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Home haemodialysis—international trends and variation

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Abstract

Background. Home haemodialysis (HD) has the best patient outcomes and is the most cost-effective of any dialysis modality, but its use has been declining in many countries.

Methods. Point prevalence rates of different dialysis modalities and transplantation were obtained from national and regional registries for the most recent available year (2001–03) for 21 high-income and 12 middle-income countries. Relationships with median age and prevalence of diabetic nephropathy, healthcare expenditure and population density were assessed. Long-term trends in the use of home HD during the last two to four decades were obtained for seven countries.

Results. The prevalence of home HD varies from 0 to 58.4 per million population, and varies between countries, more than any other renal replacement therapy (RRT) modality. There is a positive association between the use of peritoneal dialysis and home HD (Spearman's $\rho = 0.531$, $P = 0.013$), but no correlation with transplantation prevalence. There is a negative correlation with median age of the renal replacement population ($\rho = -0.552$, $P = 0.018$). There is no association with prevalence of diabetic nephropathy, healthcare expenditure or population density. Temporal trends in home HD prevalence are dramatically different in different countries, with several countries expanding its use in the last few years.

Conclusion. The use of home HD varies dramatically between and within countries. The variation cannot be explained by the variation in the use of other RRT modalities, nor by prevalence of diabetic nephropathy, national wealth or population density. The inverse correlation with median age is difficult to explain. Significant expansion of home HD is likely to be possible in most countries, and will be increasingly important as the impressive results of more frequent HD gain credence.

Keywords: chronic kidney failure; health expenditures; home haemodialysis; population density; prevalence; registries

Introduction

The first haemodialysis (HD) in a patient's home was apparently done in 1961 by Nosé [1] in Japan, shortly after the first patient received HD for end-stage renal disease (ESRD) in Seattle in 1960 [2]. In 1963, Scribner trained a Madras physician to look after the first patient to be treated by maintenance HD at home [3]. Home HD programmes were developed by Merrill in Boston, Scribner in Seattle and Shaldon in London in 1963–64. Since then it has been shown that home HD is cheaper than facility-based HD [4–6], that it is associated with better patient survival than peritoneal dialysis (PD) [7] or facility-based HD [8–10] (even after adjustment for comorbidity), and that patients are more fully rehabilitated [11]. Despite these considerable advantages, the use of HD at home has been diminishing in most countries. Various reasons have been suggested for this decline [12]: the increasing age and comorbidity of dialysis patients; the improving availability of dialysis facilities; the advent of continuous ambulatory PD in 1976 [13]; the increasing success of cadaveric kidney transplantation once ciclosporin became available in 1983; and the increasing use of live donor kidney transplantation in the 1990s.

The impressive results of more frequent HD (i.e. five or more days per week) have, however, changed this situation. Short daily HD virtually normalizes blood pressure and left ventricular mass, and probably improves renal anaemia and phosphate balance [14–16]. Nightly HD also normalizes blood pressure and left ventricular mass and improves phosphate

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clearance so much that diet is unrestricted and dialysate requires phosphate supplementation [17,18]. Middle molecule clearance is also dramatically improved [19]. Early evidence suggests that more frequent HD may improve patient survival—in the case of short daily HD at home, to levels approaching that of live donor kidney transplantation [20,21]. Whilst short daily HD has been successfully provided in-centre [22], it is more practical to provide it at home: the patient is subjected to less travel. It is very difficult to offer nightly HD in-centre—the patient would effectively be living in the facility. Home HD will have to be expanded, if the benefits of frequent HD are to be offered to more patients.

It was our impression that the use of home HD varies dramatically between countries without an easy explanation, and we wished to examine that further.

Methods

We accessed data from various registries of renal replacement therapy (RRT), including the US Renal Data System (USRDS) [23], the Canadian Organ Replacement Registry [24], ANZDATA [25], the Scottish Renal Registry [26,27] and the ERA-EDTA Registry [28–30]. Additional data were sought from individual registries, and for US data prior to 1980 from previous publications [31,32]. Countries were included if their registries provided data on the point prevalence of home HD, in-centre HD (including satellite units), PD and transplantation. Most country data are based on patient level information, but data from Bosnia-Herzegovina, Croatia, Czech Republic, Estonia, France, FYR Macedonia, Germany, Hungary, Italy, Latvia, Poland, Portugal, Russia, Serbia and Montenegro, Spain, Tunisia and Turkey are based on aggregate data reported to the ERA-EDTA Registry. Socio-economic and geographic data were obtained from the World Bank [33]. Gross national income is expressed in US$ for the year 2003. All currencies have been directly converted to US$ using the World Bank Atlas method (i.e. using a 3-year average of exchange rates). Health expenditure data are from 2002. For Scotland, England and Wales, UK economic data were used. For Flanders (Dutch-speaking Belgium) and Wallonia (French-speaking Belgium), Belgian economic data were used. Some registries had <100% coverage of their country: England and Wales (76%), Estonia (not defined), France (28%), Italy (90%), Serbia and Montenegro (60%), Spain (62%) and Turkey (95%). In those cases, economic data for the whole country were used. We used the World Bank criteria to divide countries by annual per capita gross national income into high (>US$10 066) and middle income (US$3256–10 065).

Statistics

Data with large ranges have been graphed on logarithmic scales. On those logarithmic scales, zero values have been represented as 0.01. Strength of association between parameters was assessed using Spearman's rank correlation co-efficient. Significance was set at $P < 0.05$ (two-tailed). Statistics were carried out using SPSS for Windows 13.0 (Chicago, IL, USA).

