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Original Article

The cost-effectiveness of contemporary home haemodialysis modalities compared with facility haemodialysis: A systematic review of full economic evaluations

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SUMMARY AT A GLANCE

This systematic review has examined cost utility data for home-based haemodialysis between 2000–2014 and identifies 6 studies that provide evidence in support of benefit for home-based therapies. Higher initial costs are off-set by better patient outcomes and reduced facility costs for home therapies. This information provides support for expanding home haemodialysis in a resource capped health system.

ABSTRACT:

Aim: **The financial burden of the increasing dialysis population challenges healthcare resources internationally. Home haemodialysis offers many benefits over conventional facility dialysis including superior clinical, patient-centred outcomes and reduced cost. This review updates a previous review, conducted a decade prior, incorporating contemporary home dialysis techniques of frequent and nocturnal dialysis. We sought comparative cost-effectiveness studies of home *versus* facility haemodialysis (HD) for people with end-stage kidney failure (ESKF).**

Methods: **We conducted a systematic review of literature from January 2000–March 2014. Studies were included if they provided comparative information on the costs, health outcomes and cost-effectiveness ratios of home HD and facility HD. We searched medical and health economic databases using MeSH headings and text words for economic evaluation and haemodialysis.**

Results: **Six studies of economic evaluations that compared home to facility HD were identified. Two studies compared home nocturnal HD, one home nocturnal and daily home HD, and three compared contemporary home HD to facility HD. Overall these studies suggest that contemporary home HD modalities are less costly and more effective than facility HD. Home HD start-up costs tend to be higher in the short term, but these are offset by cost savings over the longer term.**

Conclusions: **Contemporaneous dialysis modalities including nocturnal and daily home haemodialysis are cost-effective or cost-saving compared with facility-based haemodialysis. This result is largely driven by lower staff costs, and better health outcomes for survival and quality of life. Expanding the proportion of haemodialysis patients managed at home is likely to produce cost savings.**

Internationally, dialysis programs are faced with challenges of an increasing number of incident patients and limited healthcare resources with which to manage them. The provision of dialysis imposes a significant burden on the health budgets of almost all countries.[1–3] In developed nations, home haemodialysis (HD) is generally accepted to be a cost-effective alternative to traditional facility based HD at hospitals and satellite units. Moreover, the modality has been reported to by some investigators to provide superior clinical and patient-centred outcomes, particularly in respect to quality of life (QOL).[4–6] A previous systematic review reported studies published up until the year 2000, and supported the overall cost-effectiveness of home HD, and concluded that home HD was probably more effective in terms of survival, and had a lower cost per quality-adjusted life-year (QALY) than hospital-based HD.[5]

However, since that time, new techniques of home HD have been popular, including frequent (e.g. 5–7 times per week) and extended hours (e.g. nocturnal) home HD. These techniques involve treatments that undoubtedly consume more resources than those associated with conventional home HD, due to the increased number and duration of treatment sessions.[7–9] However, they also result in an improved QOL, and reduced burden of kidney disease.[10–18] Moreover, although there are no adequately powered clinical trials, available evidence suggests a potential mortality benefit as well.[7,19–26] At the present time, a large proportion of home HD treatments performed around the world involve frequent and/or extended hour regimens, provided to patient populations that are often older with greater burden of co-morbidity than previously. This change in the dialysis landscape is the motivation for an update of the previous systematic review,[5] examining cost-effectiveness under the conditions of contemporary clinical practice and modern patient selection criteria.

Economic evaluation is defined as the comparative analysis of alternative courses of action, in terms of both costs and consequences.[27] In health, the main types of economic evaluations are cost-effectiveness analysis (CEA) and cost-utility analysis (CUA), which vary only in how the health outcomes are measured and valued. In CEA health outcomes are measured in natural units (e.g. life years saved). In CUA health outcomes are multidimensional (i.e. QALY), which combine both survival and QOL into a single metric.[27,28]

Economic evaluations estimate the additional health benefits of a given intervention and the additional costs associated with achieving those benefits. The outcomes of evaluation are presented as the 'incremental cost-effectiveness ratio' (ICER), a ratio of the difference in costs between two interventions, divided by the difference in their respective outcomes.

$$ICER = \frac{Total\ Cost_{New\ Treatment} - Total\ Cost_{Current\ Treatment}}{Total\ Outcomes_{New\ Treatment} - Total\ Outcomes_{Current\ Treatment}}$$

Whether an intervention is considered good value for money is dependent on a number of factors, including the country, the health system and the clinical context. Typical published ICER values that might be considered good value for money are in the order of around US$48 500 per QALY gained in the UK, around US$50 000 per QALY gained in Australia and around US$83 900 per QALY gained in Canada.[29]If the intervention is both less costly and at least as effective as another, then the intervention is considered to be 'dominant'.

In this study, we aim to update and compare the findings of a previous systematic review of home HD,[5] examining cost-effectiveness.

METHODS

A systematic review was conducted by searching the following databases: Medline, PreMedline (Ovid); National Health Service Economic Evaluation Database (NHSEED); Health Technology Assessment Databases of Centre of Review (HTA); The Cochrane Library – CDSR, CCTR, DARE; EMBASE; Cinahl; CEA Tufts; Econlit; and Scopus from January 2000–March 2014 for economic evaluations comparing home and facility haemodialysis. Medical Subject Headings (MeSH) terms and text words for haemodialysis and economic evaluation were used (Appendix I).

The titles and abstracts of potentially relevant studies were read by first author (RW). Once abstracts were reviewed for inclusion, any that were difficult to categorize were independently assessed by a second researcher (MM). The full text of each included study was reviewed by RW and MM and any questionable studies were independently assessed for eligibility by two additional researchers (RM and KH) using pre-defined criteria. All relevant studies were assessed, regardless of language. Studies were included if they were full economic evaluations and provided comparative information on the costs, health outcomes and cost-effectiveness ratios of home HD (defined as HD in an independent fashion by the patient at home) and facility HD (defined as HD in an dependent fashion at a hospital or satellite dialysis HD unit under the direct supervision of clinical staff). Exclusion criteria were: review or opinion papers, analyses of paediatric populations, and those involving haemofiltration or haemodiafiltration. Purely descriptive studies of costs were also excluded as they are not full economic evaluations, despite some offering comprehensive cost information.[7,9,30–34]

The following data was extracted from included papers: location and setting; publication year; population characteristics; haemodialysis session frequency and length; type of economic evaluation (CEA, CUA, or cost-benefit analysis); economic evaluation methods used (model or trial based); perspective of analysis; time horizon of analysis; reference country and year of costs; health outcomes estimated; costs included; ICER reported; sensitivity analysis methods used; variables tested in sensitivity analysis; and overall outcomes.

