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# Chapter 11

## Blood Pressure Profile of Prevalent Patients Receiving Dialysis in the UK in 2008: national and centre-specific analyses

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### Key Words

Blood pressure · Chronic kidney disease · Dialysis · Epidemiology · Established renal failure · Haemodialysis · Peritoneal dialysis · Transplant

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### Abstract

**Introduction:** The UK Renal Registry (UKRR) assesses blood pressure (BP) control annually for patients receiving renal replacement therapy (RRT) at renal centres in England, Wales and Northern Ireland. **Methods:** Patients alive and receiving RRT on 31st December 2008 with a BP reading in either the fourth or third quarter of 2008 were included. Summary statistics were calculated for each renal centre, nation and primary renal disease (PRD) category. Longitudinal analyses were performed to assess the long-term impact of treatment modality and PRD on BP control for incident and prevalent patients. **Results:** In 2008, only 26.3% of peritoneal dialysis (PD) and 27.4% of transplant (Tx) patients achieved the Renal Association (RA) guidelines standard of BP <130/80 mmHg. Since the cessation of BP targets for haemodialysis (HD) patients, there has been a reduction (compared to 2007) in the number of HD patients achieving BP <130/80 mmHg. In 2008, 43.1% of patients

achieved BP <140/90 mmHg pre-HD and 46.8% BP <130/80 mmHg post-HD. BP control varied significantly between renal centres for each treatment modality ( $p < 0.001$ ). Adjusted mean systolic BP fell significantly during the first year on dialysis (6 mmHg for PD and 8 mmHg for HD). Hypertension was more common in HD patients with vascular disorders such as diabetes and renovascular disease (59.0%) than in patients with glomerulonephritis (51.9%) or tubular disorders (46.7%). **Conclusions:** In 2008, a minority of patients on RRT achieved the recommended BP standards. There remained a significant variation in achievement of standards between UK renal centres. Since the removal of specific BP targets for HD patients, there has been an increase in systolic BP pre- and post-HD. BP falls significantly during the first year after starting dialysis and patients with vascular disorders have significantly worse BP control.

### Introduction

This chapter reports on blood pressure (BP) analyses carried out by the UK Renal Registry (UKRR) for data

collected from 63 renal centres in England, Wales and Northern Ireland. The Renal Association (RA) Standards Committee sets BP guidelines for patients on renal replacement therapy (RRT) in the UK. In 2002 it recommended that the BP target should be lowered to <140/90 mmHg pre-dialysis and <130/80 mmHg post-dialysis for haemodialysis (HD) patients and <130/80 mmHg for peritoneal dialysis (PD) and kidney transplant (Tx) patients [1]. These recommendations, based on grade C evidence, are in line with BP standards set by other international organisations to reduce cardiovascular disease and mortality in the general population. In 2007, the 4th edition of the RA clinical practice guidelines omitted specific BP targets for HD patients as there was little evidence to support an optimal BP level pre- or post-dialysis [2]. In addition, there was some data to suggest home or ambulatory readings have greater prognostic value than readings obtained in the dialysis unit [3, 4]. The new guidelines recommended interdialytic BP monitoring to aid BP control. The recommended BP for PD and transplant patients remained <130/80 mmHg. Revised KDOQI clinical practice guidelines, issued in 2006, removed specific BP targets for HD patients [5]. Both UK and USA guidelines champion BP control by salt restriction and ultra-filtration as first-line therapy in dialysis patients. KDIGO is currently revising hypertension clinical practice guidelines taking advice from the USA and UK.

Hypertension affects 90% of patients starting dialysis, suggesting BP control might be an important target for intervention to reduce cardiovascular mortality. Several large observational studies in HD patients have reported U-shaped or reverse J-shaped relationships between systolic BP and mortality, with increased mortality in individuals with the highest and lowest BP [6, 7]. Low BP was consistently associated with higher mortality rates in the short term, but lower mortality rates in the long term. Longer-term studies of individuals without established cardiac disease have shown low mortality rates for sustained low BP and increased mortality after three years for patients with systolic BP >150 mmHg [8, 9]. Patients with cardiac failure or serious concurrent medical conditions account for early mortality in these studies. A similar relationship between BP and mortality has been demonstrated in PD patients [10]. In the first year, high systolic BP was associated with low mortality rates. In the 'healthy' subgroup wait-listed quickly for transplantation, high systolic BP was associated with higher mortality rates after 5 years. A large study of renal Tx recipients demonstrated the benefits of

sustained BP control, with increased mortality in the younger patient group whose systolic BP was elevated [11]. After three years, the lowest mortality rates were associated with systolic BP consistently being <140 mmHg. A reduction in cardiovascular death rates occurred if high systolic BP one year post-transplant was subsequently controlled <140 mmHg. In older patients (>50 years) changes in systolic BP did not affect cardiovascular mortality. However, graft survival improved in all patients (young and old) if systolic BP was reduced <140 mmHg. The improvement in graft survival was still evident if BP control was delayed until several years after transplantation.

Intradialytic hypotension is common when trying to achieve dry weight on conventional thrice-weekly HD. An audit of HD practice in London showed achievement of BP control was associated with an increased frequency of intradialytic hypotensive episodes [12]. In the most successful unit, 50% of patients achieved the post-dialysis BP target but 28% of patients developed symptomatic intradialytic hypotension. Antihypertensive medication did not appear to affect either BP control or the frequency of hypotensive episodes. The 'Dry weight reduction in hypertensive haemodialysis patients (DRIP)' randomised controlled trial demonstrated achievement of dry weight led to reductions in systolic and diastolic BP of 6.9 mmHg and 3.1 mmHg, respectively, but more symptomatic intradialytic hypotension [13]. Individuals who suffer this complication frequently have poor outcomes related to pre-existing cardiac disease or autonomic neuropathy. However, myocardial perfusion has been shown to drop significantly during the first hour on HD even in fit individuals [14]. Following the introduction of new RA guidelines, median BP may increase for HD patients if units switch from achieving specific BP targets to reducing intradialytic hypotension.

## Methods

All adult patients receiving RRT in the UK on 31st December 2008 were considered for inclusion in the BP analyses. The method of data extraction employed, is described in chapter 15 of the 11th UKRR Annual Report [15]. The UKRR extracts quarterly laboratory, clinical and demographic data for all patients receiving RRT in the 63 renal centres in England, Northern Ireland and Wales. Data on some variables from the nine Scottish renal centres are sent annually from the Scottish Renal Registry. However, BP measurements are not received from Scotland, and therefore Scottish renal centres were excluded from all BP analyses.

Any patient alive and receiving RRT on 31st December 2008 with a valid BP reading in either the fourth or the third quarter of 2008 was included. This included incident patients starting RRT during 2008 who were still alive on 31st December. Analyses used the last recorded BP from quarter 4, however, if this was missing, the last recorded BP from quarter 3 was used instead. Patients were excluded from analyses if they had no recorded BP readings in the last two quarters of 2008.

All patients meeting the criteria above were included in the overall national analyses, but renal centres with less than 50% data completeness for any modality, or fewer than 20 patients with results were excluded from the centre-level analysis for that modality. The number preceding the centre name in each figure corresponds to the percentage of missing data in each centre.

Most UK renal centres manage HD, PD and Tx patients. However, Colchester had no PD patients and four centres (Bangor, Colchester, Liverpool Aintree and Wirral) had no transplant patients under their care.

Analyses were performed on each RRT modality (HD, PD and Tx recipients). Patients on HD were analysed both by pre-dialysis and post-dialysis BP. Patients were included if they had been on the same modality and at the same renal centre for 3 months. The BP components analysed included systolic BP (SBP), diastolic BP (DBP) and pulse pressure (PP). The data were analysed to produce summary statistics (mean, median, maximum, minimum). Standard deviation and quartile ranges were also calculated. Median BP and inter-quartile ranges (IQRs) are presented for each analysis. In addition to this, the percentage of PD and Tx patients attaining RA Standards for BP ( $<130/80$  mmHg) in individual renal centres and each nation was calculated. There are currently no defined targets for BP in HD patients due to a lack of randomised controlled trials of hypertension management within this population. The UKRR has decided to continue to use the previous RA standards for BP in these patients (*pre-haemodialysis BP*  $<140/90$  mmHg and *post-haemodialysis*  $<130/80$  mmHg) [1] to enable comparison with previous annual UKRR reports.

In the longitudinal analyses, mean BP was studied in patients grouped by primary renal disease (PRD). Patients without a recorded PRD were excluded. Primary renal disease diagnoses are listed in appendix G Coding. Analyses were repeated after combining diabetic nephropathy and renovascular disease into a 'vascular' group, and combining pyelonephritis and polycystic kidney disease into a 'tubular' group. These two combination groups were compared with the glomerulonephritis group. For HD patients, post-HD systolic and diastolic BP measurements were used in the longitudinal analyses.

For the incident population longitudinal analyses, all patients commencing dialysis (HD or PD) between 1st January 2000 and 31st December 2004 were considered for inclusion. These patients were subsequently observed for a maximum of 5 years. Patients contributed to any quarter where a BP was recorded. For each quarter, only patients from renal centres with greater than 30% completeness were included. For both PD and HD, the longitudinal analyses were performed using a mixed regression model to account for the use of repeated BP measurements from the same individual (within-patient correlation). The model adjusted for age at starting dialysis, year of starting dialysis, PRD and changes in treatment modality.

When choosing an adequate model to represent the data variability, a linear model, with changes in BP assumed to be linear over

time, was compared to a parallel model, where time was fitted as a categorical variable. Additionally, the interaction between time and PRD group was tested to assess if any change in BP with time varied depending on the PRD group. A parallel model with no interaction appeared to be the most appropriate in all cases. This means that, although change over time is not linear, all the groups showed the same pattern of change.

For the prevalent population longitudinal analyses, all patients commencing RRT (HD, PD and Tx) between 1st January 1995 and 30th September 2008, who survived at least 90 days, were considered for inclusion. Only BP measurements between 1st January 2000 and the 31st December 2008 were used in the analyses. Patients contributed to any quarter where a BP was recorded. For each quarter, only patients from renal centres with greater than 30% completeness, by modality, were included. A mixed regression model was used, adjusting for age and duration of RRT (both as time-dependent variables) and PRD. As for the longitudinal analysis of BP in the incident cohort, comparison of a linear versus parallel model and testing for the presence of an interaction between time and PRD showed the parallel model to be the most appropriate of those tested.

Chi-squared tests were used in the analyses of the 2008 BP data to test for statistically significant differences between renal centres, nations and PRD. All statistical analyses were performed using SAS version 9.1.3.

## Results

### *Data completeness*

Blood pressure data extractions from 63 centres in England, Northern Ireland and Wales were performed. The UKRR extracted BP readings from 19,263 of a potential 40,726 patients. Most centres managed HD, PD and Tx patients and the data completeness for BP extraction is summarised in table 11.1.

Data was extracted for pre-HD BP from 64.9% of patients, post-HD BP from 61.5% of patients and BP from 41.8% of PD patients and 32.6% of Tx patients. Overall, there has been a small increase in the percentage of data extracted in HD patients but no change for PD or Tx patients.

From two centres (Wirral and Reading) there was discrepancy between extraction of pre- and post-HD BP data, with pre-HD readings available from over 90% of patients, but few returns for post-HD readings (36% and 0%, respectively).

High levels (>80%) of BP data extraction for all 3 RRT modalities was obtained from 13 centres. There were 7 centres where no BP data was available for analysis. The extent to which this is due to a lack of data entry locally in renal centres, as opposed to failings in the extraction of recorded data by the UKRR, is not clear.

**Table 11.1.** Percentage of patients in each renal centre for whom BP readings were extracted by the UKRR, by modality

Centre	% completed data				Centre	% completed data			
	Pre HD	Post HD	PD	Tx		Pre HD	Post HD	PD	Tx
Antrim	97	97	81	94	Leic	99	96	93	27
B Heart	93	93	0	0	Liv Ain	93	93	0	n/a
B QEH	0	0	0	0	Liv RI	88	87	25	55
Bangor	94	94	100	n/a	M Hope	55	55	4	0
Basldn	99	99	93	2	M RI	1	1	0	0
Belfast	92	91	26	70	Middlbr	96	95	86	39
Bradfd	12	2	97	89	Newc	0	0	0	0
Brightn	0	0	0	0	Newry	99	99	30	0
Bristol	100	98	94	78	Norwch	100	97	27	73
Camb	57	52	98	95	Nottm	99	99	98	93
Cardff	7	0	4	96	Oxford	84	81	61	11
Carlis	99	99	12	0	Plymth	5	0	2	0
Carsh	77	77	3	0	Ports	100	100	68	10
Chelms	100	100	100	94	Prestn	20	0	0	0
Clwyd	91	91	80	87	Redng	97	0	99	97
Colchr	99	100	n/a	n/a	Sheff	99	98	100	98
Covnt	100	98	73	72	Shrew	99	99	25	29
Derby	99	98	100	70	Stevng	98	98	0	1
Derry	98	98	100	92	Sthend	98	98	0	0
Donc	100	100	97	94	Stoke	98	98	4	0
Dorset	99	99	100	89	Sund	97	97	10	0
Dudley	83	81	64	52	Swanse	97	97	3	1
Exeter	100	83	97	75	Truro	99	99	42	66
Glouc	99	99	3	0	Tyrone	100	99	100	86
Hull	6	6	43	0	Ulster	100	100	40	100
Ipswi	99	99	88	90	Wirral	91	36	41	n/a
Kent	99	98	14	5	Wolve	100	99	100	93
L Barts	0	0	0	0	Wrexm	99	92	0	0
L Guys	0	0	0	0	York	95	92	95	89
L Kings	0	0	0	0	<b>England</b>	64	61	43	29
L Rfree	0	0	0	0	<b>N Ireland</b>	96	96	47	70
L St.G	2	3	0	0	<b>Wales</b>	55	51	19	71
L West	76	76	0	0	<b>E, W &amp; NI</b>	65	61	42	33
Leeds	97	96	95	80					

n/a not applicable

*Summary of BP achievements*

Figure 11.1 summarises the median SBP, DBP and PP readings (with IQRs) for all treatment modalities from renal centres in England, Wales and Northern Ireland.