Results

The prevalence of home HD varies by more than three orders of magnitude, which is substantially greater than the variation of other renal replacement modalities (Figure 1 and Table 1). Home HD prevalence ranges from 0 in Portugal and Iceland to 58.4 per million population (pmp) in New Zealand. Notably, Norway has a prevalence of 0.4 pmp, whereas Sweden, of which Norway was a part until 1905, has a prevalence of 8.0 pmp. Similarly, Flanders (Dutch-speaking Belgium) has a prevalence of 0.5 pmp compared with 6.2 pmp in the Netherlands, and 5.8 pmp in Wallonia (French-speaking Belgium). Even within countries there can be significant variation: Australian states vary from 5.1 to 74.5 pmp (Figure 2); French regions vary from 0 to 40.5 pmp; Scottish NHS Boards range from 0 to 27.1 pmp (data not shown).

Impact of national wealth

There is a strong positive correlation between national per capita healthcare expenditure and the prevalence of RRT (Spearman's $\rho = 0.633$, $P < 0.001$) (Figure 3A). There appears to be a differing relationship in the high and middle income countries. If the high-income countries are examined separately, there is no relationship with the prevalence of RRT ($\rho = -0.048$, $P = 0.840$). Similarly, if the middle-income countries are examined, there is also no clear relationship ($\rho = 0.126$, $P = 0.697$).

There is no relationship between national per capita healthcare expenditure and prevalence of home HD (Figure 3B) in high-income countries ($\rho = 0.138$, $P = 0.560$). However, in middle-income countries, home HD is virtually non-existent. Given this fact, the middle-income countries are excluded from the remainder of the correlation analyses. The three middle-income countries with low levels of home HD are, however, represented in the subsequent graphs for interest.

If gross national income per capita is used as a marker of national wealth rather than healthcare expenditure, similar relationships are seen (data not shown), but there is a borderline significant negative correlation between wealth and prevalence of RRT in high income countries ($\rho = -0.438$, $P = 0.047$).

Impact of population density and urbanization

There was no correlation between population density and the prevalence of home HD ($\rho = -0.192$, $P = 0.404$) (Figure 4A). Similarly, if one examines the percentage of the population living in urban areas ($\rho = 0.316$, $P = 0.175$, $n = 20$, no data for Iceland), or in conurbations of >1 million residents ($\rho = -0.090$,

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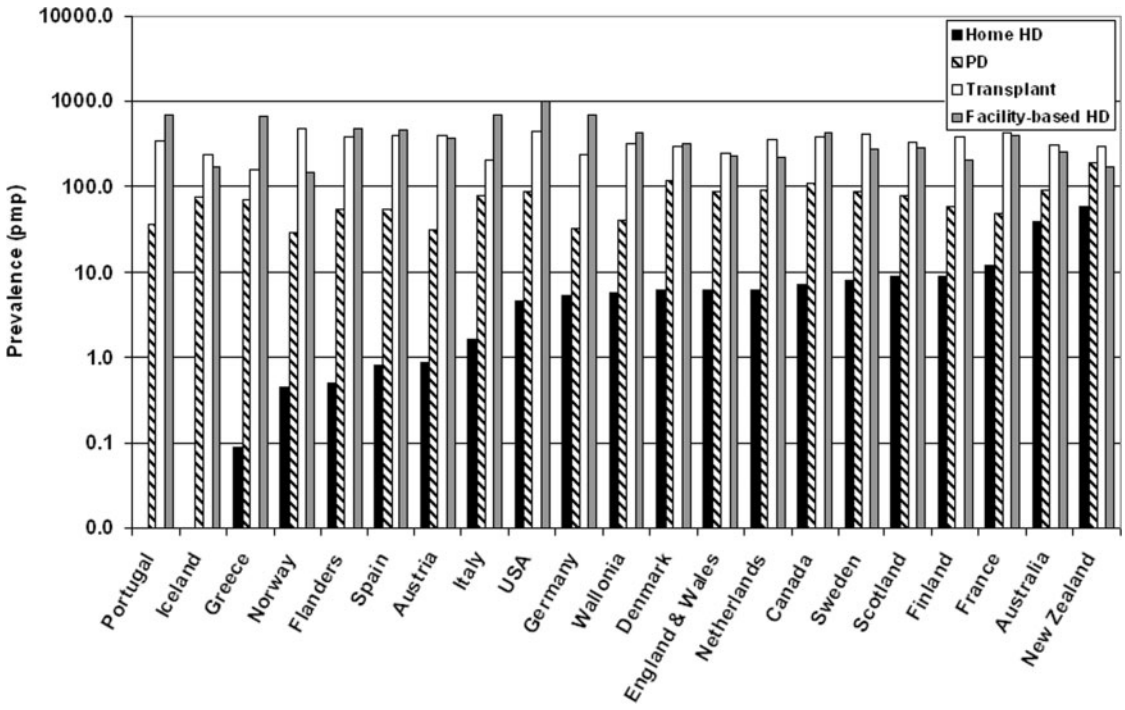

Fig. 1. The prevalence of different renal replacement modalities in 21 high-income countries. Note prevalence is presented as a logarithmic scale. All data are from 2003, except for Wallonia (2001), Canada (2002) and Portugal (2002). pmp: per million population, HD: haemodialysis, PD: peritoneal dialysis.

$P = 0.731$, $n = 17$, no data for Belgium, Iceland or Norway), there is no correlation with the prevalence of home HD (Figure 4B).

Interactions with other modalities

There is no correlation between the prevalence of home HD and total RRT prevalence ($\rho = -0.280$, $P = 0.219$) (Figure 5A). This holds true if the extreme outliers (Australia and New Zealand) are excluded.

There is a positive correlation between the prevalence of PD and home HD ($\rho = 0.531$, $P = 0.013$) (Figure 5B). This relationship disappears if Australia and New Zealand are excluded ($\rho = 0.389$, $P = 0.100$). Notably, these two countries which have very high prevalence of home HD also have high prevalences of PD.

There is no relationship between the prevalence of renal transplantation and home HD ($\rho = 0.107$, $P = 0.646$) (Figure 5C). This holds true if Australia and New Zealand are excluded ($\rho = 0.230$, $P = 0.344$).