To facilitate comparisons, we tabulated costs as reported by authors, and converted them into a single currency (2012 US$) using OECD purchasing power parities[35] (http://www.c-cemg.org/).

RESULTS

The results of the literature search are illustrated in Figure 1. The initial search identified 241 citations. After excluding duplicate and ineligible publications, six economic evaluations comparing home and facility HD were identified, and are summarized in Table 1 (excluded studies are listed in Appendix II). Evaluations of frontier home HD technologies are not yet in the public domain. Three of the six studies compared nocturnal or daily home HD to facility HD[36,37,41] and three compared conventional home HD to facility HD. Two studies employed Markov models to estimate costs and final health outcomes (survival or quality-adjusted survival) over a patient's lifetime.[38,40]

Overall these studies show that contemporary home HD is cost-effective compared with facility HD. Most analyses suggested home HD was both less costly and more effective than

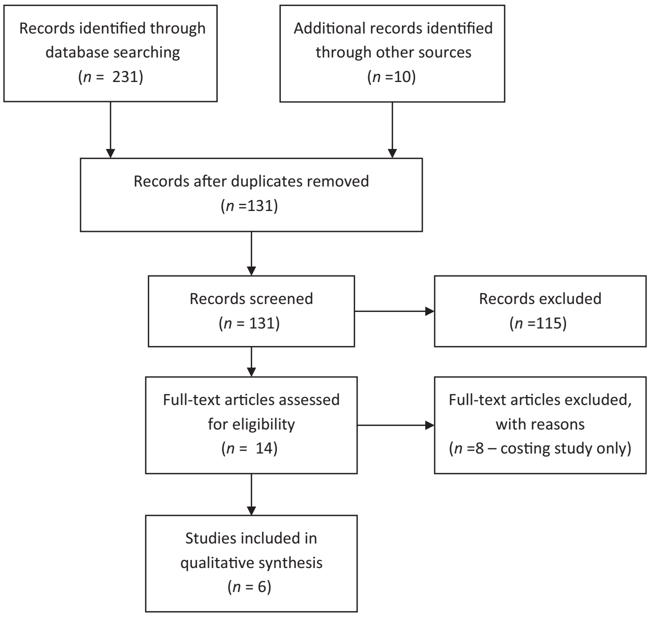

Fig. 1 Prisma flow chart of included studies.

facility HD with the caveat that start-up costs for home HD are greater in the short term and likely to be offset by cost savings in the long term (see Table 2). Specific modality comparisons and comparisons to the results of the previous systematic review[5] have been summarized (see Table 3). The six studies included in our review are discussed in more detail below.

McFarlane *et al*. 2003

McFarlane *et al*. (2003)[36] assessed the QOL and cost-utility between home nocturnal haemodialysis and conventional in-centre haemodialysis from a funder perspective. A prospective costing study was conducted from January 2000 to March 2001 and utility-based QOL was measured using the standard gamble technique.[43] Costs were from a funder perspective and presented for year 2000 Canadian dollars. Individual patient data on costs and QALY were used to bootstrap confidence intervals around mean and incremental costs and effects.

Home nocturnal dialysis ($n = 24$) and hospital dialysis ($n = 19$) patients were compared in this study and were similar at baseline. Mean total health care costs were significantly lower in the home nocturnal HD group than the in-centre group (CAN$55 139 *vs* 66 367, $P = 0.03$). The component costs of staffing and overheads were less for the home group whereas haemodialysis materials, depreciation, laboratory tests and imaging were all more expensive for home nocturnal haemodialysis. Home nocturnal HD was associated with a significantly higher QOL than in-centre HD (0.772 compared with 0.527, $P = 0.03$).

Cost-effectiveness ratios *versus* no treatment (i.e. average cost-effectiveness ratios) were reported. An incremental cost-effectiveness ratio of home nocturnal compared with in-centre HD was not appropriate as nocturnal home HD was both less costly and more effective (dominant) over in-centre HD.

The authors concluded that nocturnal home HD can provide three times as many treatment hours for significantly lower costs compared with conventional in-centre HD.

Kroeker *et al*. 2003

Kroeker *et al*. performed an economic evaluation as part of the London Daily/Nocturnal Haemodialysis Study,[37] comparing the health services costs and outcomes of short daily home HD ($n = 10$), nocturnal home HD ($n = 12$), and conventional hospital HD ($n = 22$). A before and after study approach was used, using retrospective costs of conventional HD in the 12 months prior to modality change, compared with prospective cost and QOL information (using the HUI (Health Utilities Index)[44] in patients who changed modalities). This study was conducted from the perspective of the public health system, and presented in 2001 Canadian dollars.

Costs included those dependent on the patient's own health status (pharmaceuticals and emergency visits) and those required to provide the service for patients (staff costs, biomedical engineering). The costs did not include one-time set up costs such program start-up, installation or patient training.

The study showed that total operating costs per patient-year for nocturnal home HD and hospital HD patients were similar (CAN$74 371 *vs* 72 688, respectively) whereas costs for daily home HD patients were lower (CAN$67 281). Treatment supply costs were approximately twice that of the conventional dialysis group in the daily and nocturnal patients, whereas average costs for physician consultations, hospitalizations and laboratory tests declined for the daily and nocturnal home HD groups compared with the hospital HD group. The authors concluded that cost savings may be possible by switching patients from conventional HD to either daily HD or nocturnal home HD; however these results should be interpreted with caution, given very small patient numbers, and large differences in retrospective conventional HD costs and baseline HUI values across the groups, raising questions about the comparability in the patients at baseline. Acknowledging these caveats, these data are consistent with the direction of evidence on costs and health outcomes of home HD. The authors report an 'annualized' QALY for daily home HD of 0.84, 0.70 for nocturnal home HD and 0.71 for conventional HD for the prospective part of the study; no data on QOL is available for the 12 months that has been used for retrospective cost analysis. Based on a simple comparison of retrospective and prospec-