BP readings from 18,669 out of 40,726 patients were analysed. The results shown for HD patients are post-dialysis readings. Median systolic and diastolic BP were lower in HD patients than in both PD and Tx patients (SBP: 129 mmHg (HD), 138 mmHg (PD) and 135 mmHg (Tx); DBP: 68 mmHg (HD), 80 mmHg (PD) and 79 mmHg (Tx)). Pulse pressure readings in HD patients (60 mmHg) were greater than in PD (57 mmHg) and Tx (56 mmHg) patients.

*Haemodialysis*

Pre-HD readings from 11,397 out of 17,574 patients and post-HD readings from 10,803 out of 17,574 patients were available for analysis. Due to extraction of insufficient readings, 14 centres were excluded from the pre-HD analyses and 16 centres from the post-HD analyses.

Figure 11.2 illustrates the performance of centres and nations in achieving the previous RA standard for pre-HD BP (<140/90 mmHg). Overall, 43.1% (95% CI: 42.2–44.0%) achieved this standard. There was significant variation in achievement between centres ( $p < 0.0001$ ) and between nations ( $p < 0.0005$ ).

Figure 11.3 demonstrates the attainment of the previous post-dialysis BP standard for HD patients

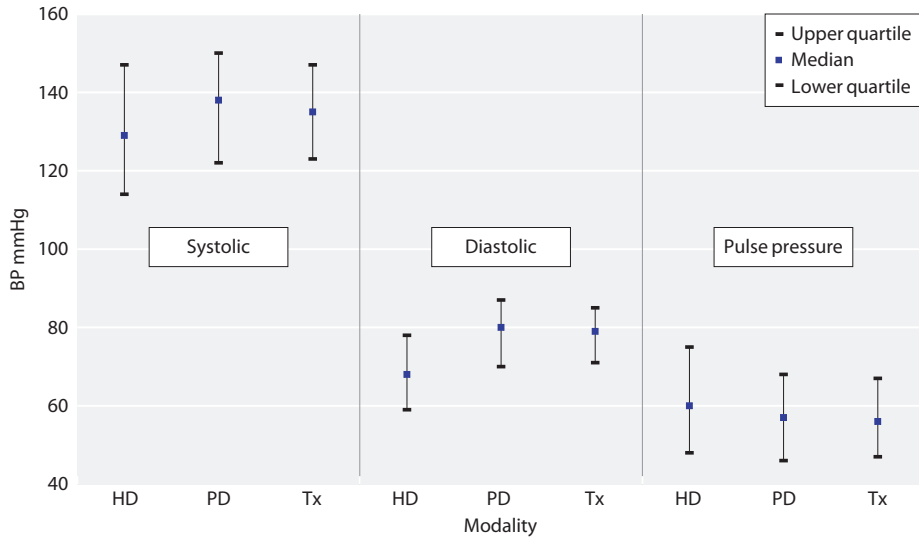


Fig. 11.1. Summary of BP achievements

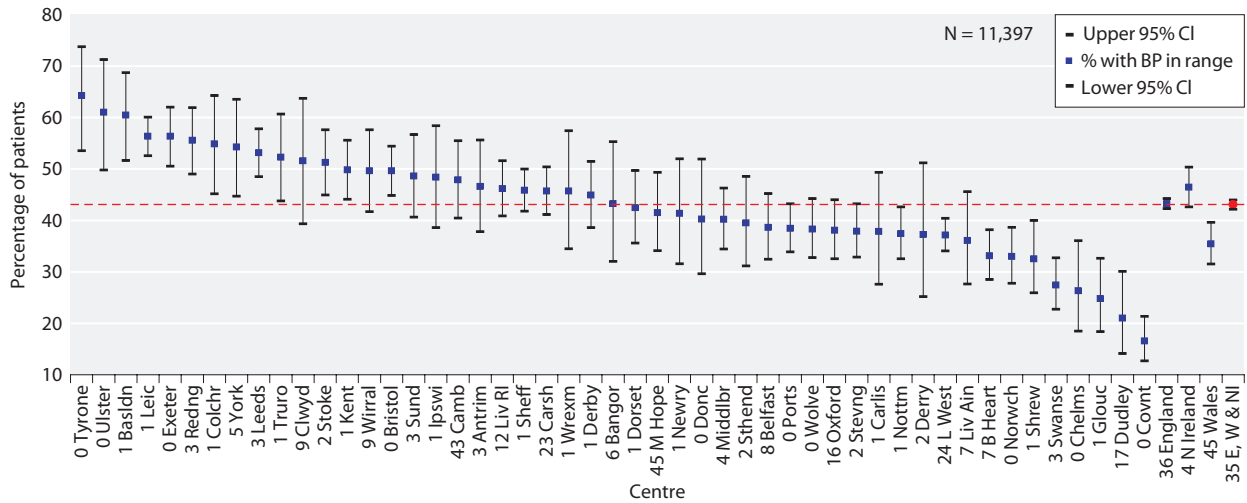


Fig. 11.2. Percentage of patients with BP <140/90 mmHg: pre-HD

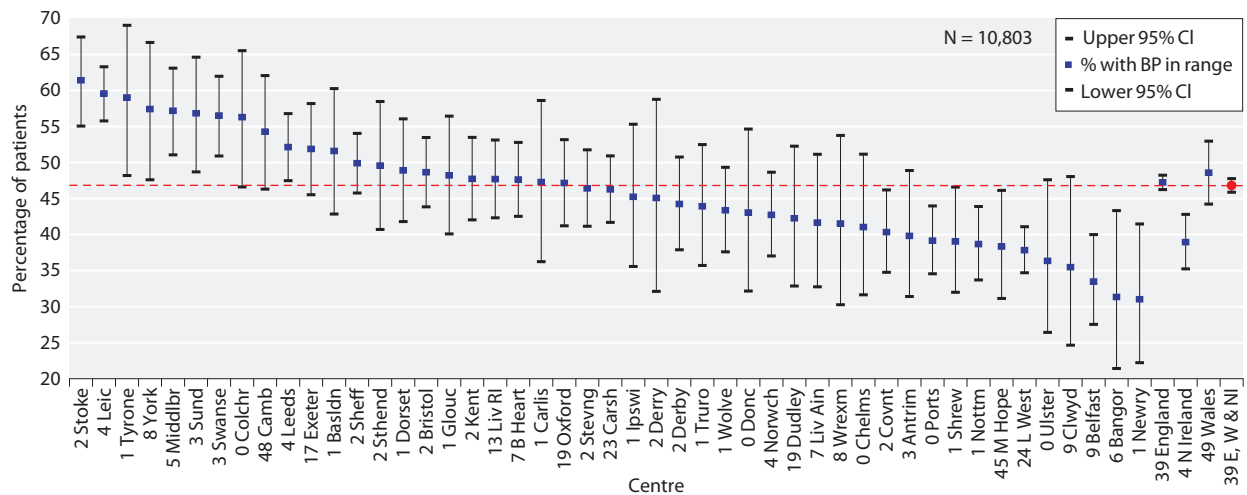
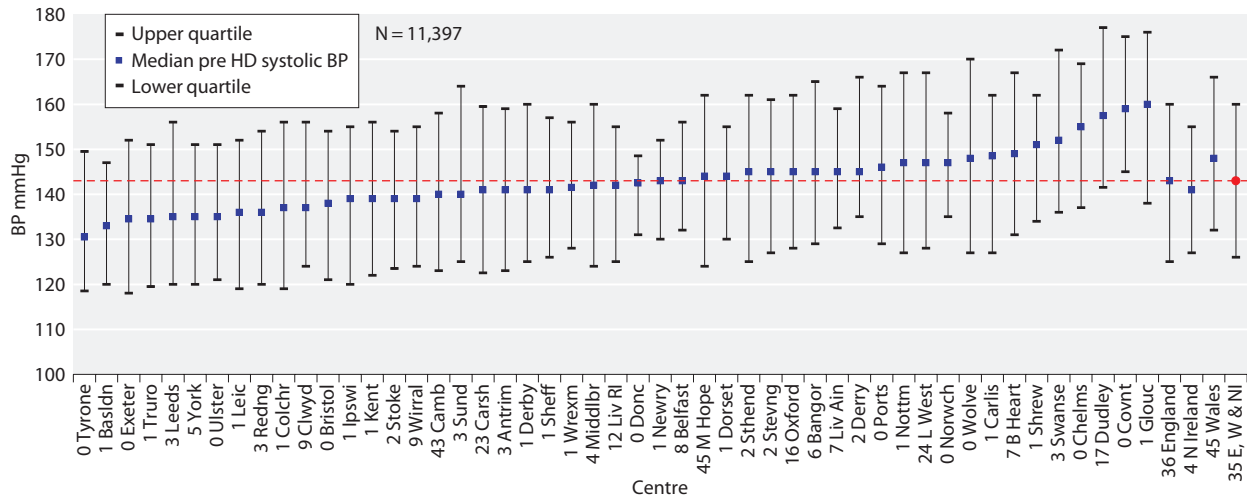


Fig. 11.3. Percentage of patients with BP <130/80 mmHg: post-HD



**Fig. 11.4.** Median systolic BP: pre-HD

(<130/80 mmHg). Overall, 46.8% of all patients (95% CI: 45.9–47.8%) achieved this standard, with a significant variation between centres ( $p < 0.0001$ ) and nations ( $p < 0.0005$ ).

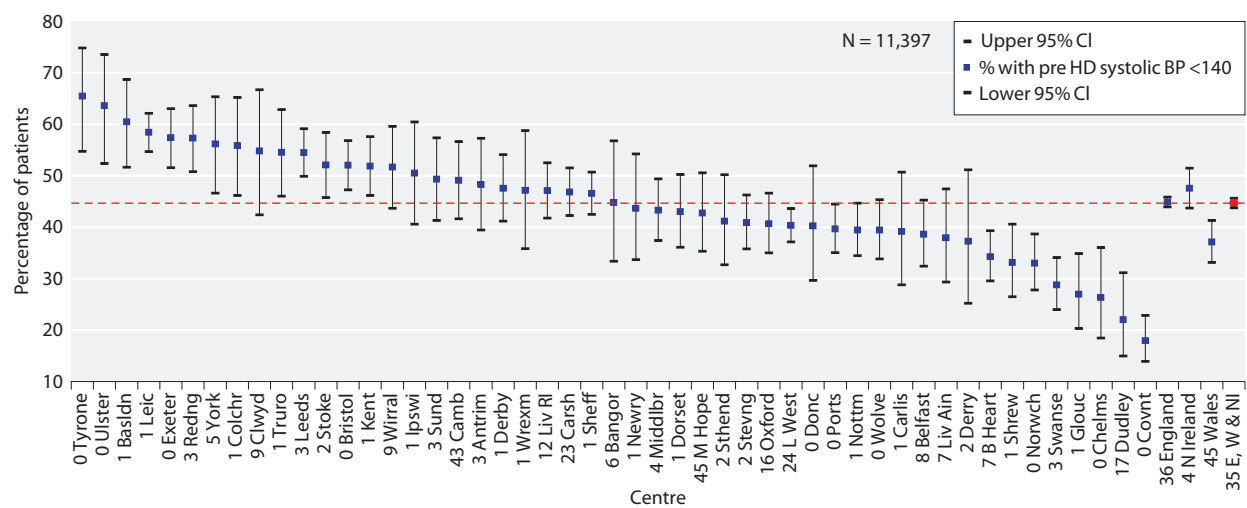
Figure 11.4 describes the median pre-HD systolic BP by both centre and nation. The median pre-HD SBP for all patients was 143 mmHg, ranging from 130.5–160.0 mmHg between centres. Northern Ireland’s SBP readings were lower (141 mmHg) compared with England (143 mmHg) and Wales (148 mmHg).

Figure 11.5 demonstrates the attainment of the previous RA standard for pre-HD systolic BP (<140 mmHg) by centre and nation. Overall, 44.7% of all patients achieved this standard (95% CI: 43.8%–45.6%), with significant variation between centres ( $p < 0.0001$ ) and nations ( $p < 0.001$ ).

Figure 11.6 illustrates the median post-HD systolic BP in all centres and nations. The median post-HD SBP for all patients was 129 mmHg, ranging from 119–143 mmHg between centres. Northern Ireland’s post-HD SBP was higher (134 mmHg) than those in England and Wales (129 mmHg).

Figure 11.7 shows the attainment of the previous RA standard for post-HD systolic readings (<130 mmHg) for all centres and nations. Overall, 50.3% of all patients achieved this standard (95% CI: 49.3%–51.2%). There was a significant variation in attaining this standard between centres (range 31.3%–64.8%,  $p < 0.0001$ ) and between nations (range 41.6%–50.8%,  $p < 0.0001$ ).