Impact of age and diabetic nephropathy

Median age of the prevalent RRT population was available for 18 of the 21 high-income countries (not Canada, Portugal or Spain). There is a strong inverse correlation between median age and the *proportion* of RRT patients on home HD ($r = -0.608$, $P = 0.007$). There is a weaker negative relationship between the *absolute prevalence* of home HD and median age ($\rho = -0.552$, $P = 0.018$) (Figure 6). If the two extreme outliers (Australia and New Zealand) are excluded, this relationship disappears ($\rho = -0.376$, $P = 0.151$). The proportion of patients with diabetic nephropathy as a cause of end-stage renal failure was available for 19 high-income countries (not Canada or Portugal). There is no relationship with the prevalence of home HD ($\rho = 0.246$, $P = 0.311$).

International trends in home HD prevalence

The trends in home HD prevalence with time are markedly different in different countries (Figure 7). For example, prevalence peaked in Scotland in the 1980s and has steadily declined thereafter. Prevalence in Canada has also declined since the 1980s, but appears to have levelled in the last decade. The Netherlands followed a similar pattern of decline, but has started to expand again now. Despite starting from a high level, however, Australia and New Zealand have continued to expand their home HD programmes in the 1990s. Finland had virtually no home HD until 1998, since which time they have rapidly expanded their programme. Sweden has also been expanding its programme over the last few years, whereas Austria, Flanders and Norway which all have very low prevalences of home HD show no evidence of expansion (data not shown). The early US data have to be interpreted with caution. Data from prior to 1976 were reported voluntarily, and exclude Veterans' Administration units which treated approximately 10% of the dialysis patients at that time. Data were managed by a variety of organizations between 1976 and 1988,

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Table 1. The prevalence of different renal replacement modalities in various countries.

Country	RRT (pmp)	Transpl (pmp)	Fac HD (pmp)	PD (pmp)	Home HD (pmp)	Home HD (*n*)	Home HD (% HD)
High income countries							
Australia	685	299	255	92	39.0	772	13.2
Austria	815	403	379	32	0.9	7	0.2
Canada	927	384	427	109	7.2	226	1.7
Denmark	739	288	326	117	6.1	33	1.8
Finland	658	390	202	58	8.8	46	4.2
Flanders	914	388	471	54	0.5	3	0.1
Germany	949	239	672	33	5.3	440	0.8
Greece	880	158	652	70	0.1	1	0.0
Iceland	494	238	169	76	0.0	0	0.0
Netherlands	678	359	222	90	6.2	101	2.7
Norway	665	483	147	29	0.4	2	0.3
New Zealand	715	291	174	192	58.4	234	25.2
Portugal	1097	353	708	36	0.0	0	0.0
Scotland	726	336	283	79	8.7	44	3.0
Sweden	776	411	270	86	8.0	72	2.9
USA	1554	441	1021	89	4.6	1325	0.4
Wallonia	802	322	430	41	5.8	25	1.3
High-income countries (incomplete registry coverage)							
England and Wales	596	244	225	87	6.2	247	2.7
France	898	433	406	48	12.0	202	2.9
Italy	995	206	704	80	1.6	84	0.2
Spain	921	408	458	54	0.8	21	0.2
Middle-income countries							
Bosnia-Herzegov.	432	7	408	12	0.0	0	0.0
Croatia	790	134	602	52	0.9	4	0.1
Czech Republic	695	267	398	31	0.2	2	0.0
Estonia	273	158	73	43	0.0	0	0.0
FYR Macedonia	540	46	492	2	0.0	0	0.0
Hungary	439	30	376	33	0.0	0	0.0
Latvia	265	124	112	29	0.0	0	0.0
Poland	457	157	271	29	0.0	0	0.0
Russia	91	22	64	5	0.0	0	0.0
Serbia and Mont.	491	72	386	26	1.6	8	0.4
Tunisia	539	4	523	12	0.0	0	0.0
Turkey	433	54	332	47	0.0	0	0.0

Home haemodialysis prevalence is also expressed as an absolute number of patients and as a percentage of total haemodialysis patients. All data are from 2003, except for Wallonia (2001), Canada, Czech Republic, Estonia, Latvia, Portugal and Tunisia (2002). pmp: per million population, RRT: renal replacement therapy, Transpl: transplant, Fac: facility-based, HD: haemodialysis, PD: peritoneal dialysis, *n*: number, USA: United States of America, Bosnia-Herzegov: Bosnia-Herzegovina, FYR: Former Yugoslav Republic, Mont: Montenegro.

and may not be as reliable as subsequent USRDS data. There appears to be two peaks in home HD in 1971 and 1985, and a trough in 1982 and 1993–94. Despite the concerns about the data quality, these may be genuine (see 'Discussion' section). However, the overall decline over the last 20 years mirrors that in several other countries.

Discussion

These data show a dramatic variation in the prevalence of home HD between different countries in 2001–03. Factors which might have been considered responsible for this variation such as healthcare expenditure, population density or kidney transplantation prevalence, in fact, show no clear relationship. Interestingly, middle-income countries provide virtually no home HD. The clinicians' focus in those countries may be on development and expansion of dialysis facilities, but it should not be forgotten that home HD is cheaper and more cost-effective, a lesson not lost on the early pioneers of HD [3]. Whilst it is certainly true that the two countries with the most active home HD programmes have low population densities, there is still a wide variation in less sparsely populated countries. Furthermore, both New Zealand and Australia's populations are more concentrated in urban environments than other countries, mitigating the impact of their large areas. However, caution should be used when interpreting these markers of urbanization, as they depend on each country's definition of administrative areas. Could low availability of facility-based HD stations cause patients to choose home dialysis? We are unable to readily answer that question from the data. In order to make a meaningful comparison between countries, one would have to know the true rate of the disease (i.e. ESRD) in each country, as well as the rate of provision of treatment (i.e. RRT). The lack of correlation of home HD prevalence with population density (essentially a surrogate marker of the distance to a dialysis unit) would, however, argue against availability of HD stations being a significant factor.