Table 1 Description of included studies and their methods

Author (year) Country	Type of home dialysis and items considered	Costs included	Types of economic evaluation	Perspective, [discount rate]	Reference year and currency for costs
McFarlane *et al*. (2003)[36] Canada *n* = 24 (nocturnal) 19 (hospital)	Compared home nocturnal HD to conventional HD	Direct healthcare costs Direct HD material costs Staffing Overhead and support Medications Admissions and procedures Laboratory tests and medical imaging Physician fees Depreciation/capital costs	Cost utility analysis	Funder discount rate not specified	2000 Canadian dollars
Kroeker *et al*. (2003)[37] Canada *n* = 10 (home daily) 12 (nocturnal) 22 (hospital)	Direct costs; detailed item list provided Compared short daily; long nocturnal and conventional thrice-weekly HD Before and after study of retrospective in-centre costs prior to modality switch and prospective costs after modality switch	Direct healthcare costs Patient-measured costs: Treatment supplies Consults Emergency visits Hospitalizations Lab tests Pharmaceuticals Support modelled costs: Physician fees Machine Water Nurse Labour Biomedical engineering Non-treatment supply Excluded: Nocturnal HD monitoring, training, program start-up, home installation and new unit construction; operating costs for monitoring system and patient transport	Cost utility analysis	Health care funder discount rate not specified	2001 Canadian dollars
Gonzalez-Perez *et al*. (2005)[38] Scotland	Clinical and cost data from a systematic review (Mowatt review) Compare hospital; satellite and home HD	Direct healthcare costs Access costs Home conversion Training costs Equipment Building costs Consumables Clinical Staff Nursing Staff Inter dialysis Intra dialysis	Cost benefit analysis using Markov model	Health care funder discount rate of 6%	2001/2002 UK pounds
Malmstrom *et al*. (2008)[39] Finland *n* = 33 (home) 32 (self-care satellite)	Compare home HD and self-care satellite HD	Direct healthcare costs Hospital – dialyses, out-patient visits, hospitalizations, surgical procedures, laboratory, radiology Labs in primary health care Medication Home installation Pseudo Societal Assistant remuneration Travel costs	Cost utility analysis	Societal Discount rate not specified	2004 Euro
Howard *et al*. (2009)[40] Australia	Compared increased uptake of home HD (to 35% in 25–44 year olds; 25% in 45–64 years; 10% in 65–74 years and 2% in 75 + year olds) to current practice patterns	Direct healthcare costs: Dialysis equipment Buildings, maintenance Salaries and wages Consumables Costs of initial access, revision of access, drugs Hospitalizations Specialist consultations	Cost utility analysis using multi-cohort Markov model	Health care funder discount rate of 5% per annum	2004 Australian dollars
Klarenbach *et al*. (2014)[41] Canada	Compared frequent home nocturnal HD to conventional HD (4 h 3× week)	Annual dialysis costs Training and set up costs Medication costs Physician billing Patient-borne costs; training time and productivity losses	Cost utility analysis	Health payer perspective; societal perspective	2012 Canadian dollars

Table 2 Description of Included Studies –costs and outcomes (costs also converted to 2012 US$)

