a]			\$82 861
$\Delta C/\Delta$QALY excluding cost of future care[a]			\$83 501
$\Delta C/\Delta$QALY including cost of future care[a]			\$121 124

[a] Cost of future care = cost of unrelated medical care + cost of non-medical consumption − income (adjusted for age and labor workforce participation).
[b] Five per cent discount rate for both costs and effects.

Firstly, as Table 2 suggests, the magnitude of the cost-utility ratio for synthetic dialysers may be more dependent on the estimate used for future outpatient hemodialysis costs rather than the costs and benefits that are directly related to the intervention. We can find no examples in the literature where the inclusion of such costs, even those which are for related medical care, has had such a drastic effect on the cost per QALY ratio [4]. This may be due in part to the fact that the intervention in question increases length of life more than the quality of life [4]. Moreover, because hemodialysis is only marginally cost effective (cost of >\$60 000 per year [20] and associated with a utility score of ~0.6 [27]) and is required on an indefinite basis, interventions for hemodialysis patients that improve survival without reducing the need for hemodialysis will inevitably be associated with a cost-utility ratio at least as great as that of hemodialysis itself. Alternatively, interventions for ESRD patients that improve health-related QOL, more so than survival, may still appear cost effective.

Secondly, and more generally, dialysis provision has traditionally not been questioned by health-care providers. Without dialysis, patients with ESRD face certain death. How can this view be reconciled with the controversial indication from health economics that hemodialysis is of borderline efficiency? One possibility is that health-care providers fund care for ESRD patients based on equity considerations. Alternatively, health-care providers may not view all QALYs equally [33, 34]. A QALY attained using a treatment that prevents certain death (e.g. dialysis for people with ESRD) may be more valuable than one resulting in an improvement in the probability of survival or of experiencing a higher QOL (e.g. treatment of hypertension) [35]. This has been suggested previously by David Hadorn who has written on the 'Rule of Rescue' [36], a rule that was first described by Jonsen [37] who noted the difficulties that it posed for resource allocation planning. On the other hand, in the case specifically at hand, the use of cellulose dialysers is not associated with certain death, raising the question whether the 'Rule of Rescue' is relevant to the choice of dialyser.

How to reconcile the discomfort one may feel about withholding an effective and apparently 'inexpensive' therapy due to a set of 'hidden' future costs is not clear. Perhaps another method, such as willingness to pay, may be better able to value the non-medical benefits in this area not captured by the QALY. For example, it may be that people are willing to pay more for life years which are saved for certain, as in the case of ESRD, as opposed to the same number of statistical life years saved by investing in other interventions. However, even if decision makers may be willing to fund dialysis for patients with ESRD (based in part on the rule of rescue), they may not be willing to fund treatments for patients with ESRD (such as the intervention that we examined) which are not associated with certain death and have an unfavourable cost per QALY. This view may seem paradoxical since the magnitude of cost per QALY in this example was largely due to the cost of ongoing dialysis, not the intervention itself.

We must remember that decision analysis is meant only to inform decision makers of the consequences of choosing or not choosing a new therapy. As such, for treatments that extend length of life for dialysis patients, it may be of benefit to present decision makers with information on the following: the difference in expected health outcomes, the direct health-care costs arising from the intervention (excluding the cost of dialysis and transplantation) and the expected increase in costs due to the ongoing need for dialysis as a result of increased survival.

It is interesting to note that in comparison to the effect of inclusion of the costs for related medical care, inclusion of future costs for unrelated medical care and non-medical expenditures had a smaller relative effect on the cost-utility ratio, particularly when the analysis was repeated for younger 40 year old patients. However, the absolute increase in the cost-utility ratio was still large (> \$35 000), which would be expected for a treatment which extends length of life more than QOL [4]. This absolute increase suggests that for interventions aimed at patients with lower costs for related medical care, even for those with relatively short life expectancies, inclusion of future costs for unrelated medical care and non-medical expenditures is still an important issue to consider. Another interesting observation was that the impact of inclusion of future costs for unrelated medical care and non-medical expenditures differed by patient age, due to higher work force participation among younger patients. Equity would clearly become a consideration if a decision were taken to fund a therapy only for younger people based on this discrepancy.

There were several limitations to our study. It is possible that the results of our meta-analysis do not reflect the true RR of mortality with cellulose dialysers since a recent meta-analysis done comparing synthetic and cellulose dialysers did not find an elevated risk of mortality associated with cellulose dialysers [38]. However, that meta-analysis pooled only the results of two randomised trials that were small, had several methodological problems, and were not intended to study the effect of the dialyser on mortality [15,16]. We included, in addition to the above two studies, a larger prospective, but non-randomised study ($n = 2410$) comparing synthetic and cellulose dialysers [11]. In our sensitivity analysis, our results remained similar as long as the relative risk of mortality associated with cellulose dialysers was > 1.04. Moreover, the focus of our study was on methodological aspects of economic evaluation for interventions that prolong survival for hemodialysis patients, rather than determining an exact cost per QALY figure for synthetic over cellulose dialysers (which will likely not be possible in the absence of a well-designed clinical trial). Some may criticise the use of the human capital-cost approach to estimate indirect costs as this approach has been reported to have several drawbacks [39,40]. However, in situations where primary data collection is not feasible, it does provide a reasonable estimate of indirect costs.

Our study provides an important test for the formula proposed by Meltzer to approximate the effect of including future costs for unrelated medical care and non-medical expenditures on the cost-utility ratio [4]. Previously, this formula had been tested only once in an economic evaluation using a societal perspective studying intensive therapy for Type 1 Diabetes for young adults [6]. In that study, the formula was only moderately predictive of the actual effect that incorporation of future costs had on the cost per QALY [6]. We found the formula to be accurate at predicting the effect of including future costs for unrelated medical care and nonmedical expenditures on cost per QALY. For published studies that have not considered future costs, our study suggests that this formula may provide a reasonable estimate of the effect of including them.

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