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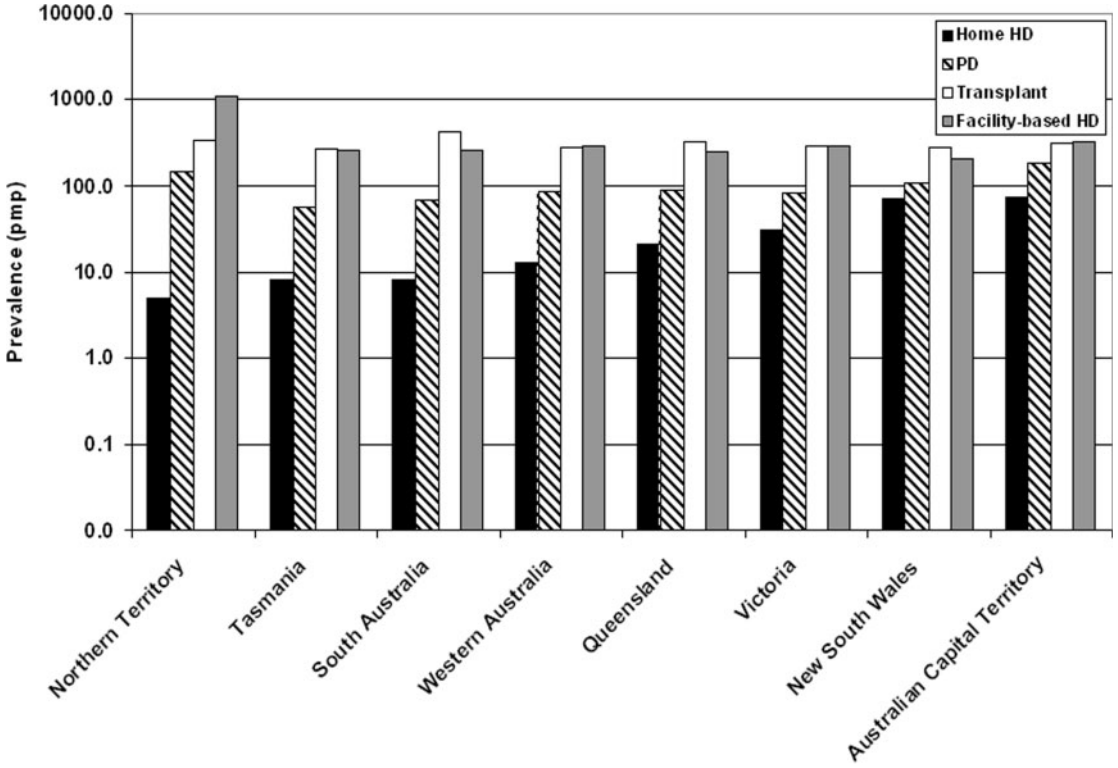

Fig. 2. The prevalence of different renal replacement modalities in the eight Australian States and Territories in 2003. Note prevalence is presented as a logarithmic scale. pmp: per million population, HD: haemodialysis, PD: peritoneal dialysis.

Peritoneal dialysis has often been seen as a competing modality for home HD, but in fact there was a weak positive correlation between these two modalities, suggesting that countries are either orientated towards providing community dialysis or not. Kidney transplantation has also been seen as a competing modality. We found no correlation. It should, however, be noted that because the transplant prevalence is 40 times greater than the home HD prevalence, relatively small proportional changes in transplant prevalence could explain variation in home HD. Nevertheless, even countries with very similar transplant rates have very different home HD rates.

It is notable that the trends with time in home HD prevalence are dramatically different in different countries. Whilst the proportion of RRT patients receiving home HD has declined in all countries, the absolute number of patients has been growing in several countries recently. Notably, New Zealand has a higher number of home HD patients now than ever before. New Zealand is of course renowned for its active home HD programmes, particularly in the South Island, and this has been written about previously [34]. However, more recently two large units in the North Island have been developing more active home HD programmes, leading to further increases in the national prevalence. Finland, and to a lesser extent the Netherlands, have also expanded the use of home HD over the last 5–10 years. In Finland, most home HD patients have been trained by a single unit, where a team at Helsinki University Central Hospital started a home HD programme in 1997 [35]. In the Netherlands, most home HD patients are trained by a non-profit organization, Dianet [36]. Whilst the patients continue to be supervised by their own dialysis centre, Dianet co-ordinates training, technical support and quality control. Interestingly, the increase in home HD in the Netherlands seems to coincide with Dianet starting nightly HD in 2001. Thus, the main feature in countries with expanding home HD programmes seems to be small groups of committed clinicians, and in two cases centralization of the home HD programme.

Our study was limited to data from countries with registries. A recent detailed worldwide survey [37] estimated that only 0.4% of all HD patients globally were on home HD (~5200 patients). About 57% of them were concentrated in three countries (USA, Australia and France), agreeing with our findings of considerable variation internationally. According to that survey's estimate of the global number of home HD patients, our data, which are based on reliable validated registry data, covers 75% of the world's home HD population.

Political imperatives and the structure of healthcare funding could also potentially have a major impact on the uptake of home HD, and we have not examined those. For example, the introduction of Medicare funding for HD in 1973 precipitated a rapid decline in home HD in the USA [12]. Subsequent changes improved the funding of home HD and may be responsible for the apparent temporary resurgence in the 1980s. Changes in the funding of more frequent HD