Author (year) Country	Health outcomes and method of measurement	Costs	ICER and main results	Sensitivity analysis	Notes
McFarlane *et al*. (2003)[36] Canada *n* = 24 (nocturnal) 19 (hospital)	QOL –standard gamble technique ICHD 0.527 (over 12 months) NHHD 0.772 (over 12 months)	Mean annual costs ICHD $66 367 (2012 US$71 237) NHHD $55 139 (2012 US$59 185)	NHHD is both less costly and more effective than ICHD (Home HD dominant) Mean cost savings: $11 227 (2012 US$12 051) Mean QALY gain 0.2444 Unadjusted NMB of NHHD ranged from $11 227 (at WTP of $0) to $35 669 (at WTP of $100 000),(2012 US$12 051 to 38 286 respectively)	Uncertainty captured using bootstrapping of mean and incremental costs and QALY	
Kroeker *et al*. (2003)[37] Canada *n* = 10 (home daily) 12 (nocturnal) 22 (hospital)	QALY –health utility index (HUI). Measured at baseline immediately prior to modality switch, and over 12 months, reported as 'annualized QALY' ICHD – 0.80 (baseline) 0.71 (annualized QALY) DHHD – 0.80 (baseline) 0.84 (annualized QALY) NHHD – 0.69 (baseline) 0.70 (annualized QALY)	Total operating costs per patient year (retrospective (retro) and prospective (prosp)) ICHD: $69 626 (retro) *vs* $72 688 (prosp) (2012 US$73 908 *vs* (2012 US$77 158) DHHD $77 055 (retro) *vs* $67 281 (prosp) (2012 US$81 794) *vs* (2012 US$71 419). NHHD $91 793 (retro) *vs* $74 371 (prosp) (2012 US$97 438) *vs* (2012 US$78 945)	DHHD likely to offer both lower costs and improved QALY Authors only report 'total annualized Cost/QALY' but these are average cost-effectiveness ratios, and not ICER compared with in-centre DHHD$85 442 (2102 US$90 697) NHHD $120 903 (2012 US$128 338) Control $116 753 (2012 US$123 933)	Not conducted	Very small patient numbers. Likely between group differences at baseline, given baseline costs and QOL Average CER reported, not incremental CER *vs* ICHD
Gonzalez-Perez *et al*. (2005)[38] Scotland	QALY Utilities from SR (Mowatt), utility data from de Wit EQ5D, assuming home HD had same QOL as satellite in base case Satellite HD 0.81 total QALY 2.08 and 3.03 at 5 and 10 years Home HD 0.81 total QALY 2.32 and 3.45 at 5 and 10 years Hospital HD 0.66 total QALY 1.69 and 2.487 at 5 and 10 years	Mean annual per patient costs: Hospital £22 246 (2012 US$42 690) Satellite £21 264 (2012 US$40 806) Home £22 654 (2012 US$43 473) Total per patient costs Analysis 1: Satellite: £46 001 (5 years); £62 054 (10 years) (2012 US$88 276; 11 9082) Home HD £47 657 (5 years); £63 539 (10 years) (2012 US$91 454; 12 1931) Hospital HD £48 254 (5 years); £65 131 (10 years) (2012 US$92 600; 12 4987) Analysis 2: Satellite: £46 000 (5 years); £62 052 (10 years) (2012 US$88 274; 11 9078) Home HD £53 494 (5 years); £71 616 (10 years) (2012 US$102 655; 13 7431) Hospital HD £48 255 (5 years); £65 132 (10 years) (2012 US$92 601; 12 4988)	2 analyses: (1) assuming same duration and frequency of HD for all modalities, and (2) home HD frequency set to short daily ICER for home HD ($ per QALY gained) Base case 1 *vs* hospital HD: Home HD is dominant at both 5 and 10 years *vs* satellite HD: £6665/QALY gained at 5 years and £3943 at 10 years (2012 US$12 790; 7567) Base case 2 Short daily home HD *vs* hospital HD: £7586/QALY gained at 5 years and £6696 at 10 years (2012 US$14 558; 12 850) *vs* satellite HD: £30 188/QALY gained at 5 years and £22 515 at 10 years (2012 US$57 931; 43 206)	Using base case 1 under all scenarios home HD was dominant over hospital HD *vs* satellite home HD dominant over satellite with (1) increased clinical cover for satellite HD, (2) home HD mortality = satellite and hospital, and (3) satellite and hospital mortality = home HD home HD utility = 0.92 £1661–2938/QALY gained Home HD assistant £1661–2938/QALY gained Minimal clinical cover for satellite £31 460–41 764/QALY gained	Markov model
Malmstrom *et al*. (2008)[39] Finland *n* = 33 (home) 32 (self-care satellite)	QOL – measured with generic 15D instrument, QALYS not calculated Home HD = *n* = 23/33 Mean utility of 0.84 Self-care satellite HD *n* = 24/32 mean utility = 0.85	Average annual per patient costs home HD €38 477 (*n* = 23/33) (2012 US$47 551) satellite HD €39 781 (*n* = 28/32) (2012 US$49 162) Mean incremental cost of Home HD -€1304 (2012 US$1612)	ICER not calculated as QOL equivalent between home HD and satellite HD	Not done	HHD patients had longer and more frequent sessions. HHD cost higher but offset by travel costs
Howard *et al*. (2009)[40] Australia	QALYS Assumes same QOL weights for all dialysis modalities (0.55) LYS	Total cumulative cost over 5 years of current practice: $2 595 326 368 (2012 US$2 288 323 954) Total cumulative cost over 5 years of optimizing home HD uptake $2 548 742 213 (2012 US$2 247 250 261) Incremental cost savings over 5 years: $46 584 155 (2012 US$41 073 693)	ICER not calculated Improving home HD uptake is less costly and at least as effective (in terms of LYS and QALY gained) as current practice. QALY gains likely to be underestimated as QOL assumed to be the same for all dialysis modalities.	Discount rate: 2.5% to 7.5% did not substantially influence results; plausible changes in costs of transplantation and dialysis did not substantially influence cost savings either.	Multi-cohort Markov model
Klarenbach *et al*. (2014)[41] Canada	QALY – calculated with EuroQol-5D scores obtained in RCT. ICHD (0–6 months) = 0.66 ICHD (>6 months) = 0.61 NHHD (0–6 months) = 0.70 NHHD (>6 months) = 0.71	Year 1/2 + estimate annual dialysis costs based on RCT microcosting ICHD: 73 922/73 920 (2012 US$59 666/59 664) Satellite: 62 260/62 259 (2012 US$50 253/50 251) Home HD: 46 985/45 203 (2012 US$37 924/36 485) NHHD: 57 041/53 477 (2012 US$46 040/43 164) PD: 29 338/37 615 (2012 US$23 680/30 361)	NHHD dominated ICHD with an incremental cost saving of 2012 CAN$6700 (2012 US$5382) and incremental effectiveness of 0.384 over a lifetime horizon. NHHD is dominant over ICHD at both 5 years and 10 years time horizons but not at 1 year.	Discount rate: 5% applied to costs and effects. NHHD remained dominant compared with ICHD when the annual base risk of mortality was ≤3.6% or when the annual technique failure with NHHD compared with ICHD was ≤6%. FHNHD was no longer cost-effective when the annual probability of technique failure was ≥19%.	NHHD remained dominant up until hospitalization costs for NHHD were ≥25% higher than ICHD. NHHD was still cost-effective when the average patient training time was 8 weeks. When ICHD was the only comparator, NHHD remained dominant; whereas NHHD compared with satellite HD was cost-effective with an ICER of CAN 2012 $18 548/QALY.

DHHD, daily home haemodialysis; HD, haemodialysis; ICER, incremental cost-effectiveness ratio; ICHD, in-centre haemodialysis; LYS, life years saved; NHHD, nocturnal home haemodialysis; QALY, quality-adjusted life-years; QOL, quality of life; RCT, randomized controlled trial.

Table 3 Comparison of previous and current reviews of cost-effectiveness presented in 2012 US dollars

Modality Comparison	Mowatt review	Current review	
		Result	Conclusion
Conventional home HD *vs* facility HD	Home HD is cost-effective[42]	Total per patient costs of home HD US$91 454 and US$121 931 at 5 and 10 years, respectively, with costs for satellite HD of US$88 276 and US$119 082 and hospital US$92 600 and 124 987 Incremental cost per QALY gained for home HD compared with satellite HD was US$12 790 at 5 years and US$7 567 at 10 years.[38] Home HD was less costly and more effective than compared with hospital HD. Home HD total cost saving US$2 247,250 261 over a 5 year period 2005–2010[40] Total average annual costs of home HD: US$47 551; and satellite HD US$49 162[39]	Increasing uptake of home HD is dominant over current practice patterns (less expensive and at least as effective) Home and satellite HD are cost comparable
Nocturnal home HD *vs* facility HD	Not specifically examined in Mowatt	Mean annual costs ICHD US$71 237 and NHHD US$59 185 [36] Total operating costs per patient year ICHD: US$73 908 (retro) *vs* US$77 158 (prosp) DHHD: US$81 794 (retro) *vs* US$71 419 (prosp) NHHD US$97 438 (retro) *vs* US$78 945 (prosp)[37] Costs based on within-trial RCT resource use and extrapolated to patient's lifetime: ICHD: US$59 666/59 664 Satellite HD: US$50 253/50 251 Home HD: US$37 924/36 485 NHHD: US$46 040/43 164	Nocturnal home HD is both less costly and more effective that in-centre HD Nocturnal home HD is slightly more expensive than facility HD per QALY gained Frequent home nocturnal haemodialysis is both less costly and more effective than in-centre HD
Frequent (daily) home HD *vs* facility HD	Not specifically reported	Total annualized cost/QALY Daily US$90 697 ± 24 031 *vs* Facility – US$123 933 ± 29 417[37]	Frequent (daily) home HD is less expensive per QALY gained

DHHD, daily home haemodialysis; HD, haemodialysis; ICER, incremental cost-effectiveness ratio; ICHD, in-centre haemodialysis; NHHD, nocturnal home haemodialysis; QALY, quality-adjusted life-year.

tive costs it would appear that daily HD may result in cost savings and health outcomes that are at least comparable to conventional HD.