Figure 11.8 demonstrates the median pre-HD diastolic BP by both centre and nation. The median



**Fig. 11.5.** Percentage of patients with systolic BP <140 mmHg: pre-HD

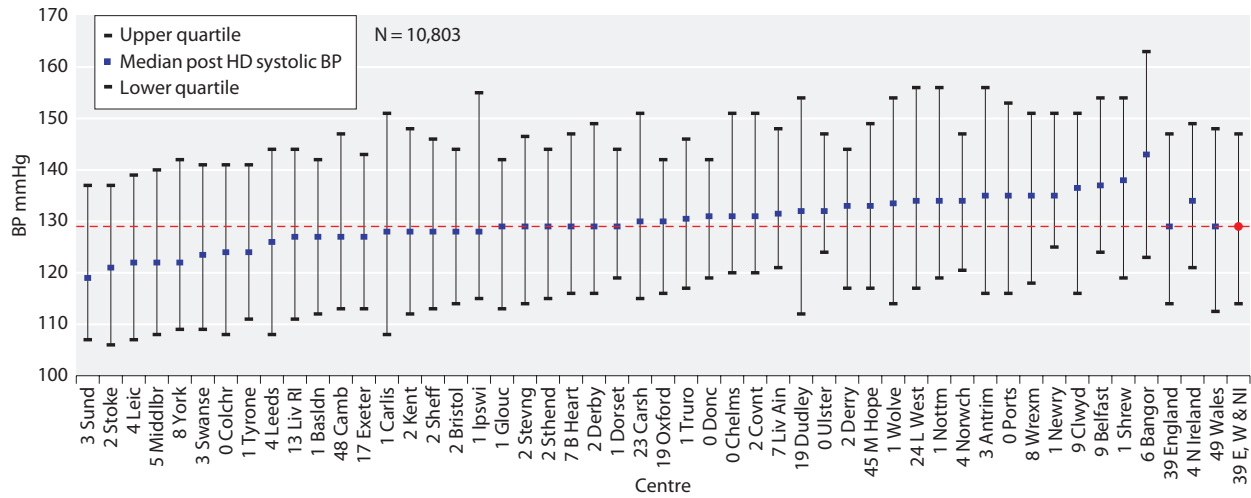


Fig. 11.6. Median systolic BP: post-HD

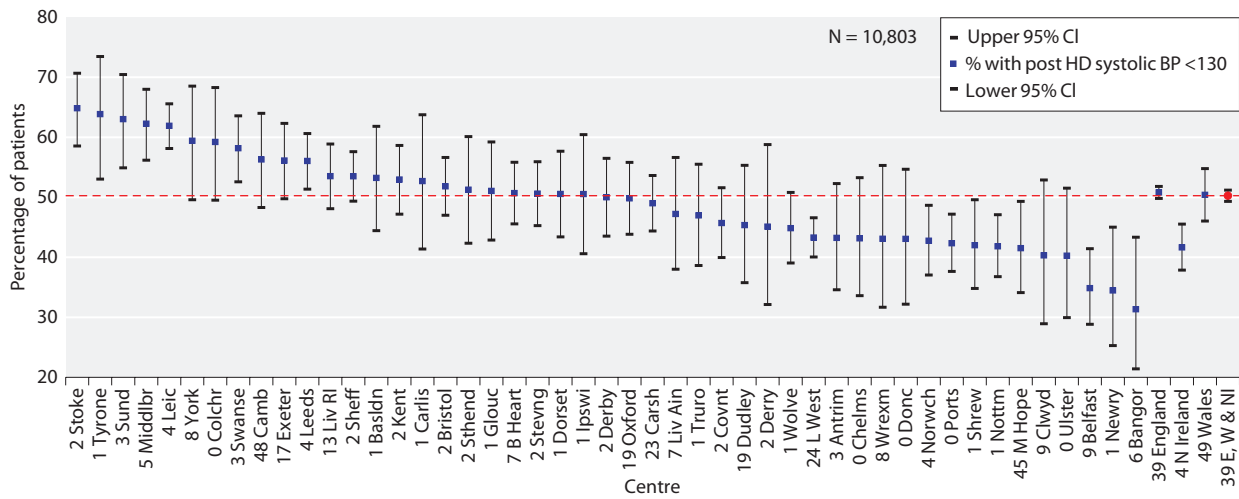


Fig. 11.7. Percentage of patients with systolic BP <130 mmHg: post-HD

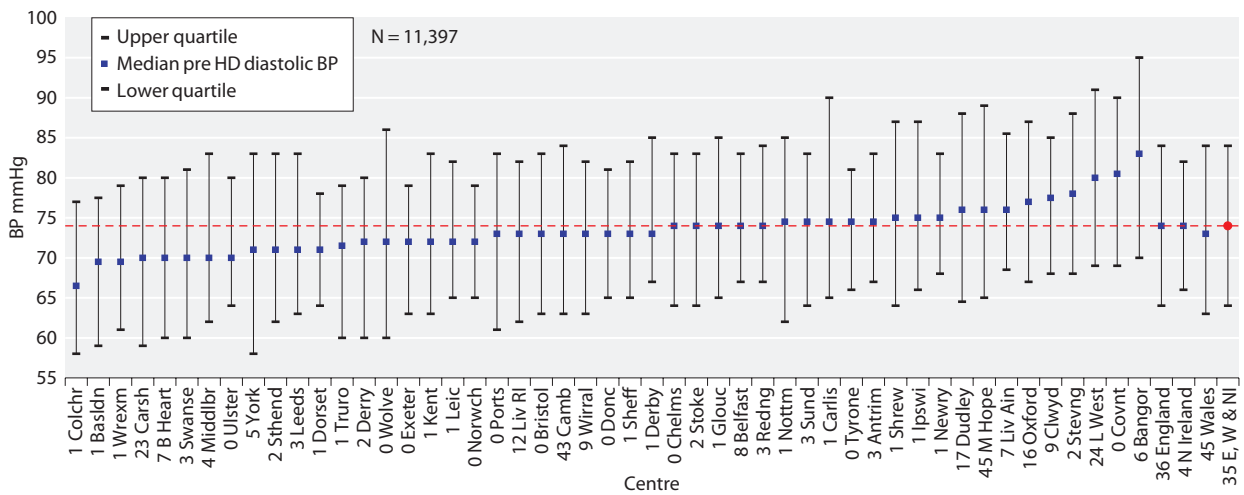
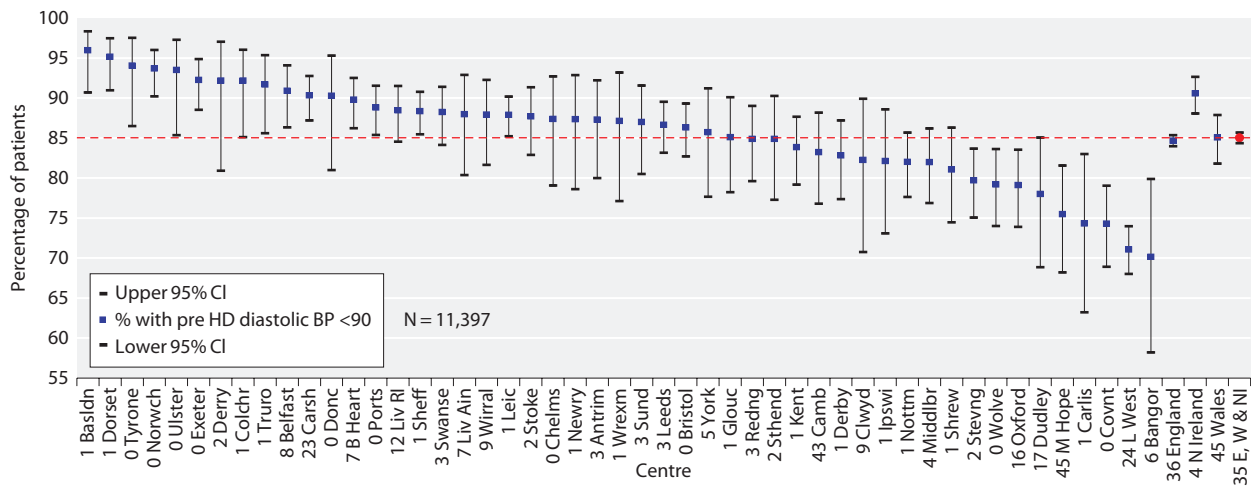


Fig. 11.8. Median diastolic BP: pre-HD



**Fig. 11.9.** Percentage of patients with diastolic BP <90 mmHg; pre-HD

pre-HD DBP in all patients was 74 mmHg, ranging from 66.5–83.0 mmHg between centres.

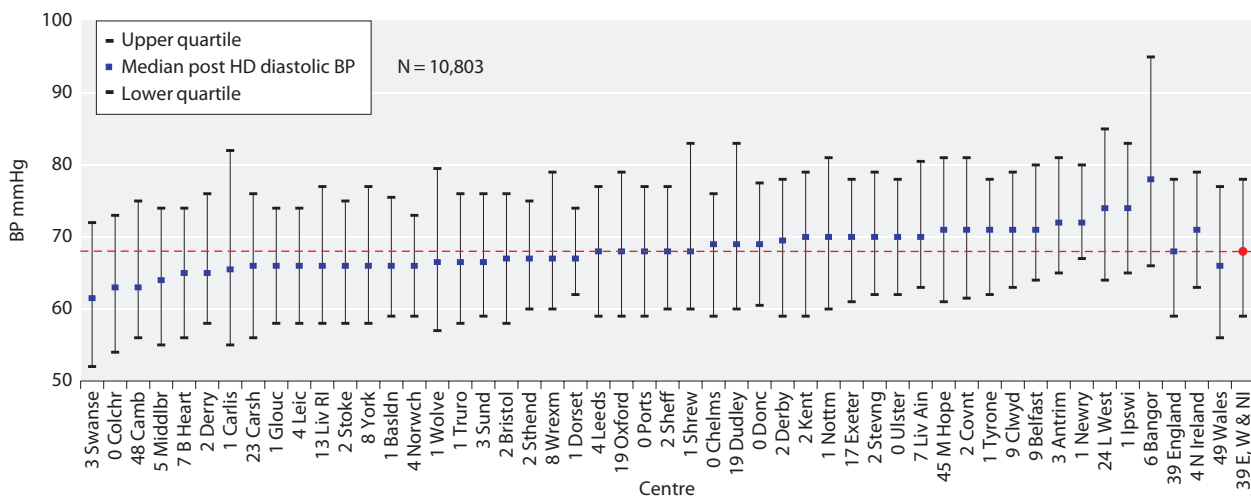
Figure 11.9 illustrates the performance of centres and nations in achieving the previous RA standard for pre-HD diastolic BP (<90 mmHg). Overall, 85.0% of patients achieved this standard (95% CI: 84.4% to 85.7%). There was a significant variation in the achievement of this standard between centres (range 70.2%–96.0%,  $p < 0.0001$ ) and between nations (range 84.7%–90.6%,  $p < 0.0005$ ).

Figure 11.10 shows the median post-HD diastolic BP by both centre and nation. The median post-HD DBP for all patients was 68 mmHg, ranging from 61.5–78.0 mmHg between centres. Wales achieved a lower post-HD DBP (66 mmHg) compared with England (68 mmHg) and Northern Ireland (71 mmHg).

Figure 11.11 demonstrates the performance of centres and nations in achieving the previous RA standard for post-HD diastolic BP (<80 mmHg). Overall 78.1% of all patients achieved this standard (95% CI: 77.3%–78.8%). There was a significant variation in attaining this standard between centres (range 56.7%–90.3%,  $p < 0.0001$ ) but not between nations.

Figure 11.12 describes the median pre-HD pulse pressure for all centres and nations. The median pre-HD PP for all patients was 67 mmHg. The median pre-HD PP ranged from 60.0–81.5 mmHg between centres, and from 65–74 mmHg between nations.

Figure 11.13 illustrates the median post-HD pulse pressure by both centre and nation. The median post-HD PP for all patients was 60 mmHg. The median