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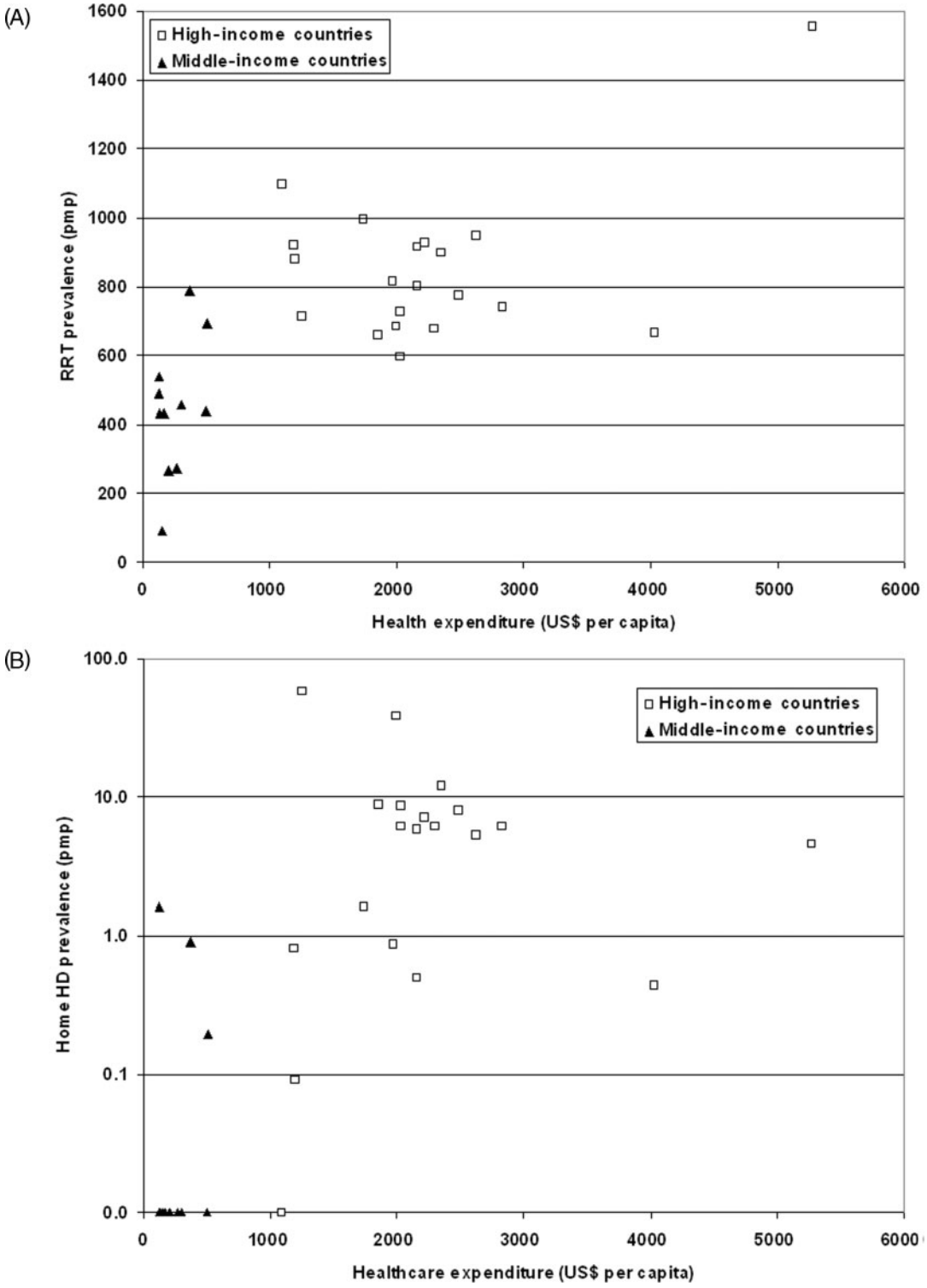

Fig. 3. Impact of countries' annual per capita health expenditure on (**A**) prevalence of RRT and (**B**) prevalence of home HD. Note home HD prevalence is presented on a logarithmic scale, RRT: renal replacement therapy, pmp: per million population, HD: haemodialysis.

are being lobbied for in the USA, while at the same time the National Institutes of Health and the Centers for Medicare and Medicaid Services are commencing a trial of the feasibility of randomizing patients to daily or nightly dialysis *vs* conventional dialysis, due to complete in 2009, which should provide additional data on intermediate outcomes such as anaemia, blood pressure, nutrition, medications and hospitalizations. The outcome of this study will be used by the National Institutes of Health to decide whether to fund a