Gonzalez-Perez *et al*. 2005

Gonzalez-Perez *et al*.[38] developed a Markov model using previously published clinical and cost data from the previous Mowatt review,[5] and compared the health services costs and outcomes of hospital, satellite and home HD. The model included direct health service costs and QALY. Costs were taken from a health care funder perspective for year 2001/2002 in UK pounds sterling.

Two main analyses were conducted: (1) where the duration and frequency of HD was the same for all modalities and (2) a short-daily home HD schedule. For base case 1, average per patient costs over 5 years of home HD were estimated to be £47 657 and £63 539 over 10 years, and the average per patient costs for satellite HD were £46 001 and £62 054, both comparing favourably to hospital HD with corresponding costs of £48 254 at 5 years and £65 131 at 10 years.

Total QALY per patient at 5 years were 2.32, 2.08 and 1.69 for home HD, satellite HD and hospital HD respectively; the corresponding QALY at 10 years were 3.45, 3.03 and 2.47. Home HD was both less costly and more effective (dominant) compared with hospital HD at both time points; the ICER of home HD compared with satellite HD were £6665 and £3943 per QALY gained, at 5 years and 10 years respectively.

For base case 2, assuming short daily home HD, the ICER of home HD compared with hospital HD were £7586 and £6696 per QALY gained at 5 years and 10 years respectively. When comparing home HD with satellite HD these increased to £30 188 and £22 515 per QALY gained at 5 years and 10 years respectively.

The authors reported extensive sensitivity analyses (see Table 2). Under all scenarios, home HD was less costly and more effective than hospital HD. ICER comparing home HD to satellite HD ranged from home HD being dominant (when mortality rates were comparable across all modalities, or when extra clinical cover was required for satellite patients), to £31 460 per QALY gained at 10 years when minimal clinical cover was required for satellite patients. Increasing the QOL associated with home HD also influenced the ICER compared with satellite HD, reducing them to between £2938 and £1661 per QALY gained at 5 and 10 years respectively.

Malmstrom *et al*. 2008

Malmstrom *et al.*[39] performed an economic evaluation of patients attending self-care HD from a single centre, and compared the health services costs and outcomes of satellite and home HD. This analysis used a societal perspective with costs presented in 2004 Euros; and QOL weights estimated using the 15D instrument.[45]

Cost data were available for 23 of 33 (70%) home HD and 28 of 32 (88%) for self-care satellite HD. The per patient costs included; inpatient, outpatient hospital costs and dialysis costs; travel and outpatient medication costs; costs of laboratory tests; costs of machine and water treatment installation; remuneration of an assistant if used. QOL data were available for 23 of 33 home HD patients and 24 of 32 self-care satellite patients.

The costs of home HD and satellite HD were similar (€38 477 *vs* €39 781, with a mean difference of €1304 (95% CI 6491 to 3883), although there was variation in the relative contribution to total cost across modalities. For example, costs of home installation were higher in home HD patients and average hospital costs were also significantly higher (€4306 per year)for home HD compared with satellite HD, mainly as a result of higher dialysis-related and radiology costs. These were offset by significantly lower annual travel costs for home HD patients of EUR€4802/patient less than satellite HD patients. Home HD patients in this study had longer and more frequent dialysis than their satellite HD counterparts contributing to the higher dialysis costs for this group. In the satellite HD group these costs were offset by patient travel costs to attend dialysis.

There was no significant difference between the two groups in QOL (0.84 and 0.85 in home HD and satellite HD respectively), and thus ICER were not calculated.

Howard *et al*. 2009

Howard *et al.*[40] developed a multi-cohort Markov model of incident patients over 2005–2010, based on patient characteristics and practice patterns from the Australia and New Zealand Dialysis and Transplant (ANZDATA) registry, to compare costs and outcomes of increasing home dialysis in Australia relative to current practice. The model included the costs of dialysis, including equipment, buildings and staffing; consumables; access costs; medications; hospitalizations; specialist consultations; and health outcomes were measured in Lys and QALY over a 5 year period (2005–2010). Costs were taken from a healthcare funder perspective and presented in 2004 Australian dollars. It was conservatively assumed that all dialysis modalities had the same QOL weight (0.55).

Increased uptake of home HD was modelled, compared with current practice patterns (See Table 1), and the analysis suggested that changing practice patterns would result in a cost-saving of AU$46.6 million over 5 years.

Incremental cost-effectiveness ratios were not calculated as it was assumed that QOL weights (and therefore QALY) were the same across all dialysis modalities. This assumption is likely to have underestimated the potential health outcome gain with increased home HD. The authors concluded that home HD was less costly and at least as effective as current practice patterns.

Klarenbach *et al*. 2014

Klarenbach *et al.*[41] performed a cost-utility analysis to compare costs and outcomes of increasing home nocturnal home HD to conventional HD based on 4 hours 3 times a week and a 75% facility model (in-centre and satellite haemodialysis). This model used patient information from the Alberta nocturnal haemodialysis randomized control trial (RCT) and presented costs from a health payer perspective over a life-time horizon. The costs included: dialysis, training and set-up, medications and physician billings using administrative data and microcosting methods. Costs were reported in 2012 Canadian dollars. Health outcomes were measured in QALY gained. HRQOL by modality was determined using EUROQoL-5D scores obtained from RCT participants.

In the base case, nocturnal home HD was dominant over the conventional dialysis group. Increased uptake of nocturnal home HD led to an incremental cost saving of CAN$6700 and additional 0.38 QALY. The authors conducted a series of sensitivity analyses; nocturnal home HD remained dominant when the annual baseline risk of mortality was ≤3.6% or when the annual technique failure from nocturnal home to conventional HD was ≤6%. Nocturnal home HD was no longer cost-effective when the annual probability of technique failure was ≥19%. Nocturnal home HD remained dominant up until hospitalization costs were ≥25% higher than conventional HD. Nocturnal home HD was still cost-effective when the average patient training time was 8 weeks.

DISCUSSION

Previous studies and a comprehensive systematic review that evaluated studies to 2000 have suggested home HD to be less expensive than facility (hospital and satellite) HD.[5] This review adds 6 new studies which address cost-effectiveness of the more contemporary practice of home HD, accounting for modern health service delivery systems and selection criteria. The main finding of this review is that contemporary home HD including nocturnal and daily regimens are generally of equivalent cost or are cost-effective compared with conventional facility HD. Our results re-confirm the general findings from the previous systematic review, which also found lower costs and better outcomes for home HD compared with facility haemodialysis.