**Fig. 11.10.** Median diastolic BP: post-HD



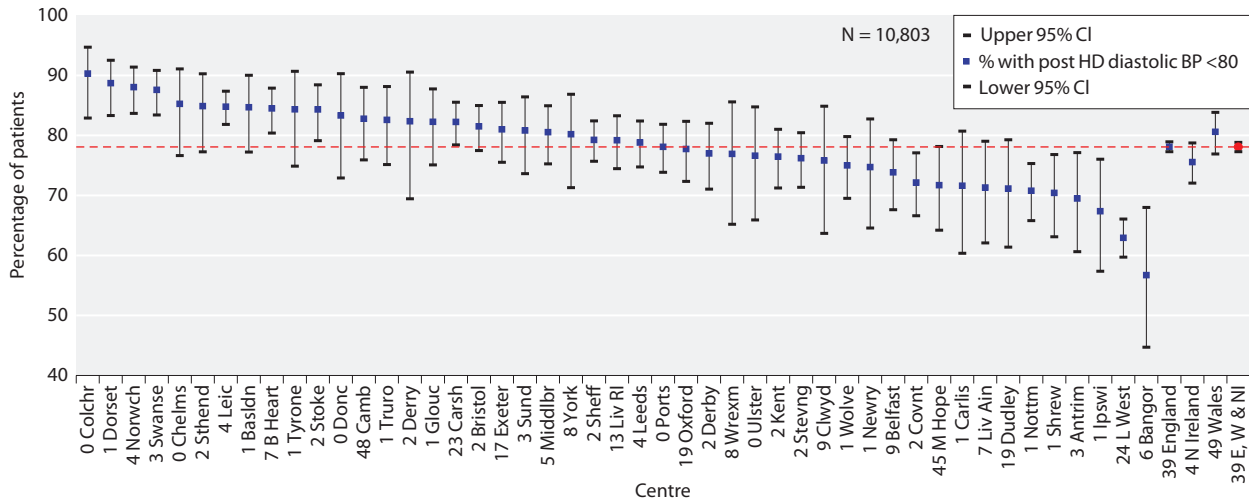


Fig. 11.11. Percentage of patients with diastolic BP <80 mmHg: post-HD

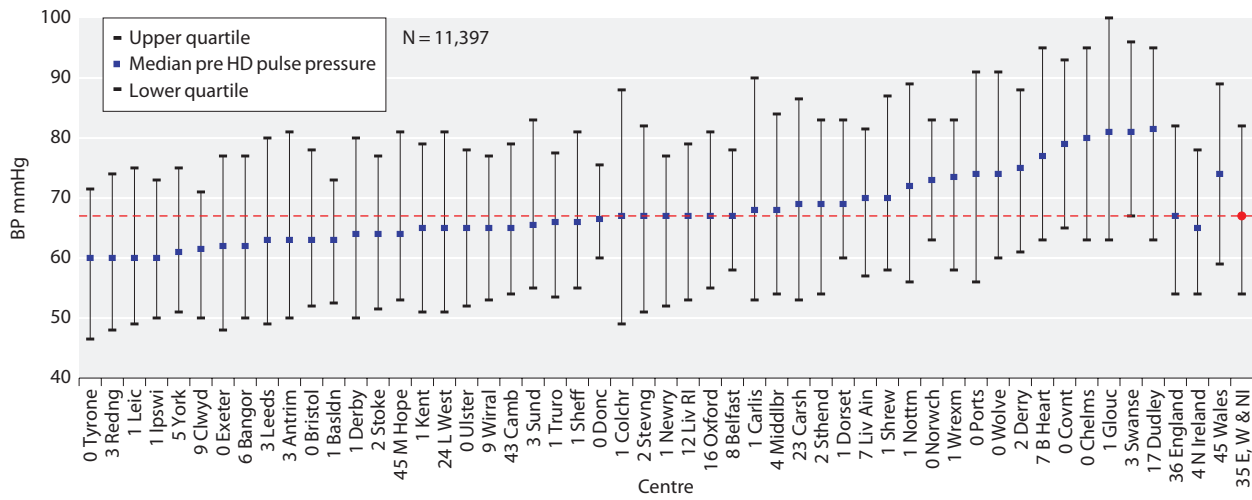


Fig. 11.12. Median PP: pre-HD

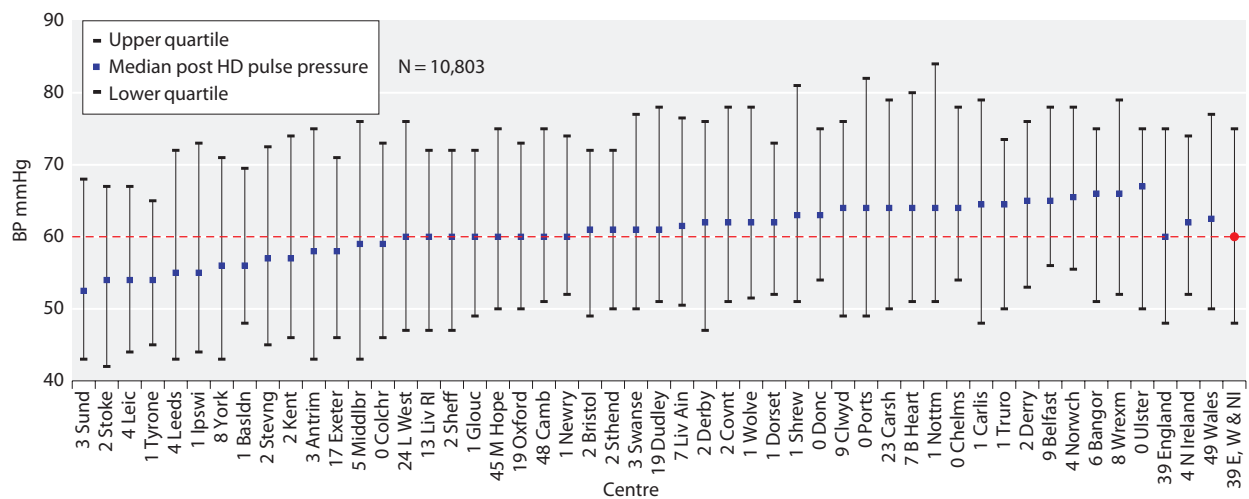
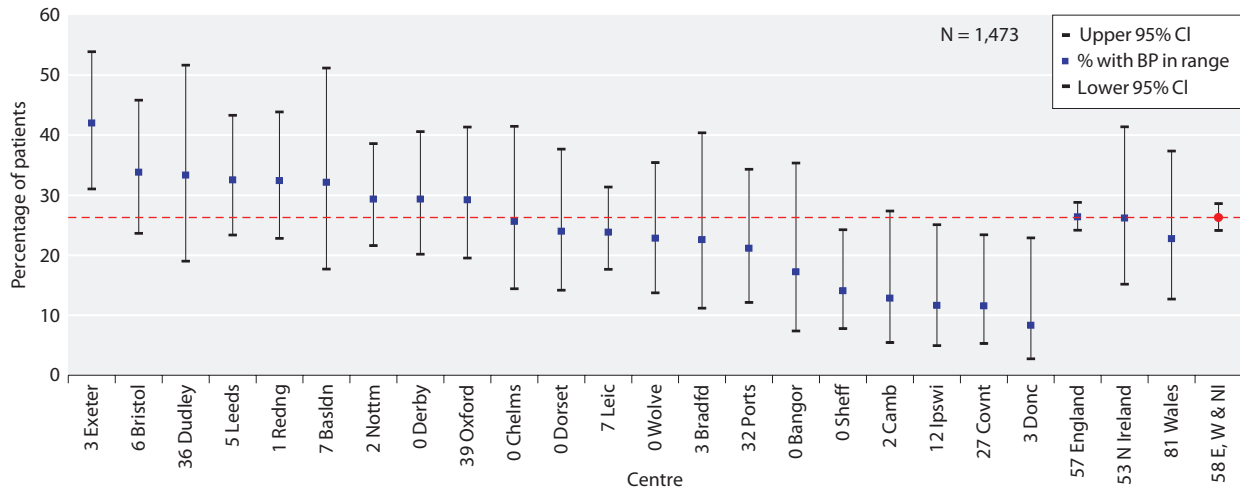


Fig. 11.13. Median PP: post-HD



**Fig. 11.14.** Percentage of patients with BP <130/80 mmHg: PD

post-HD PP ranged from 52.5–67.0 mmHg between centres and from 60.0–62.5 mmHg between nations.

*Peritoneal dialysis*

A total of 1,473 recordings (41.8%) from 3,524 PD patients were available for analysis. Due to extraction of insufficient readings 41 centres were not included in the centre specific analyses.

Figure 11.14 demonstrates the performance of centres and nations in achieving the RA standard for BP control in patients on PD (<130/80 mmHg). Overall, 26.3% of patients achieved this standard (95% CI: 24.1%–28.6%). There was a significant variation between centres (range 8.3%–42.0%,  $p < 0.001$ ) in attaining this standard.

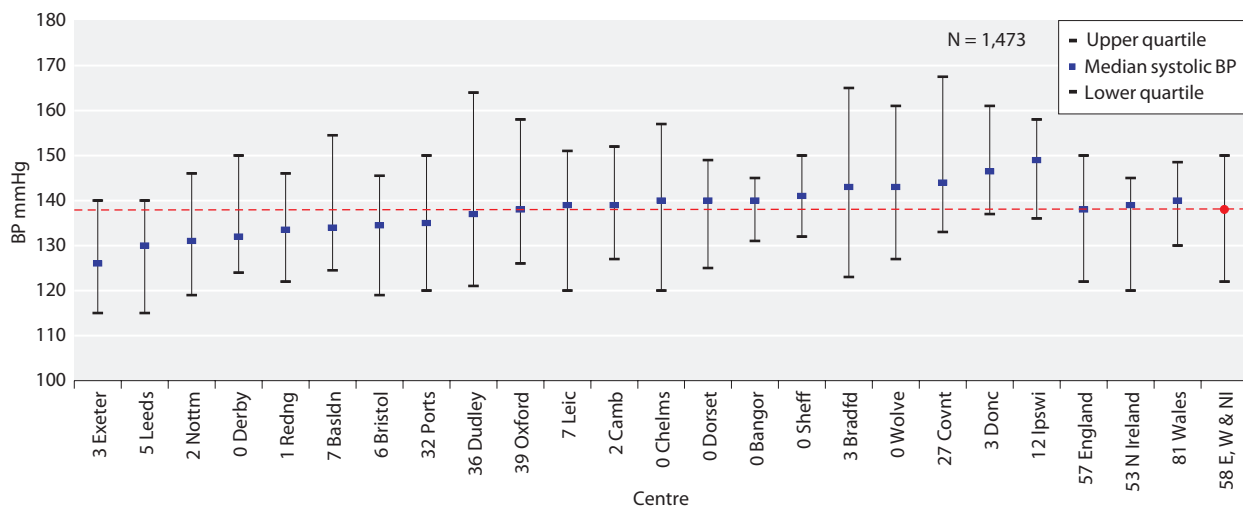
Figure 11.15 shows the median systolic BP in PD patients by both centre and nation. The median SBP

for all PD patients was 138 mmHg, ranging from 126–149 mmHg between centres.

Figure 11.16 illustrates the performance of centres and nations in achieving the RA standard for systolic BP control in patients on PD (<130 mmHg). Overall, 35.2% of PD patients (95% CI: 32.8%–37.7%) achieved this standard. There was a significant variation in the attainment of this standard between individual centres (range 8.3%–58.0%,  $p < 0.0001$ ).

Figure 11.17 shows the median diastolic BP in PD patients by both centre and nation. The median DBP for all PD patients was 80 mmHg, with a range of 73.0–85.5 mmHg between centres.

Figure 11.18 illustrates the performance of centres and nations in achieving the RA standard for diastolic BP control in patients on PD (<80 mmHg). Overall,