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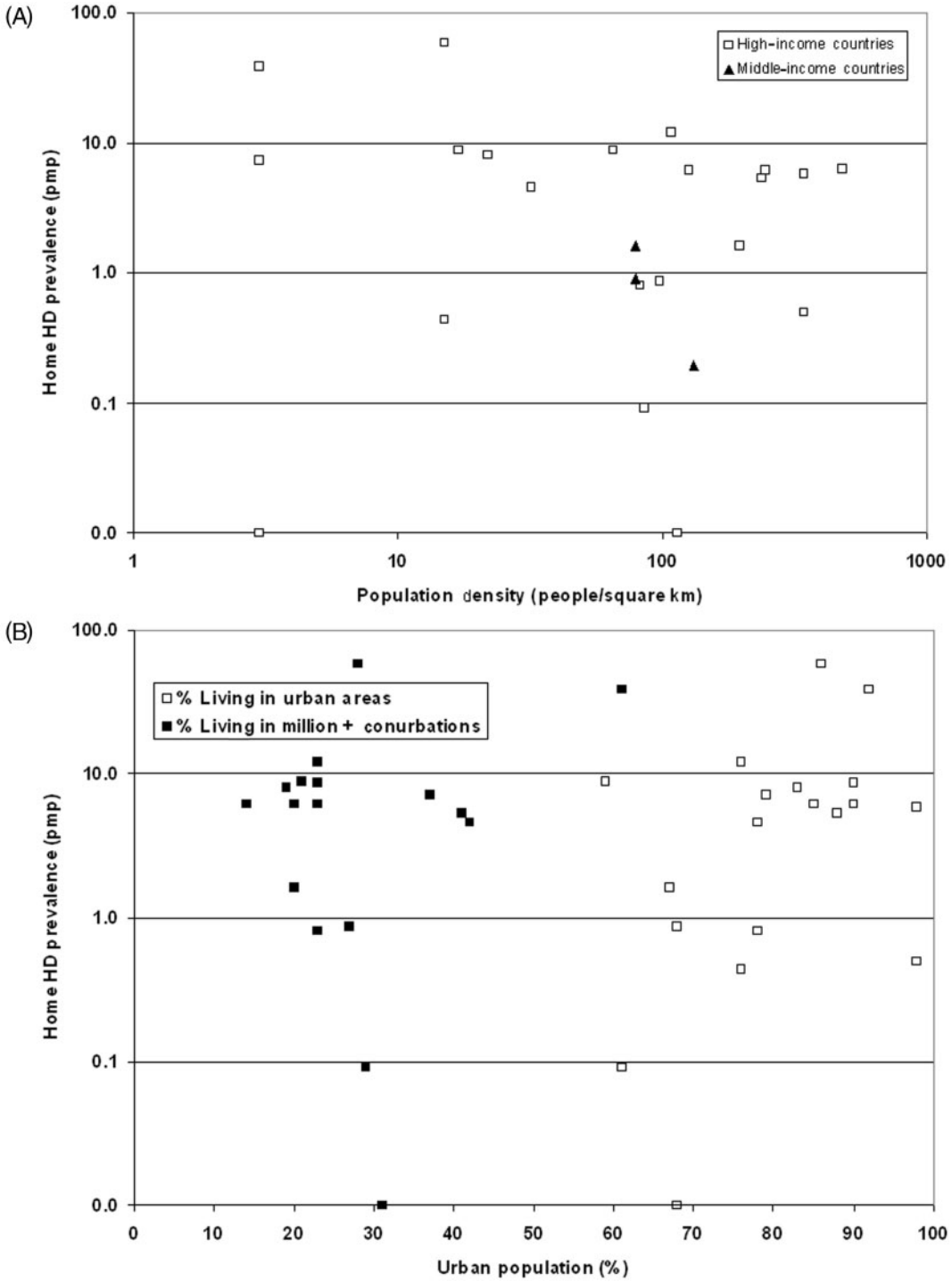

Fig. 4. (**A**) The prevalence of home HD in relation to population density. Note both axes are logarithmic scales. (**B**) The prevalence of home HD in relation to the percentage of the population living in urban areas, and living in conurbations with a population of greater than one million people. Note prevalence is presented on a logarithmic scale. pmp: per million population, HD: haemodialysis, km: kilometre.

large-scale study with hard endpoints such as mortality or cardiovascular events [38]. These initiatives potentially could increase the prevalence of home HD again. Similarly, the National Institute for Clinical Excellence in England and Wales has recommended that home HD should be offered to all suitable dialysis patients, and has suggested that 10–15% of dialysis patients should be on home HD if all units performed as successfully as the best [39]. If achieved, this would catapult England and Wales to a prevalence of 35–53 pmp. In November 2005, the Australian Commonwealth Government introduced Item 13104

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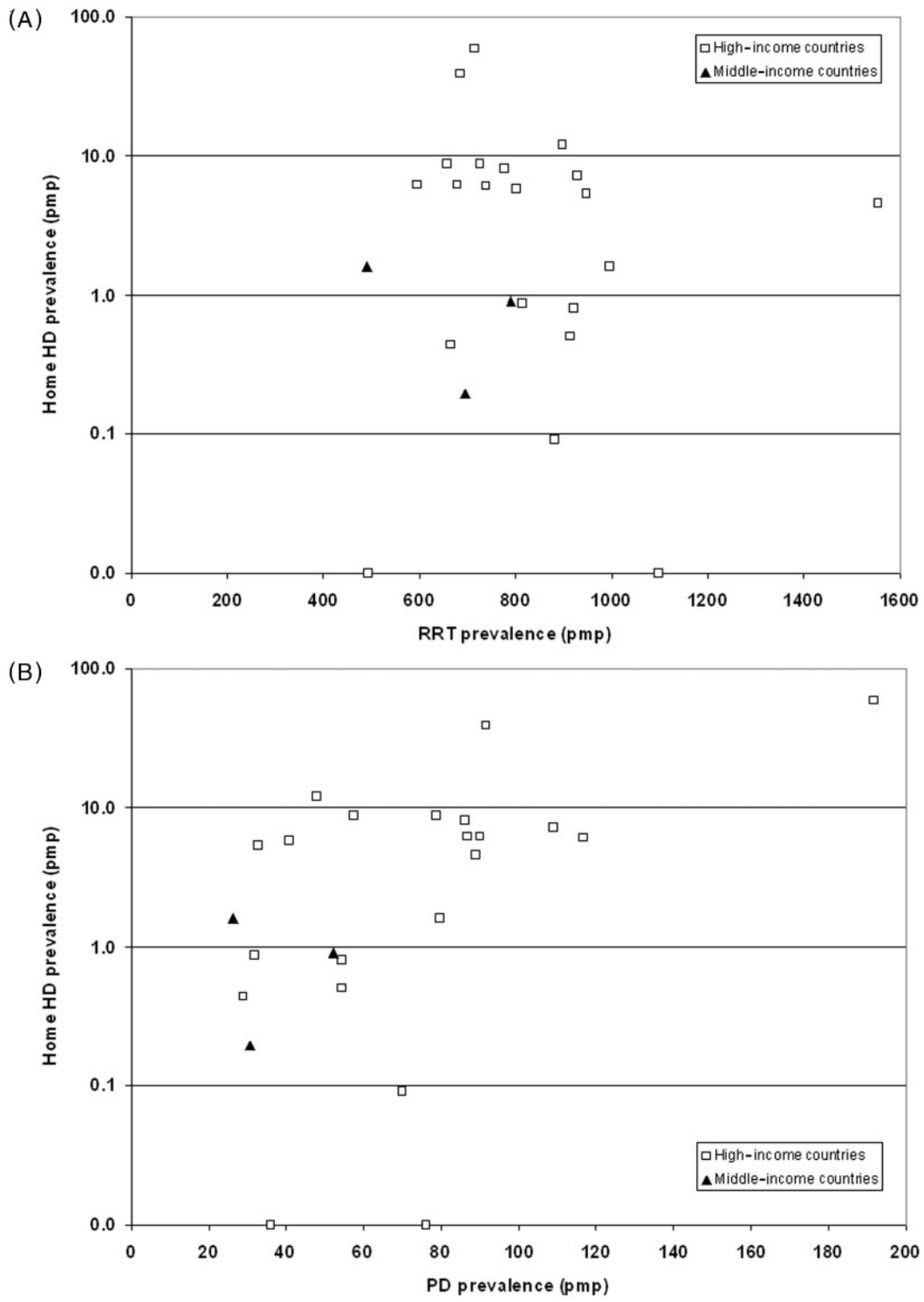