Our findings around extended hour home HD should be interpreted with caution, however, since the studies included in this review involved small cohorts of patients from single centres within already well-established home programs. As might be expected, the major differences in costs between home and facility HD was attributable to staffing requirements, transport from the patient's home to the dialysis facility and (when appropriate) the consumables required with more frequent dialysis.

There are obvious limitations around the generalizability of the findings, arising from the small number of studies, which hail from Canada, Australia, Finland and Scotland. In every system, there are unique definitions of home, satellite and hospital HD, with correspondingly different associated staffing levels and criteria for patient selection. Moreover, all studies used different financial years and currencies, and even within our review the actual costs in each country were difficult to compare. Although we converted study findings to 2012 US$ for the purpose of comparison, this could be misleading to the reader as all studies are by definition specific to their country's healthcare context, including respective funding policies and reimbursement factors.

There are also some concerns arising from the design of included studies, only one of which used data from randomized clinical trials. As described, there is considerable variation in the way included studies estimated total costs, and differences in the perspective and time horizon of their evaluation. In terms of costs, not all included the initial infrastructure for a new home HD training unit. The majority of included studies were conducted over a short time horizon, which may not be reflective of the potentially lower costs which occur as the program develops efficiencies of scale over time. Future economic evaluations should be guided by the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement.[46]

Only two of the six analyses included in this review considered the economic impact to the patient and their families,.[39,41] The study which included a societal perspective included transport costs and caregiver time, however employment or productivity changes were not considered.[39] The study by Klarenbach *et al*. included patient out-of-pocket costs; training time and productivity losses.[47] This issue has growing importance, both in terms of the financial implications to society and increasing the uptake of home HD. The societal perspective is important to identify and account for the transfer of costs from the health care system to the household and therefore to society. It has already been reported that patient reimbursement is a barrier to clinicians promoting home dialysis[48] and also influences patient and caregiver uptake of home dialysis.[49,50] To successfully promote home HD the financial implications to the patient and society require greater transparency.

Implications for practice

The results of this review suggest that, for appropriate groups, use of contemporary home HD modalities offer good value for money, or can even be cost-saving, compared with conventional facility HD. Coupled with the knowledge that home HD, (particularly extended hours home HD) improves both clinical and patient-centred outcomes, our review makes a strong case for the promotion of home HD through the initiation of new programs and the scaling of existing ones. In general terms, this is possible by ensuring all patients suitable for home HD are offered the choice of home HD, are adequately educated on the benefits of home HD and are supported throughout this process with a comprehensive multidisciplinary pre-dialysis program. Additionally, the home HD training program also needs to ensure that it can provide comprehensive on-going support to monitor and maintain satisfactory outcomes of patients on home HD. Finally, consideration should be given to the support and care of older patients with multiple comorbidities in home HD programs, while avoiding over-burdening of family and social networks.[47,49]

Implications for future research

At a fundamental level, more research is needed to confidently establish the cost-effectiveness for modern home HD modalities in larger patient cohorts. Moreover, research should evaluate costs and outcomes of home HD in older people and ethnic minorities to inform service planning and development and the optimal selection of patients. Further economic evaluation for these groups also should include the collection of longitudinal utility-based QOL data, and perhaps clarify the time interval required for patients on home HD to be cost neutral from a provider perspective. Future research might expand more on the opportunities for concurrent data collection under a single template and across several countries. A suggested Template for future economic evaluations of home HD has been included (Appendix III).

CONCLUSIONS

Our review supports the finding that contemporary home HD (including nocturnal and daily home HD) is cost-effective compared with facility HD. This result is largely driven by lower staff costs, and better health outcomes for survival and QOL. Expanding the proportion of haemodialysis patients managed at home is likely to result in significant reductions in health care expenditure.

CONFLICT OF INTEREST STATEMENT

The results presented in this paper have not been published previously in whole or part, except in abstract format.