**Fig. 11.15.** Median systolic BP: PD

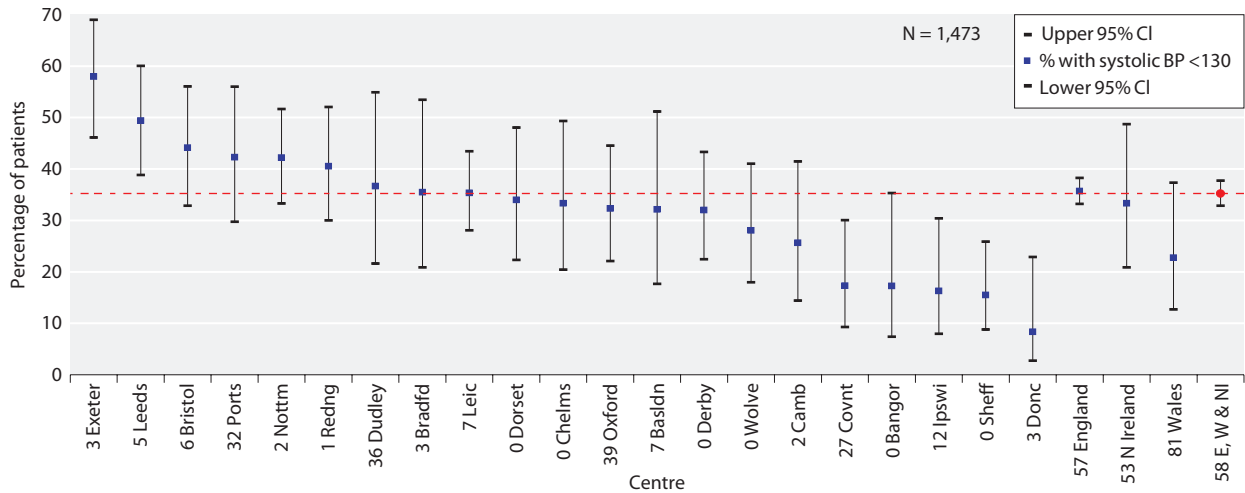


Fig. 11.16. Percentage of patients with systolic BP <130 mmHg: PD

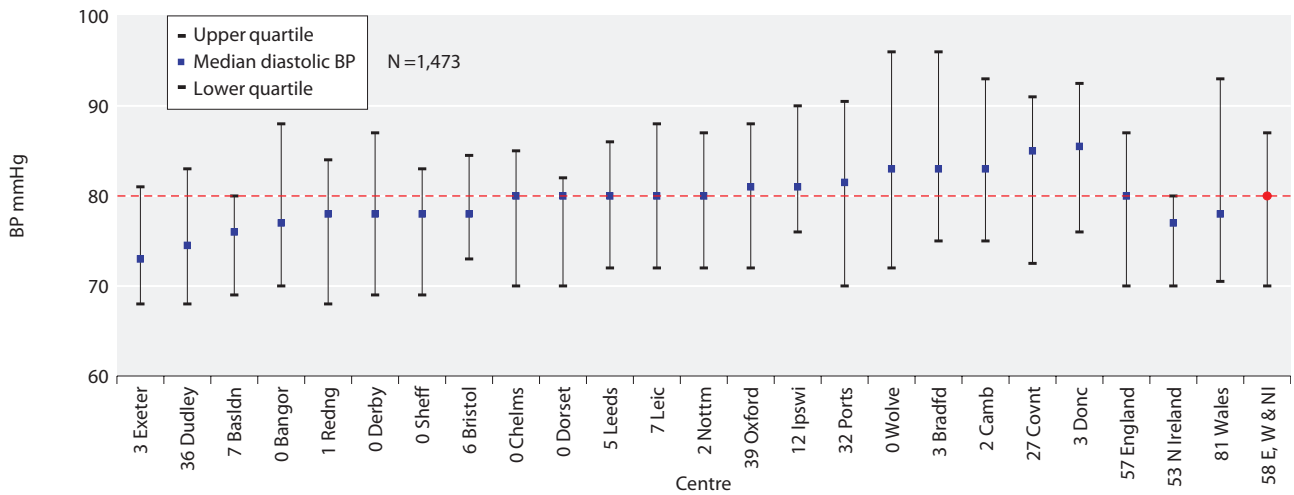


Fig. 11.17. Median diastolic BP: PD

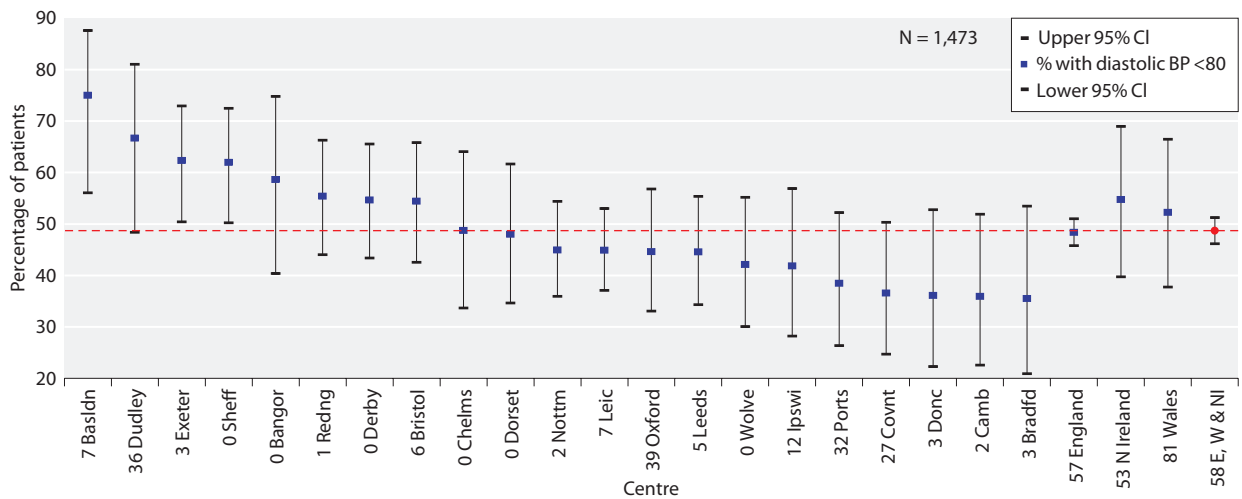


Fig. 11.18. Percentage of patients with diastolic BP <80 mmHg: PD

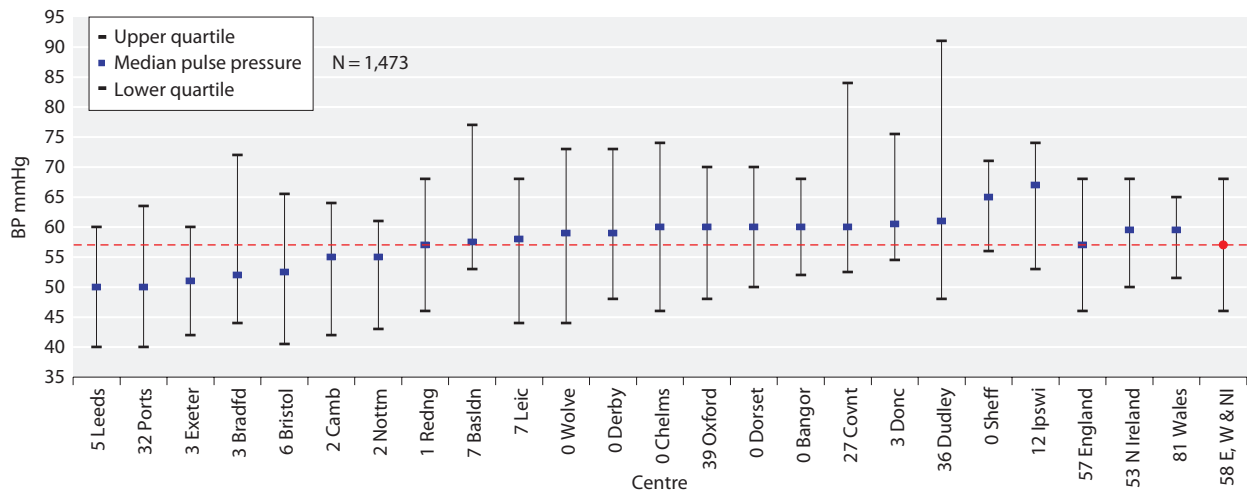


Fig. 11.19. Median PP: PD

48.7% of PD patients (95% CI: 46.1%–51.2%) achieved this standard. There was a significant variation in attaining this standard between individual centres (range 35.5%–75.0%,  $p < 0.005$ ).

Figure 11.19 demonstrates the median pulse pressure in PD patients by both centre and nation. The median PP for all PD patients was 57 mmHg, ranging from 50–67 mmHg between centres.

*Transplant*

A total of 6,393 (32.6%) blood pressure readings from 19,628 Tx recipients were analysed. Thirty-three centres were excluded from the centre-specific analyses because insufficient readings were extracted.

Figure 11.20 illustrates the performance of centres and nations in achieving the RA standard for BP control in Tx recipients (<130/80 mmHg). Overall, 27.4% (95% CI: 26.3%–28.5%) of patients achieved this standard but there was significant variation in achievement between centres (range 14.9%–43.8%,  $p < 0.0001$ ) and nations (range 25.8%–41.1%,  $p < 0.0001$ ).

Figure 11.21 shows the median systolic BP in Tx recipients by both centre and nation. The median SBP for all Tx patients was 135 mmHg and ranged from 120–141 mmHg between centres.

Figure 11.22 illustrates the performance of centres and nations in achieving the RA standard for systolic BP control in Tx recipients (<130 mmHg). Overall,

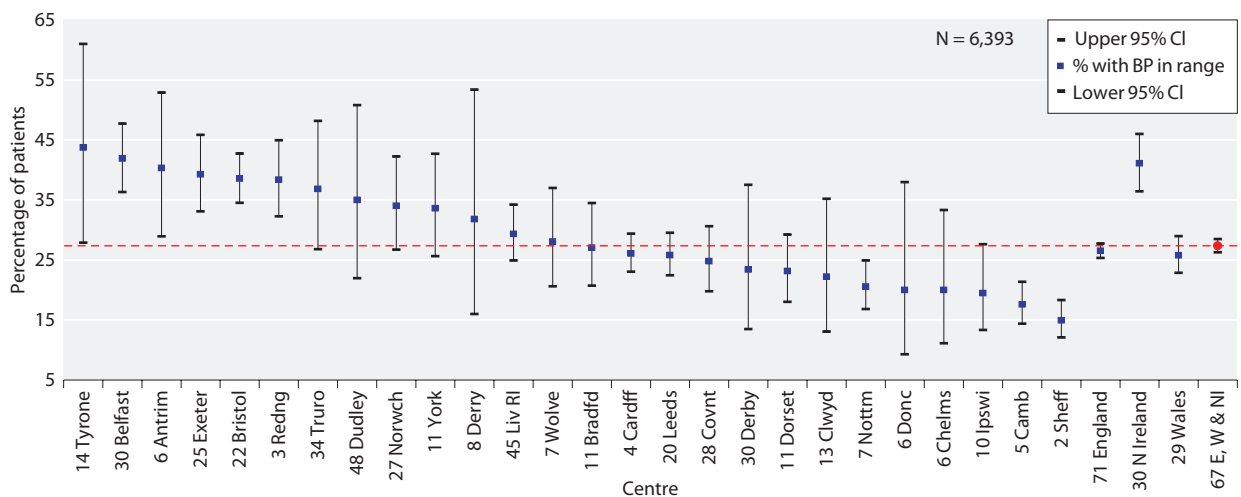


Fig. 11.20. Percentage of patients with BP <130/80 mmHg: Tx

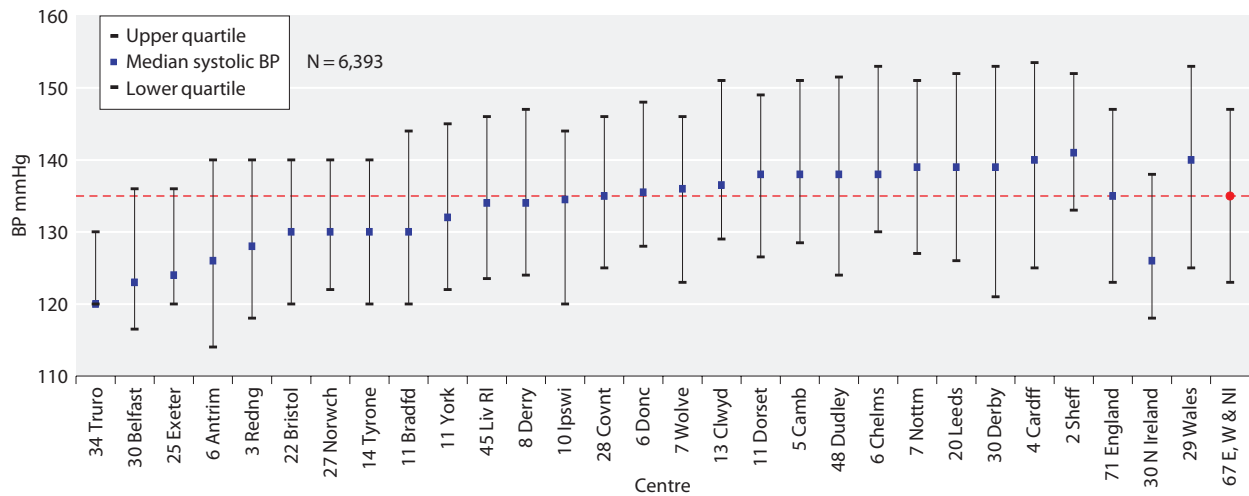


Fig. 11.21. Median systolic BP: Tx

36.7% of Tx patients achieved this standard (95% CI: 35.5%–37.8%). There was a significant difference in achievement of this standard between centres (range 18.7%–65.8%,  $p < 0.0001$ ) and nations (range 30.0%–54.4%,  $p < 0.0001$ ).

Figure 11.23 shows the median diastolic BP in Tx recipients by both centre and nation. The median DBP in all patients was 79 mmHg and ranged from 72.5–83.5 mmHg between centres.

Figure 11.24 illustrates the performance of centres and nations in achieving the RA standard for diastolic BP control in Tx recipients (<80 mmHg). Overall, 52.0% of all patients (95% CI: 50.8%–53.3%) achieved this standard, but there was significant variation in achievement between centres (range 34.0%–66.1%,

$p < 0.0001$ ) and nations (range 51.1%–62.1%,  $p < 0.0001$ ).

Figure 11.25 describes the median pulse pressure in Tx recipients by both centre and nation. The median PP for all Tx patients was 56 mmHg, ranging from 50–62 mmHg between centres and 50–60 mmHg between nations.

*Blood pressure by primary renal diagnosis*

The prevalence of hypertension was assessed for each renal diagnostic category. BP profiles for each modality were analysed after patients were grouped by primary renal diagnosis (PRD). For prevalent RRT patients in 2008, a renal diagnosis was not available in 4.5% of patients and an uncertain diagnosis was recorded