Fig. 5. The relationship between the prevalence of home HD and (**A**) the prevalence of RRT, (**B**) the prevalence of PD and (**C**) the prevalence of renal transplants. Note home HD prevalence is presented on a logarithmic scale, pmp: per million population, HD: haemodialysis, RRT: renal replacement therapy, PD: peritoneal dialysis.

into its Commonwealth Medicare Benefits Schedule [40]. This reimbursement is made directly to the managing physician as an additional financial incentive of $128/month for each patient sustained on home dialysis. No similar reimbursement is made for facility-based care. It will be of interest to see what effect this has in a country with an already high prevalence of home HD and PD.

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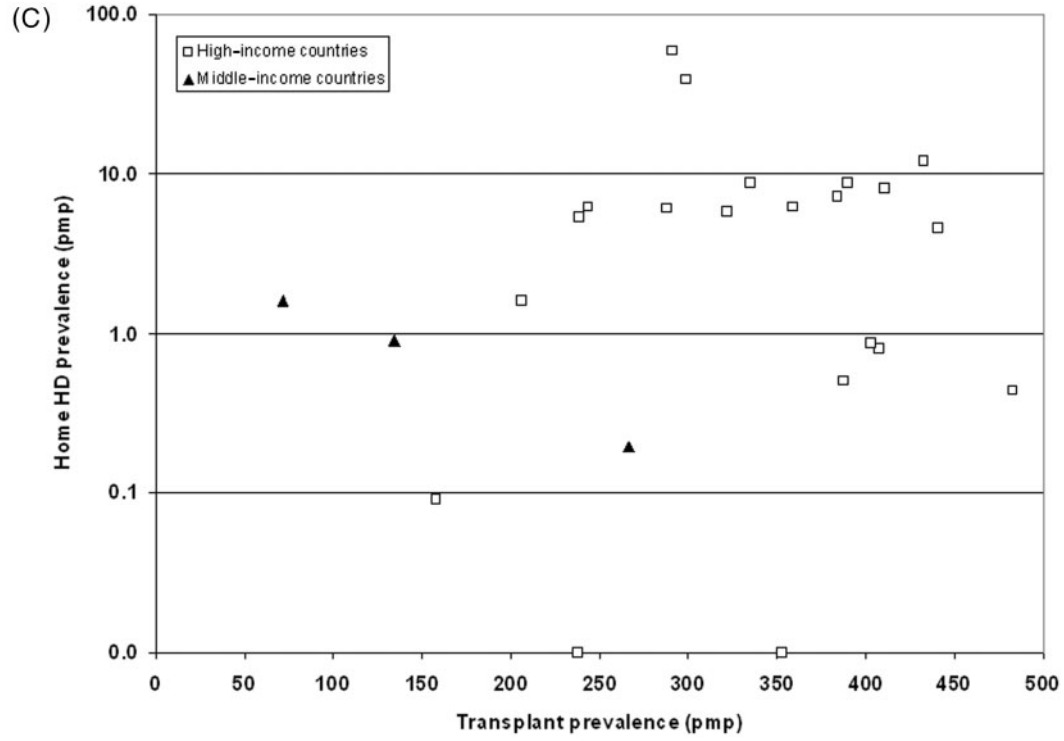

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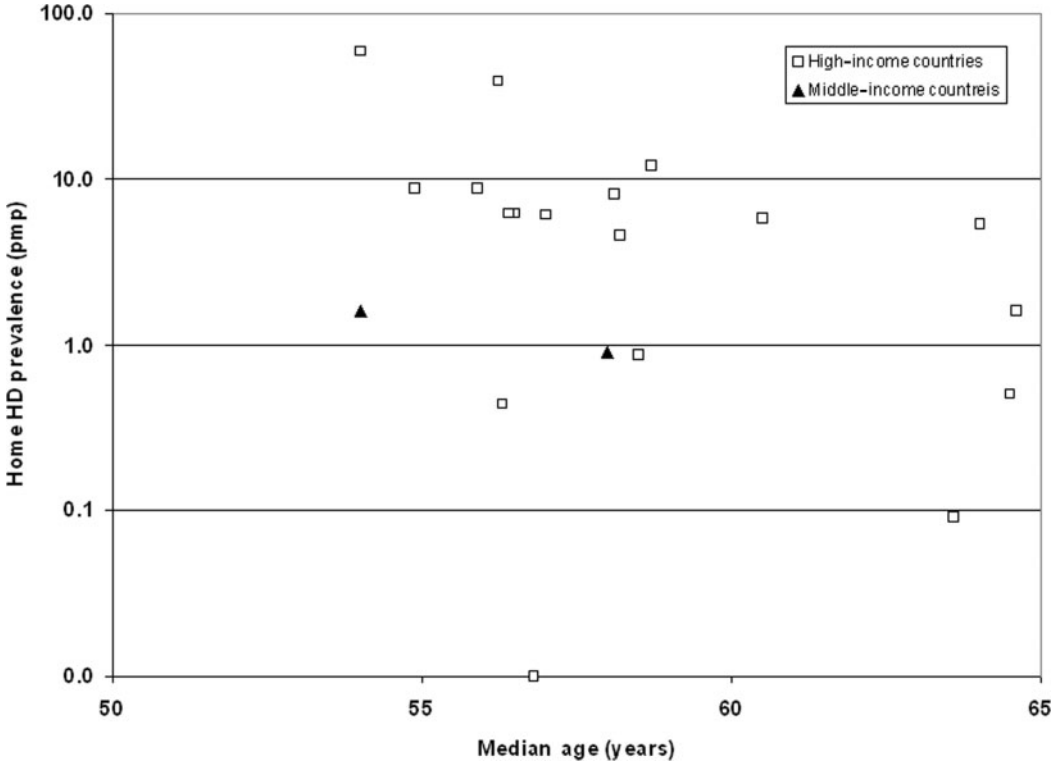