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REFERENCES

1. Ashton T, Marshall MR. The organization and financing of dialysis and kidney transplantation services in New Zealand. *Int. J. Health Care Finance Econ.* 2007; **7**: 233–52.
2. Kerr M, Bray B, Medcalf J, O'Donoghue DJ, Matthews B. Estimating the financial cost of chronic kidney disease to the NHS in England. *Nephrol. Dial. Transpl.* 2012; **27** (Suppl 3): iii73–80.
3. Cass A, Chadban S, Gallagher M *et al*. The Economic Impact of End-stage Kidney Disease in Australia: Projections to 2020. 2010. Contract No.: ISBN: 978-0-9808596-2-1.
4. Mowatt G, Vale L, MacLeod A. Systematic review of the effectiveness of home versus hospital or satellite unit hemodialysis for people with end-stage renal failure. *Int. J. Technol. Assess. Health Care* 2004; **20**: 258–68.
5. Mowatt G, Vale L, Perez J *et al*. Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of home versus hospital or satellite unit haemodialysis for people with end-stage renal failure. *Health Technol. Assess.* 2003; **7**: 1–174.
6. Marshall MR, Hawley CM, Kerr PG *et al*. Home hemodialysis and mortality risk in Australian and New Zealand populations. *Am. J. Kidney Dis.* 2011; **58**: 782–93.
7. Agar JW, Knight RJ, Simmonds RE, Boddington JM, Waldron CM, Somerville CA. Nocturnal haemodialysis: An Australian cost comparison with conventional satellite haemodialysis. *Nephrology* 2005; **10**: 557–70.
8. McFarlane P, Komenda P. Economic considerations in frequent home hemodialysis. *Semin. Dial.* 2011; **24**: 678–83.
9. Komenda P, Gavaghan MB, Garfield SS, Poret AW, Sood MM. An economic assessment model for in-center, conventional home, and more frequent home hemodialysis. *Kidney Int.* 2012; **81**: 307–13.
10. Finkelstein FO, Schiller B, Daoui R *et al*. At-home short daily hemodialysis improves the long-term health-related quality of life. *Kidney Int.* 2012; **82**: 561–9.
11. Vos PF, Zilch O, Jennekens-Schinkel A *et al*. Effect of short daily home haemodialysis on quality of life, cognitive functioning and the electroencephalogram. *Nephrol. Dial. Transpl.* 2006; **21**: 2529–35.
12. McFarlane PA, Pierratos A, Bayoumi AM, Redelmeier DA. Estimating preference scores in conventional and home nocturnal hemodialysis patients. *Clin. J. Am. Soc. Nephrol.* 2007; **2**: 477–83.
13. Heidenheim AP, Muirhead N, Moist L, Lindsay RM. Patient quality of life on quotidian hemodialysis. *Am. J. Kidney Dis.* 2003; **42** (1 Suppl): 36–41.
14. Painter P, Krasnoff JB, Kuskowski M, Frassetto L, Johansen K. Effects of modality change on health-related quality of life. *Hemodial. Int. Symp. Home Hemodial.* 2012; **16**: 377–86.
15. Jiang JL, Ren W, Li Y *et al*. The role of short daily hemodialysis in the control of hyperphosphatemia, secondary hyperparathyroidism and anemia. *Int. Urol. Nephrol.* 2013; **45**: 1725–31.
16. Group FHNT, Chertow GM, Levin NW *et al*. In-center hemodialysis six times per week versus three times per week. *N. Engl. J. Med.* 2010; **363**: 2287–300.
17. Goldfarb-Rumyantzev AS, Leypoldt JK, Nelson N, Kutner NG, Cheung AK. A crossover study of short daily haemodialysis. *Nephrol. Dial. Transpl.* 2006; **21**: 166–75.
18. Kooistra MP, Vos J, Koomans HA, Vos PF. Daily home haemodialysis in The Netherlands: Effects on metabolic control, haemodynamics, and quality of life. *Nephrol. Dial. Transpl.* 1998; **13**: 2853–60.
19. Mohr PE, Neumann PJ, Franco SJ, Marainen J, Lockridge R, Ting G. The case for daily dialysis: Its impact on costs and quality of life. *Am. J. Kidney Dis.* 2001; **37**: 777–89.
20. Culleton BF, Walsh M, Klarenbach SW *et al*. Effect of frequent nocturnal hemodialysis *vs* conventional hemodialysis on left ventricular mass and quality of life: A randomized controlled trial. *JAMA* 2007; **298**: 1291–9.
21. Walsh M, Culleton B, Tonelli M, Manns B. A systematic review of the effect of nocturnal hemodialysis on blood pressure, left ventricular hypertrophy, anemia, mineral metabolism, and health-related quality of life. *Kidney Int.* 2005; **67**: 1500–8.
22. Lockridge RS, Kjellstrand CM. Nightly home hemodialysis: Outcome and factors associated with survival. *Hemodial. Int. Symp. Home Hemodial.* 2011; **15**: 211–18.
23. Nesrallah GE, Lindsay RM, Cuerden MS *et al*. Intensive hemodialysis associates with improved survival compared with conventional hemodialysis. *J. Am. Soc. Nephrol.* 2012; **23**: 696–705.
24. Johansen KL, Zhang R, Huang Y *et al*. Survival and hospitalization among patients using nocturnal and short daily compared to conventional hemodialysis: A USRDS study. *Kidney Int.* 2009; **76**: 984–90.
25. Blagg CR, Kjellstrand CM, Ting GO, Young BA. Comparison of survival between short-daily hemodialysis and conventional hemodialysis using the standardized mortality ratio. *Hemodial. Int. Symp. Home Hemodial.* 2006; **10**: 371–4.
26. Pauly RP, Gill JS, Rose CL *et al*. Survival among nocturnal home haemodialysis patients compared to kidney transplant recipients. *Nephrol. Dial. Transpl.* 2009; **24**: 2915–19.
27. Drummond MF, Drummond MF. *Methods for the Economic Evaluation of Health Care Programmes*, 3rd edn. Oxford, New York: Oxford University Press, 2005.
28. Jones AM (ed.) *The Elgar Companion to Health Economics*, 2nd edn. Cheltenham: Edward Elgar Publishing Limited, 2012.
29. Eichler HG, Kong SX, Gerth WC, Mavros P, Jonsson B. Use of cost-effectiveness analysis in health-care resource allocation decision-making: How are cost-effectiveness thresholds expected to emerge? *Value Health* 2004; **7**: 518–28.
30. Winkelmayer WC, Weinstein MC, Mittleman MA, Glynn RJ, Pliskin JS. Health economic evaluations: The special case of end-stage renal disease treatment. *Med. Decis. Making* 2002; **22**: 417–30.
31. Lee CP, Chertow GM, Zenios SA. A simulation model to estimate the cost and effectiveness of alternative dialysis initiation strategies. *Med. Decis. Making* 2006; **26**: 535–49.
32. Piccoli GB, Bermond F, Mezza E *et al*. Home hemodialysis a la carte: A tailormade program (1998–2003). *J. Nephrol.* 2004; **17**: 76–86.
33. Tediosi F, Bertolini G, Parazzini F, Mecca G, Garattini L. Cost analysis of dialysis modalities in Italy. *Health Serv. Manage. Res.* 2001; **14**: 9–17.
34. Komenda P, Copland M, Makwana J, Djurdjev O, Sood MM, Levin A. The cost of starting and maintaining a large home hemodialysis program. *Kidney Int.* 2010; **77**: 1039–45.
35. Shemilt I, Thomas J, Morciano M. A web-based tool for adjusting costs to a specific target currency and price year. *Evid. Policy* 2010; **6**: 51–9.
36. McFarlane PA, Bayoumi AM, Pierratos A, Redelmeier DA. The quality of life and cost utility of home nocturnal and conventional in-center hemodialysis. *Kidney Int.* 2003; **64**: 1004–11.
37. Kroeker A, Clark WF, Heidenheim AP *et al*. An operating cost comparison between conventional and home quotidian hemodialysis. *Am. J. Kidney Dis.* 2003; **1** (Suppl): 49–55.
38. Gonzalez-Perez JG, Vale L, Stearns SC, Wordsworth S. Hemodialysis for end-stage renal disease: A cost-effectiveness