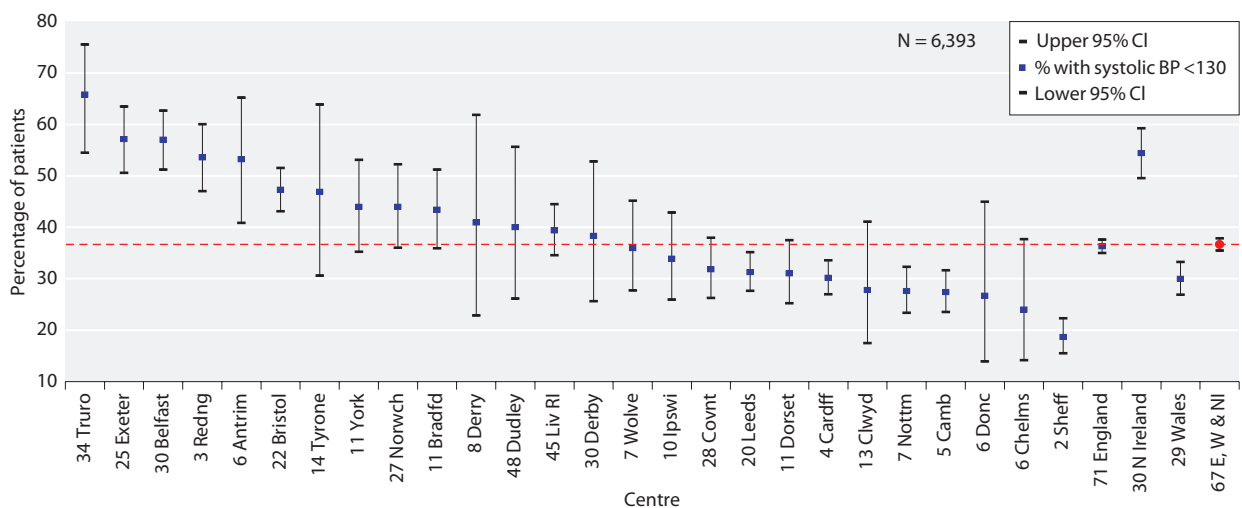


Fig. 11.22. Percentage of patients with systolic BP <130 mmHg: Tx

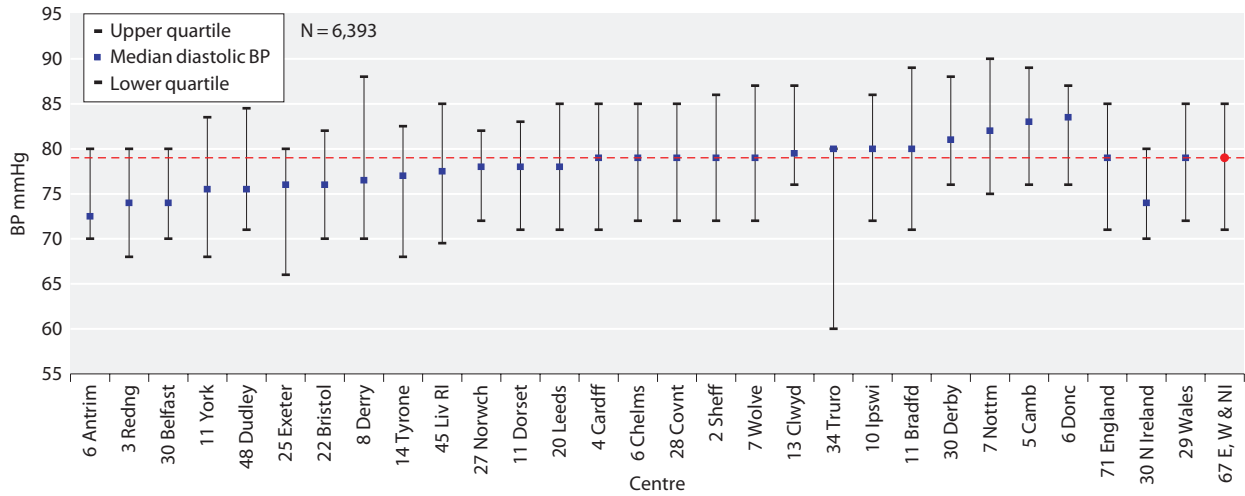


Fig. 11.23. Median diastolic BP: Tx

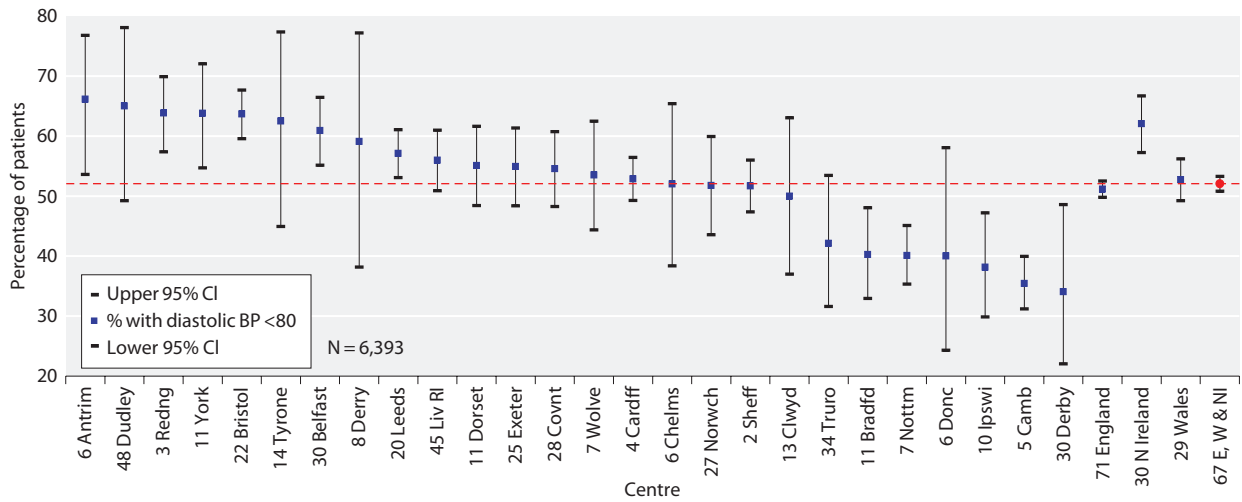


Fig. 11.24. Percentage of patients with diastolic BP <80 mmHg: Tx

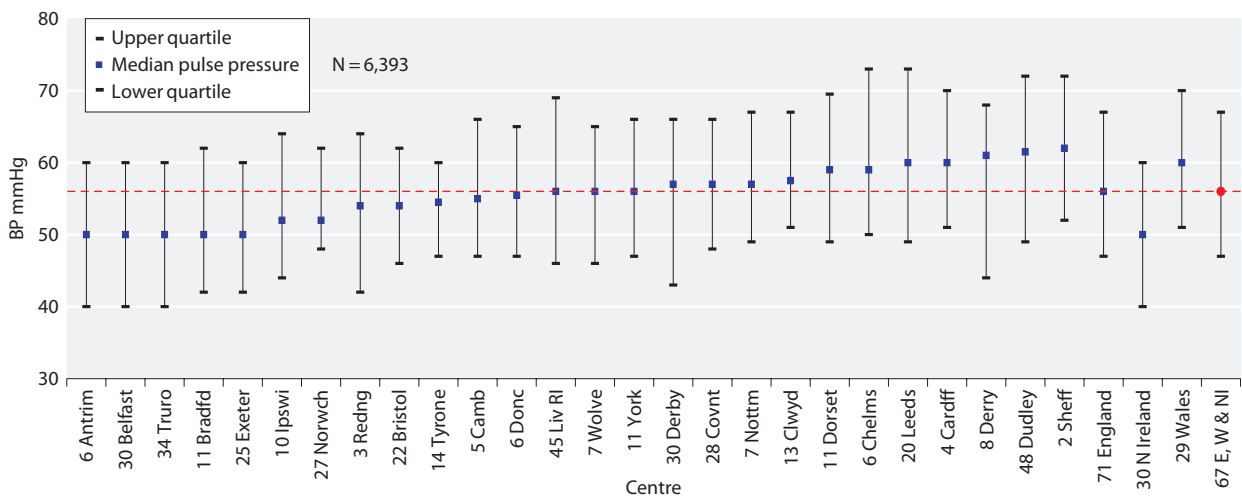
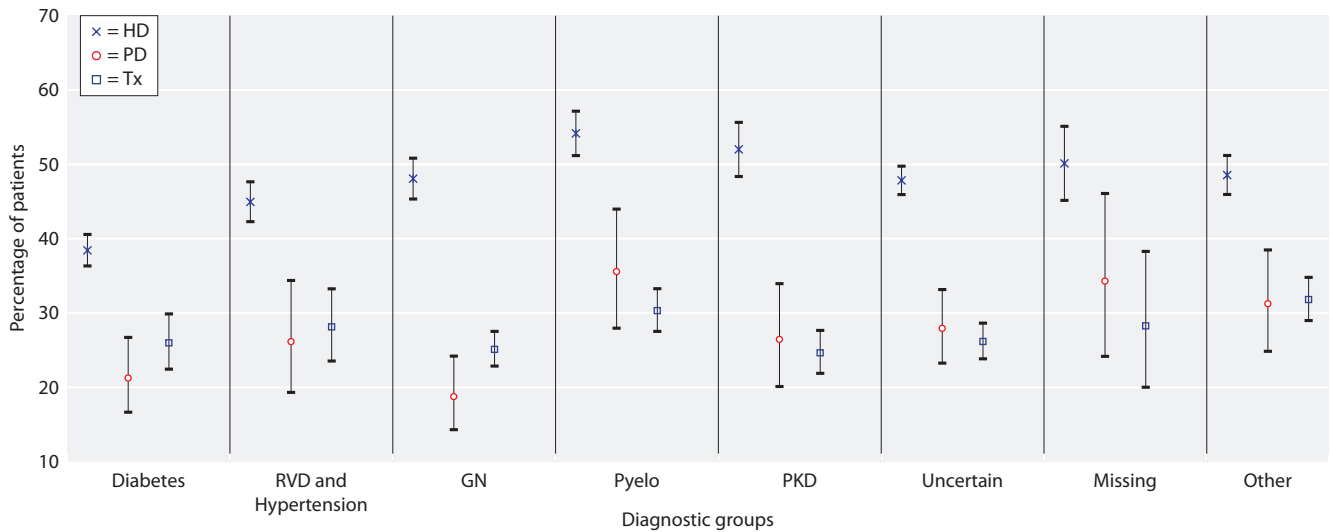


Fig. 11.25. Median PP: Tx



**Fig. 11.26.** Percentage of patients with BP <130/80 mmHg by primary diagnosis

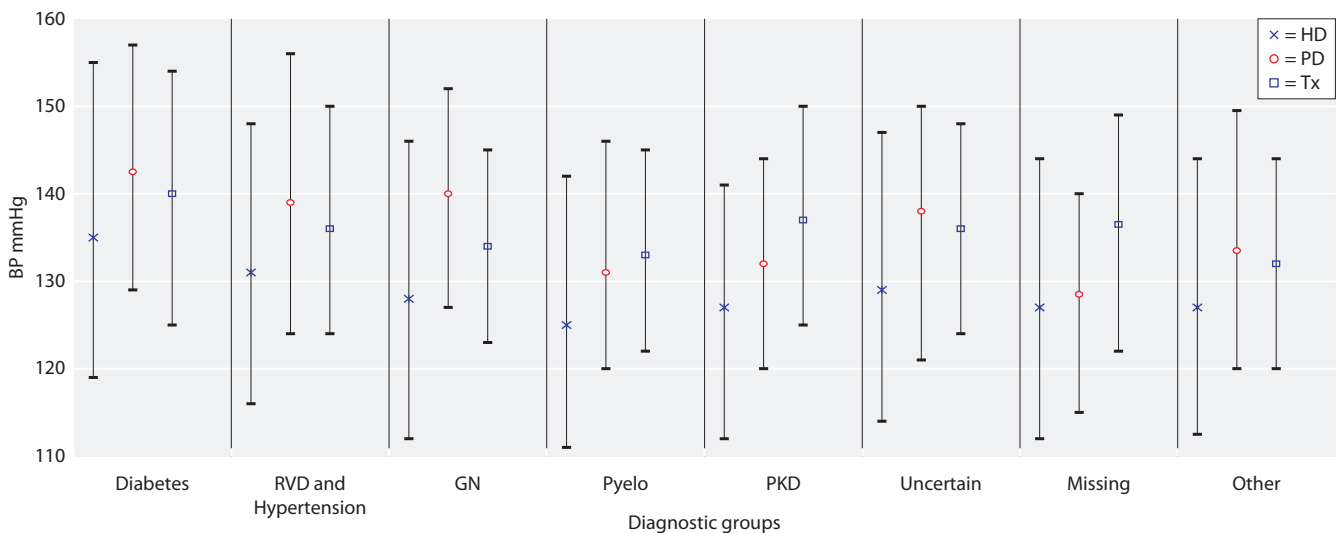
in a further 21.6%. The main diagnostic groups included glomerulonephritis (15.6%), diabetes (13.4%), pyelonephritis (11.9%), polycystic kidneys (9.4%), renovascular disease (8.9%) and ‘other’ conditions (14.2%). BP readings within the last two quarters of 2008 were available for between 44.2%–50.1% of patients in each diagnostic category. For those patients with no recorded renal diagnosis only 30.3% had BP data.

Figure 11.26 describes the attainment of BP <130/80 mmHg by diagnostic category and RRT modality (post-HD data shown). There was a significant difference in the attainment of this standard across the PRD groups and each modality ( $p < 0.0001$  in HD patients,  $p < 0.05$  in PD and Tx patients). In addition, a significantly

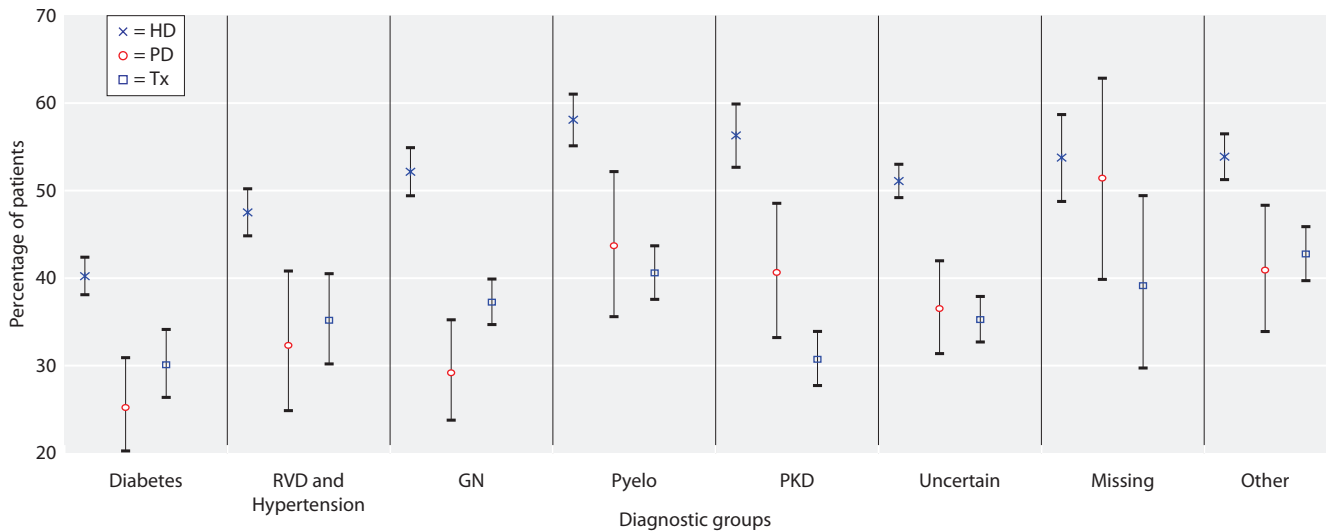
greater percentage of HD patients achieved this standard (<130/80 mmHg) than patients on PD or Tx recipients. When PD patients were compared with Tx patients, there was a borderline significant difference in achieving a BP <130/80 mmHg in patients with glomerulonephritis ( $p < 0.05$ ). These patterns are shown in figures 11.26–11.31. SBP and PP were significantly higher in patients with vascular disorders (diabetes and renovascular) than patients with glomerulonephritis or tubular disorders.

*Longitudinal analysis of incident HD patients*

In order to investigate trends in BP control over time, a longitudinal analysis of the BP profile of incident HD patients from 2000 to 2004 was performed. Of the



**Fig. 11.27.** Median systolic BP (IQR) by primary diagnosis



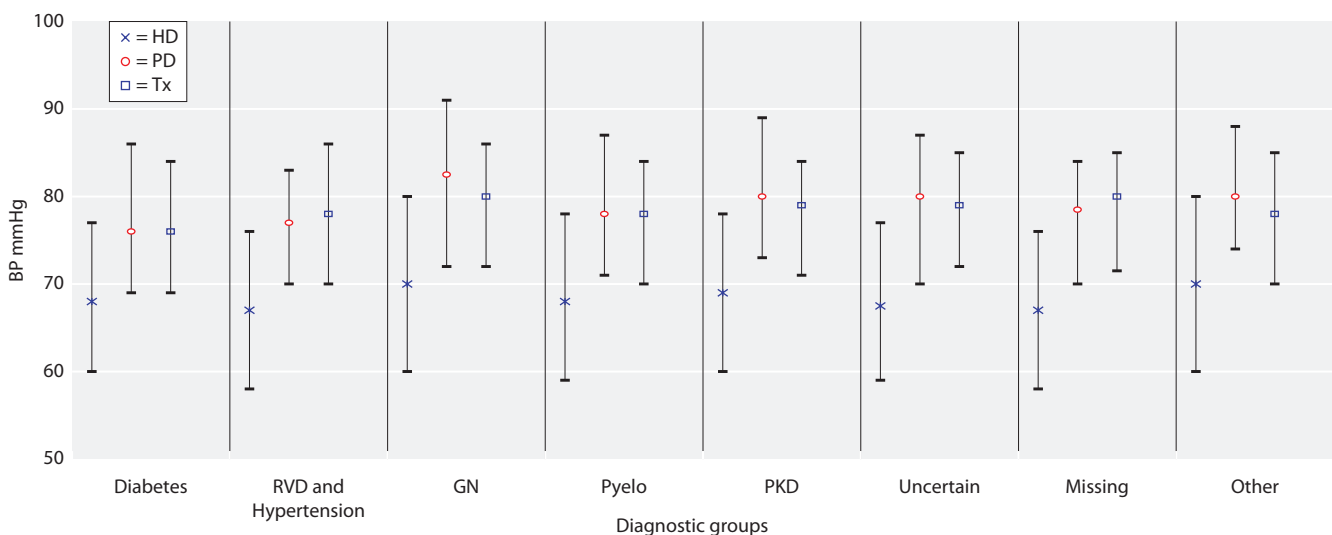
**Fig. 11.28.** Percentage of patients with systolic BP <130 mmHg by primary diagnosis

13,074 incident HD patients, 7,221 had at least one BP measurement available following dialysis initiation. BP measurements in the 5 years following HD commencement were analysed. There were 4,944 patients who had had BP data extracted during the quarter in which they had started RRT. At one year, there were 3,391 HD, 259 PD and 53 Tx patients with BP measurements. At five years, there were 1,544 HD, 58 PD and 397 Tx patients with BP measurements.