Fig. 6. The relationship between the prevalence of home HD and the median age of the RRT population. Note home HD prevalence is presented on a logarithmic scale. pmp: per million population, HD: haemodialysis, RRT: renal replacement therapy.

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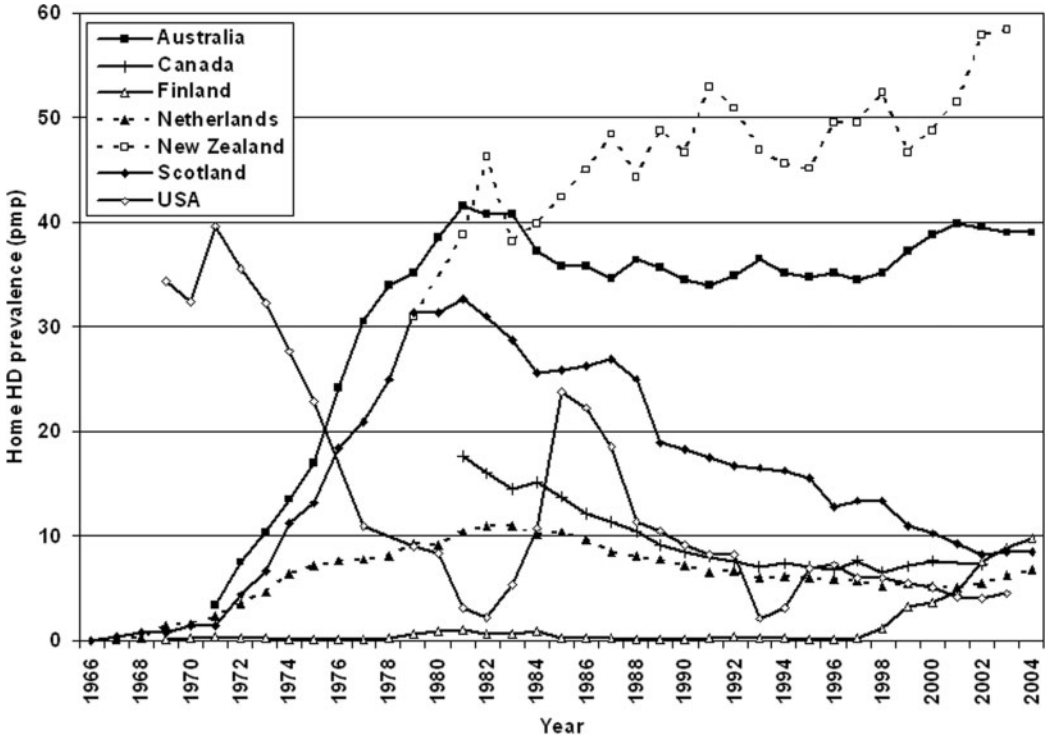

Fig. 7. The prevalence of home HD in seven countries from 1966 to 2004. pmp: per million population, HD: haemodialysis.

We were unable to examine patient-specific issues such as comorbidity and vascular access, which are known to vary between populations [41,42]. We examined the proportion of RRT patients with diabetic nephropathy in each population as a crude marker of comorbidity, and found no correlation with home HD prevalence, suggesting that the level of comorbidity in each population is not a significant explanation for the uptake of home HD. Unsurprisingly, there was a negative correlation between the median age of the RRT population and home HD expressed as a *proportion* of RRT. Although home HD is not contra-indicated by advanced age *per se*, and has been successfully practiced by patients in their 80s, age is often associated with increasing frailty, which will increase the reluctance to utilize home HD. The weaker negative correlation between median age and the *absolute prevalence* of home HD is much harder to explain. The higher age of prevalent patients in some countries is probably due to higher numbers of older patients rather than fewer young patients. Therefore, the same number of young fit patients should be available for home HD. Nor should these young fit patients be more likely to be treated with PD or transplanted, just because there are more older patients. We cannot explain this finding, and can only suggest that perhaps physicians' energy is expended on the older, more complicated patients, rather than on developing home HD. This is, however, pure speculation.

We were also unable to assess cultural differences which might have an impact on the availability and willingness of helpers. However, the fact that prevalence of home HD varies substantially, even within the regions of single countries, suggests that these are not the major cause of variability.

Finally, the nephrologist's attitude will inevitably have a major impact on the choice of dialysis modality. It is likely that very few nephrologists outside of Australasia have much experience of home HD and the benefits which it can bring. However, nephrologists in Canada [43], the British Isles [44] and the USA [45] seem to believe that home HD is under-utilized, believing that it should make up 9, 11 or 12.2% of the dialysis population, respectively. Achieving expansion of home HD to these levels will require multi-faceted action. For example, various models of pre-dialysis education have been shown to increase the uptake of self-care dialysis [46,47].

In conclusion, utilization of home HD varies markedly between and within countries. These variations are not explained by national healthcare expenditure, population density or utilization of other dialysis modalities. Whilst there has been a long-term decline in the use of home HD, some countries are continuing to expand its use. We believe that a large part of the variability is due to local practice variation, and thus there is a great potential for home HD to be expanded internationally, with improved morbidity and mortality for patients, and at a reduced cost to society.

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