analysis of treatment-options. *Int. J. Technol. Assess. Health Care* 2005; **21**: 32–9.
39. Malmstrom RK, Roine RP, Heikkila A *et al*. Cost analysis and health-related quality of life of home and self-care satellite haemodialysis. *Nephrol. Dial. Transpl.* 2008; **23**: 1990–96.
40. Howard K, Salkeld G, White S *et al*. The cost-effectiveness of increasing kidney transplantation and home-based dialysis. *Nephrology* 2009; **14**: 123–32.
41. Klarenbach S, Tonelli M, Pauly R *et al*. Economic evaluation of frequent home nocturnal hemodialysis based on a randomized controlled trial. *J. Am. Soc. Nephrol.* 2014; **25**: 587–94.
42. de Wit GA, Ramsteijn PG, de Charro FT. Economic evaluation of end stage renal disease treatment. *Health Policy* 1998; **44**: 215–32.
43. Ferguson BM, Keown PA. An introduction to utility measurement in health care. *Infect. Control Hosp. Epidemiol.* 1995; **16**: 240–47.
44. Spiker B. *Health Utilities Index: Quality of Life and Pharmacoeconomics in Clinical Trials*. Philadelphia: Lippincott-Reaven, 1996.
45. Sintonen H. The 15D instrument of health-related quality of life: Properties and applications. *Ann. Med.* 2001; **33**: 328–36.
46. Husereau D, Drummond M, Petrou S *et al*. Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement. *BMJ* 2013; **346**: f1049.
47. Morton RL, Tong A, Howard K, Snelling P, Webster AC. The views of patients and carers in treatment decision making for chronic kidney disease: Systematic review and thematic synthesis of qualitative studies. *BMJ* 2010; **340**: c112.
48. Ludlow MJ, George CR, Hawley CM *et al*. How Australian nephrologists view home dialysis: Results of a national survey. *Nephrology* 2011; **16**: 446–52.
49. Tong A, Palmer S, Manns B *et al*. The beliefs and expectations of patients and caregivers about home haemodialysis: An interview study. *BMJ* 2013; **3**: 1–13.
50. Morton RL, Snelling P, Webster AC *et al*. Dialysis modality preference of patients with CKD and family caregivers: A discrete-choice study. *Am. J. Kidney Dis.* 2012; **60**: 102–11.

APPENDIX I

Medline search strategy with MeSH terms and text words

Economic evaluation	Haemodialysis
Cost-effect$	Renal replacement therapy
Cost util$	Renal dialysis
Economic evaluation	'renal dialysis', 'haemodialysis home', 'home renal dialysis', 'home renal dialyses'
Cost	hospital haemodialysis units
QALY or quality-adjusted life-year	haemodialysis units
	hospital
	dialysis centres
	dialysis patients
	home renal
	dialysis centres.tw, facility dialysis.tw, nocturnal dialysis.tw, extended hour dialysis.tw, supported dialysis.tw, satellite dialysis.tw,' in-center dialysis.tw', ', home HD
	(hemodia$ or haemodia$ or dialy$).tw. esrd.tw.; home nursing,professional/(home or domiciliary or community).tw./night care/(nocturnal or night).tw./((slow or daily or regimen?) adj2 (hemodia$ or haemodia$ or dialy$)).tw.

APPENDIX II

Studies excluded from the review

Author (year) Country	Items considered	Type of costs	Reference year for costs	Main results	Reason for exclusion
Agar *et al.* (2005) Australia	Wage costs Recurrent expenditure Fixed costs Estimated costs of infrastructure and building	Annual costs	2003/2004 AUD	The total NHHD programme expenditure was $A33 392/patient per year ($103.82/treatment) and was 3892/patient per year less (a 10.75% saving) when compared with the SHDU expenditure of $36 284/patient per year $232.58/treatment). This represented an annual $116 750 programme saving for a 30 patient cohort.	Costing study – no outcome measure
Baboolal *et al.* (2008) UK	Direct costs, medication costs, transport costs, excluded access costs, building capital cost, water treatment costs and complications	Annual costs	2006 GBP	ICHD cost 35 023/annum, satellite 32 669. HHD cost 20 764 (one unit data only) based on 3 sessions/week. Average cost for initial 5627 for HHD year	Costing study – no outcome measure
Komenda *et al.* (2010) Canada	Start-up, training, home re-modelling, medications and in-centre runs	Annual costs	2005–2006 financial year CAN$	Annual costs in the start-up phrase: 41 824E; annual costs at optimization: 34 381E; the start up phase needs to be considered in the planning; further hidden costs need to be assessed.	No comparator; no outcome measure
Komenda (2012)	Detailed costs including direct costs, patient transport, home modification, water and electricity costs	Annual costs, Base case costing model based on lit from Aus, Canada and UK studies	2010 US$	Over time and depending on location, conventional HHD saves between $7612 and $12 403 over the first year, compared with ICHD. Frequent HHD would cost UK payers $4408 in subsequent years but save Canadian payer $3411 and AUS $4036 compared with ICHD	Costing study – no outcome measure
Lee *et al.* (2002) Canada	Direct costs; Outpatient dialysis costs Inpatient dialysis costs Dialysis access Physician fees Outpatient non-dialysis expenses Societal costs (time transport excluded)	Annual costs, based on 6 month costs	2000 US$	Home and self-care dialysis costs less than ICHD/adjusted for co-morbidity ICHD = $51 252/$50 928 Satellite $42 057/42 893 Home/Self-care = $29 961/31 679	Costing study – no outcome measure
McFarlane *et al.* (2002) Canada	Direct costs with detailed item list provided	Projected mean annual costs	2000 Can$	Projected annual costs were lower for HHD (40 513 Euro *vs* ICHD 49 522 Euro)	Costing study – no outcome measure
Olsen *et al.* (2010) Denmark	Includes hospitalizations and training	Savings	2009 Euro	The increase in out-going modalities (home) does not increase and may reduce costs.	Does not distinguish home-based modalities – unable to compare
Piccoli *et al.* (2004) Italy	Direct costs of dialysis sessions; Personnel, Dialysis kit, Social worker and diagnostics. Transport and medications excluded	Costs per session	Euro Jan–Dec 2001	On conventional 3× weekly dialysis, satellite costs were less than HHD (133 *vs* 131 Euro) the reverse was true for daily dialysis (96 *vs* 99)	Costing study – no outcome measure

APPENDIX III

Suggested template for conducting economic evaluations of home haemodialysis (This list is not exhaustive – but suggests points that are of particular importance in this area).

- Items of resource use (costs) should include all initial home dialysis training infrastructure as well as on-going costs.
- Outcomes should be reported in quality-adjusted life-years (QALY) and the results of the economic evaluation should be reported as an incremental cost-effectiveness ratio (ICER) of cost per QALY gained.
- The cost-effectiveness result reported at the study end point (e.g. 3 years), and also modelled over a patient's lifetime.
- In a multi-country study the economic evaluation conducted should be from one particular perspective e.g. AUS, US or UK, by using all the counts of resource use from each participating country, and then valued in a single currency.
- Cost-effectiveness acceptability curves should be included which demonstrate the cost-effectiveness of home haemodialysis at different willingness to pay thresholds.
- The evaluation should ideally be conducted from a societal perspective, i.e. includes costs that are borne outside the health system, such as patient and family out-of-pocket costs, and lost work time.
- Sensitivity analyses should be undertaken that include a variation in patient mix and the proportion managed at home.