Figure 11.32 shows the adjusted mean systolic BP (post-dialysis in HD patients) for incident HD patients (2000–2004) based upon the RRT modality utilised over the follow-up period. As outlined in the methods,

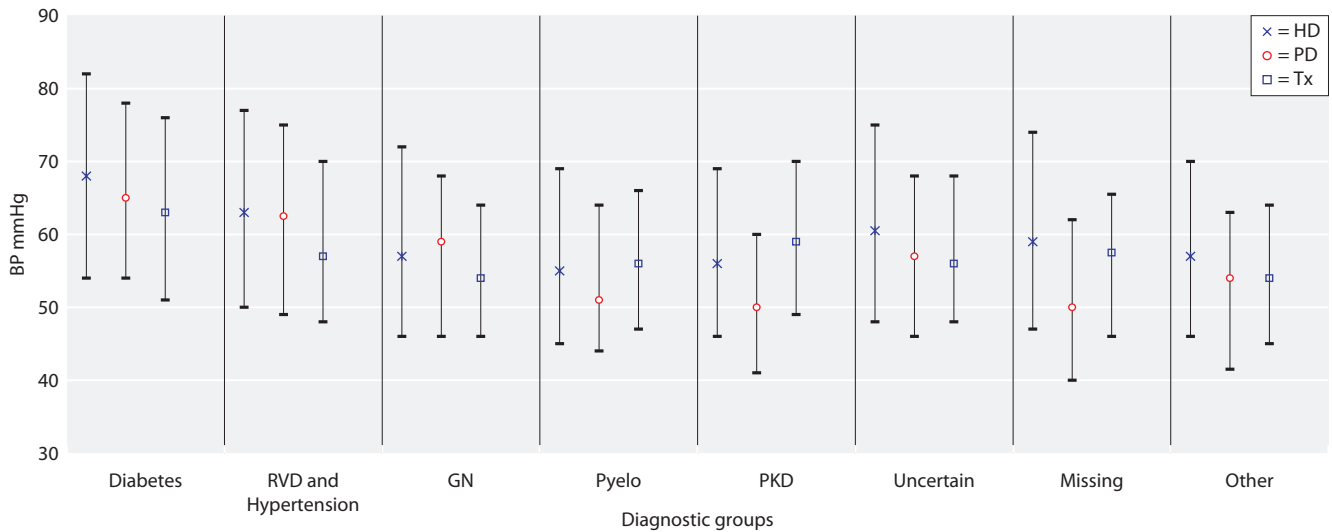
a parallel model rather than a linear one appeared to be most appropriate, as the SBP decreases at different rates depending on time from RRT start. Mean SBP recordings fell an average 8 mmHg within the first year of treatment, decreasing slightly further in the following year. After the end of the second year following RRT start, there was no further change in SBP.

Incident HD patients who remained on HD, achieved a significantly lower mean SBP over the 5 year observation period ( $p < 0.0001$ ). Incident HD patients who were subsequently transplanted during the study period had higher mean SBP measurements than incident HD patients who changed to PD ( $p < 0.0001$ ).



**Fig. 11.29.** Median diastolic BP (IQR) by primary diagnosis



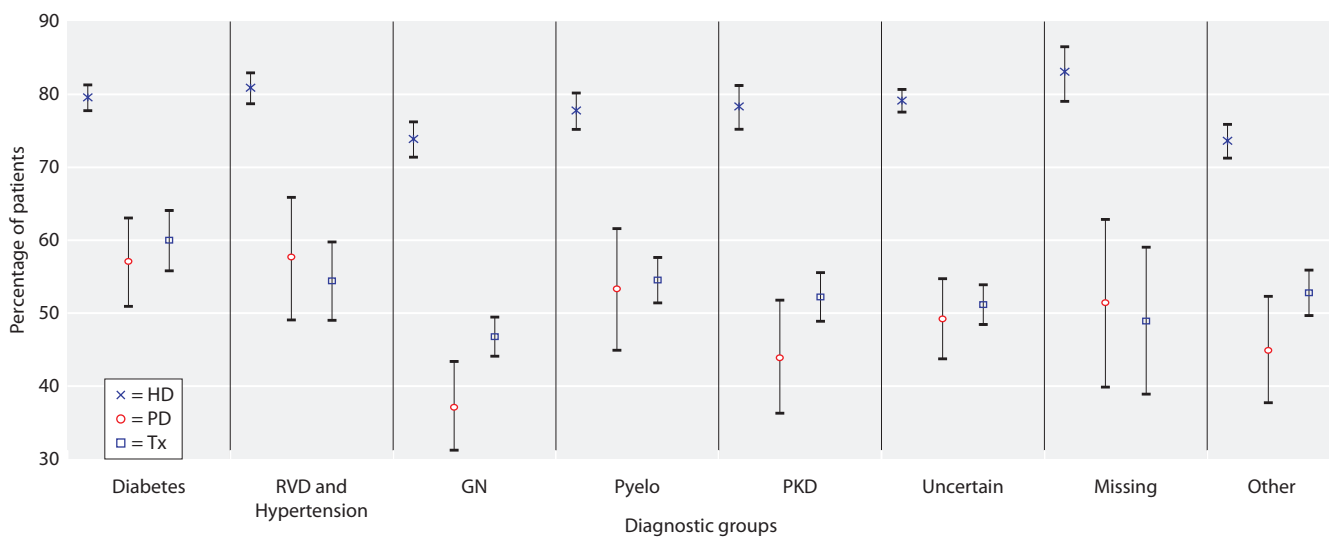


**Fig. 11.30.** Percentage of patients with diastolic BP <80 mmHg by primary diagnosis

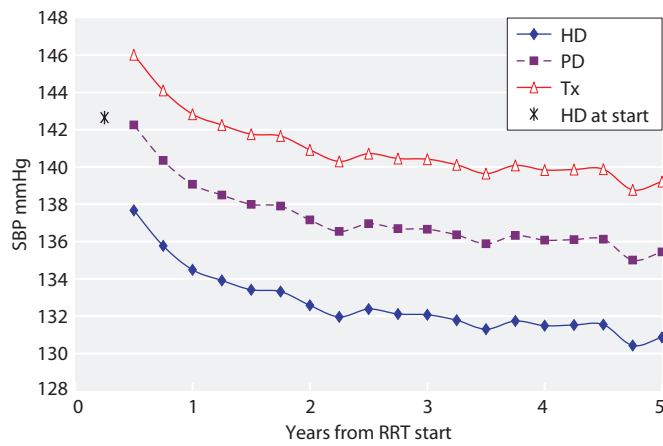
Figure 11.33 illustrates the adjusted mean systolic BP of incident HD patients (2000–2004) stratified by PRD. A test for interaction between time and PRD was not significant. This means that the trend of SBP decreasing with time is not different between PRD groups. A parallel model was therefore applied, which assumes identical SBP trajectories for each PRD group (the same applies to the model for DBP and models for BP in PD patients). Results showed that patients with macrovascular diseases maintained significantly higher BP measurements, compared with all other PRD groups ( $p < 0.0001$ ). SBP was higher in those patients with an uncertain diagnosis

(commonly ‘small kidneys’), than in patients with tubular or ‘other’ as their PRD ( $p < 0.001$ ). Finally, SBP was significantly higher in patients with glomerular disorders than in those with tubular diseases ( $p < 0.01$ ), but not compared with patients with ‘other’ as their PRD.

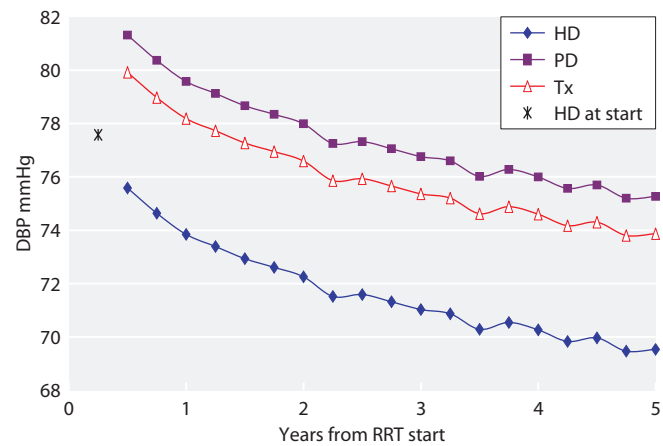
Figure 11.34 describes the adjusted mean diastolic BP (post-dialysis in HD patients) for incident HD patients (2000–2004) based upon the RRT modality utilised over the follow-up period. Patients who changed modality to Tx or PD had significantly higher DBP recordings than those patients continuing on HD ( $p < 0.0001$ ). In



**Fig. 11.31.** Median PP by primary diagnosis



**Fig. 11.32.** Adjusted mean systolic BP of incident HD patients (2000–2004), by subsequent RRT modality<sup>a</sup>  
<sup>a</sup> Reference glomerulonephritis, aged 65, starting in 2000



**Fig. 11.34.** Adjusted mean diastolic BP of incident HD patients (2000–2004), by subsequent RRT modality<sup>a</sup>  
<sup>a</sup> Reference glomerulonephritis, aged 65, starting in 2000

addition, the diastolic readings of HD patients who had moved to PD were significantly higher than the HD patients who had been transplanted ( $p < 0.005$ ).

Figure 11.35 demonstrates the adjusted mean diastolic BP of incident HD patients (2000–2004) stratified by PRD. DBP was higher in patients with glomerular disorders than in patients with macrovascular diseases or tubular disorders ( $p < 0.01$ ). Although patients with macrovascular diseases had higher SBP measurements than other PRD groups, the DBP of patients with macrovascular disease only differed significantly when compared with the glomerular disease group.

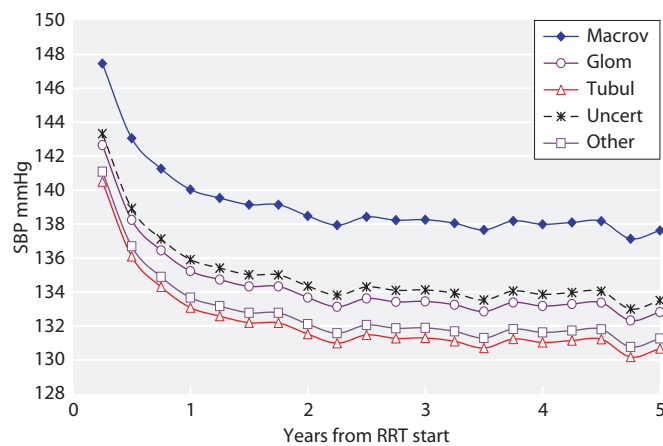
*Longitudinal BP analysis of incident PD patients*

There were 4,606 incident PD patients between 2000 and 2004, of which 2,675 patients had BP data available.

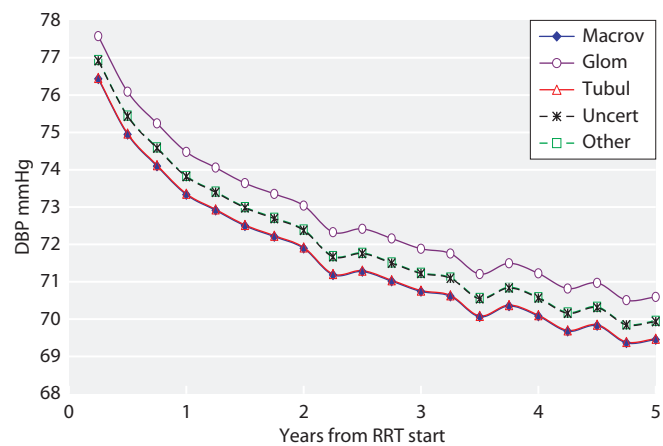
BP measurements in the 5 years following PD commencement were analysed. There were 1,440 patients who had had BP data extracted during the quarter in which they had started RRT. At one year, there were 1,101 PD, 202 HD and 60 Tx patients with BP measurements. At five years, there were 194 PD, 337 HD and 344 Tx patients with BP measurements.

Figure 11.36 shows the adjusted mean systolic BP for incident PD patients (2000–2004) based upon the RRT modality utilised over the follow-up period. Mean SBP recordings in patients starting on PD fell by an average of 6 mmHg within the first year of RRT, but then remained static.

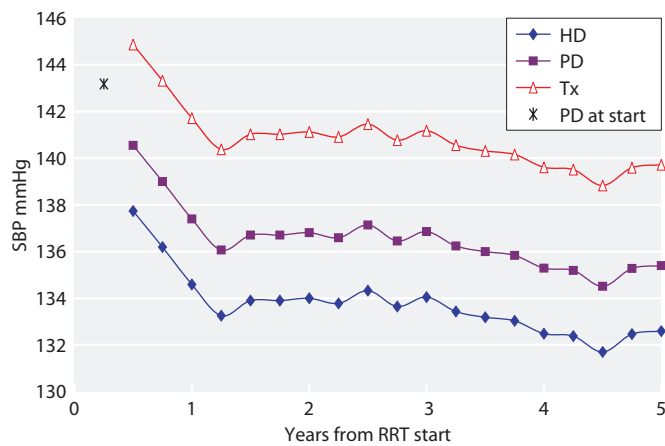
Incident PD patients who switched to HD achieved significantly lower SBP measurements than those patients who remained on PD or received transplants.



**Fig. 11.33.** Adjusted mean systolic BP of incident HD patients (2000–2004), by primary renal disease



**Fig. 11.35.** Adjusted mean diastolic BP of incident HD patients (2000–2004), by primary renal disease



**Fig. 11.36.** Adjusted mean systolic BP of incident PD patients (2000–2004), by subsequent RRT modality<sup>a</sup>  
<sup>a</sup> Reference glomerulonephritis, aged 60, starting in 2000

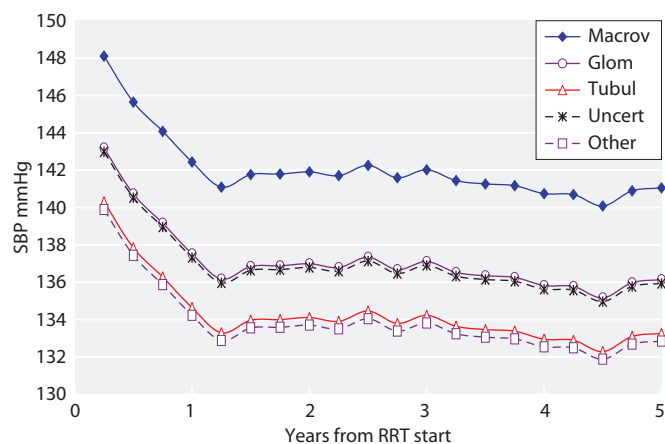
In addition, SBP was significantly higher in Tx patients than in patients continuing on PD ( $p < 0.0001$ ).

Figure 11.37 illustrates the adjusted mean systolic BP of incident PD patients (2000–2004) stratified by PRD. Patients with macrovascular diseases maintained significantly higher SBP measurements, compared to all other PRD groups ( $p < 0.0001$ ).

DBP was significantly higher in incident PD patients with glomerular disorders, compared with other PRD groups (data not shown).

*Longitudinal BP analysis of prevalent RRT patients*

All prevalent RRT patients from 2000 to 2008 with BP recordings were analysed. The number of prevalent patients with BP measurements increased from 2,646



**Fig. 11.37.** Adjusted mean systolic BP of incident PD patients (2000–2004), by primary renal disease

in the first quarter of 2000, to 12,812 by the last quarter of 2008.

A reduction in BP is seen over the 9 year study period with pre-HD systolic BP changing from a mean of 152.9 mmHg to 144.7 mmHg, post-HD BP from 137.4 mmHg to 132.4 mmHg, PD SBP from 143.1 mmHg to 138.9 mmHg and Tx SBP from 142.7 mmHg to 137.2 mmHg. In addition, post-HD DBP has fallen from 74.2 mmHg to 69.1 mmHg, PD DBP from 82.1 mmHg to 79.5 mmHg and Tx DBP from 80.4 mmHg to 78.2 mmHg.

When modeling the prevalent longitudinal BP data, no interaction between time and PRD was observed. This is similar to that observed in the incident cohort analysis, producing a model with equal BP trajectories for each PRD. Both parallel and linear models were examined, with the parallel model appearing more appropriate and showing a significant seasonal effect. A simpler linear analysis was also conducted, which ignored the ‘seasonal’ oscillations, to evaluate any overall decrease of BP in time.

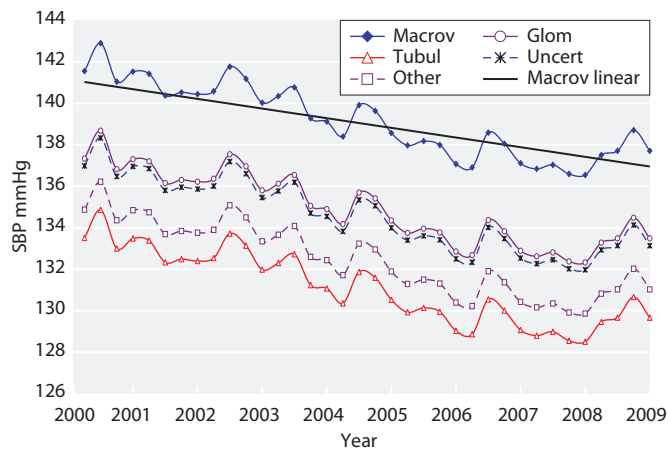
Following longitudinal multivariate modelling, adjusting for PRD, patient age and time from RRT start, post-HD SBP and DBP differed significantly with time ( $p < 0.0001$ ). Similarly there was a significant difference in SBP and DBP in transplanted patients ( $p < 0.0001$ ).

Longitudinal analysis of BP readings from PD patients had to be restricted to a shorter time range (years 2003–2008). When applying a parallel model, significant seasonal effect variation of BP in time was observed. However, the analysis showed no linear change with time in the average BP of PD patients. Corresponding restricted analysis on BP measurements from Tx and HD patients still showed a significant linear decrease of BP with time.

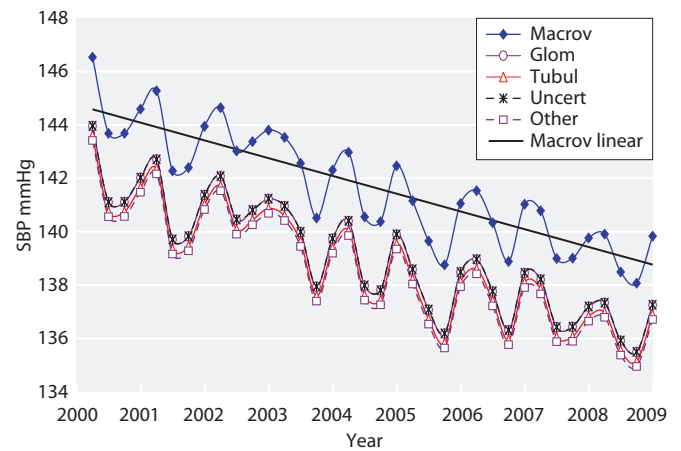
*PRD considerations in prevalent HD patients*

Figure 11.38 demonstrates adjusted mean post-HD systolic BP in prevalent HD patients, stratified by PRD. This adjusted longitudinal analysis shows post-HD SBP in patients with macrovascular diseases remained significantly elevated in comparison with all the other PRD groups ( $p < 0.0001$ ). However, a reduction in mean SBP, over time, is demonstrated in all PRD categories, with a cyclical fluctuation over the course of each year. SBP in all PRD groups fell by an average of 4 mmHg over the nine years (for illustration the linear trend for decrease is showed only for the macrovascular group). Tubular disorders in general had the lowest SBP and DBP.

Adjusted longitudinal analysis of post-HD DBP showed patients with a glomerular pathology maintained



**Fig. 11.38.** Adjusted mean post-HD systolic BP in prevalent HD patients, by primary renal disease<sup>a</sup>  
<sup>a</sup> Adjusted for age 60 years, 1year from RRT start

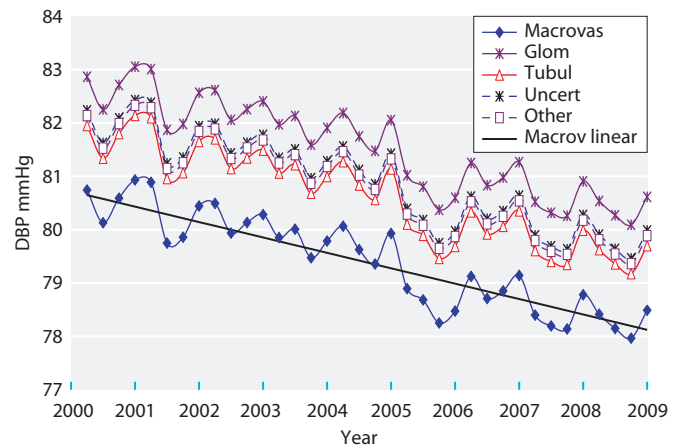


**Fig. 11.40.** Adjusted mean systolic BP in prevalent transplant patients, by primary renal disease<sup>a</sup>  
<sup>a</sup> Adjusted for patient age and time on RRT

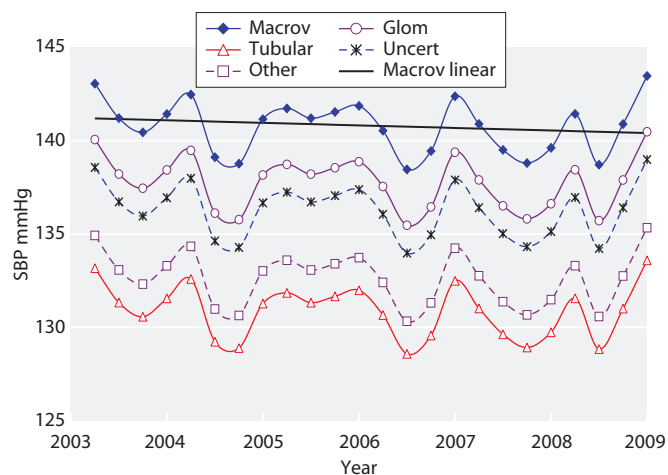
higher DBP over the nine-year study period compared with all other PRD groups ( $p < 0.0001$ ). In addition, the patterns of DBP readings remained similar and DBP in all PRD groups fell by an average of 4.4 mmHg over the nine years (data not shown).

*PRD considerations in prevalent PD patients*

Figure 11.39 shows the adjusted mean systolic BP in prevalent PD patients, stratified by PRD. The analysis fails to demonstrate a linear change in SBP, over time, in prevalent PD patients, regardless of the underlying disease pathology.



**Fig. 11.41.** Adjusted mean diastolic BP in prevalent transplant patients, by primary renal disease<sup>a</sup>  
<sup>a</sup> Adjusted for patient age and time on RRT



**Fig. 11.39.** Adjusted mean systolic BP in prevalent PD patients, by primary renal disease<sup>a</sup>  
<sup>a</sup> Adjusted for age 60 years, 1year from RRT start

*PRD considerations in prevalent transplant patients*  
 The adjusted longitudinal analyses in figures 11.40 and 11.41 show SBP and DBP differ significantly between PRD groups in Tx recipients ( $p < 0.0001$ ). Patients with macrovascular disorders have higher SPB and lower DBP measurements compared with any other PRD, while minor differences were observed between the other four PRD groups.

**Discussion**

The current study showed only a minority of patients on RRT in England, Wales and Northern Ireland

achieved RA standards for BP control in 2008. Despite BP targets no longer existing for HD patients, the UKRR continues to report achievement against the previous standard to document any effect the new clinical practice guidelines may have. Significantly, more HD patients achieved the old BP standards (43.7% pre-dialysis and 46.8% post-dialysis) than PD (26.3%) or Tx (27.4%) patients achieving the current targets. BP control continues to vary significantly between different renal centres for each treatment modality. BP data were extracted from more patients than previously, but both recording outpatient readings on renal IT systems and extraction of that information by the UKRR remains a challenge, with data analysed for only 41.8% of PD and 32.6% of Tx patients. In the future, the UKRR hopes to collect BP data from every HD session in the UK.

Longitudinal analysis of prevalent BP data collected between 2003 and 2008 showed a significant linear trend of reducing BP for prevalent HD and Tx patients, but not for PD patients. A smaller percentage of HD and PD patients achieved BP standards in 2008 compared with the previous year. A longer period of observation is required to see if this is due to BP variability or the first indication of a rise in BP following the introduction of the new guidelines. The impact of dialysis on BP was shown by analysing incident patients over a five-year period. Systolic BP fell significantly during the first year but then stabilised at that reduced level for both HD and PD. The drop in mean SBP during this first year was greater for HD patients (8 mmHg) than for PD patients (6 mmHg). No drug data for these patients were available, though other studies suggest lower BP is achieved by probing dry weight rather than using antihypertensive medication. A retrospective study of 124 home HD and 44 PD patients from New Zealand examined the effect of BP one-year post-RRT commencement on subsequent survival [16]. Less than five percent continued antihypertensive medication after starting dialysis and only seven percent were diabetic. Although low BP at baseline was associated with decreased survival, patients whose BP became low in the first year were not at additional risk. Median survival after one-year for low, medium and high BP (defined by mean arterial pressure) was 3.79, 4.05 and 1.82 years respectively. These analyses show UK dialysis practice significantly reduces BP in the first year, which could improve life expectancy. HD patients who remained on HD had significantly better BP control than patients who transferred to PD or were transplanted. BP rose

significantly when HD or PD patients were transplanted. The introduction of cyclosporin may be one contributing factor to this phenomenon as mean SBP has been shown to fall by 7 mmHg when this drug is withdrawn [17]. The UKRR does not currently collect drug data to pursue the link between hypertension and immunosuppression in Tx patients.

In the UK, patients with vascular disorders (diabetics and renal vascular disease) have the worst prognosis on dialysis and are least likely to be transplanted [18]. The current study showed SBP remained significantly higher in these patients compared to those with glomerulonephritis or tubular disorders over a five-year period. The effect was marked for both HD and PD patients. An audit of London renal centres showed diabetics had the highest BP despite taking more antihypertensive medication and that this was associated with higher interdialytic weight gains and more frequent symptomatic intradialytic hypotension [19, 20]. Diabetics with the lowest HbA1c values had the lowest SBP despite taking fewer antihypertensive medications. Hyperglycaemia clearly influences thirst and fluid intake so should be targeted aggressively to control hypertension in diabetics. There are no equivalent data for patients with renal vascular disease but they often have established cardiac atherosclerosis which would make them more prone to intradialytic hypotension.

Several limitations of this study should be noted. Blood pressure measurements during routine patient care would not have been taken using a standardised protocol across the renal centres. The high rates of missing data may introduce bias and inadequate comorbidity data and absent drug data prevents the UKRR performing the appropriate risk adjustments for BP analyses. A recent meta-analysis has highlighted the need to collect appropriate drug data in dialysis hypertension trials [21]. The study analysed eight small, randomised controlled trials and concluded lowering BP reduced cardiac events and mortality in dialysis patients. Mean systolic and diastolic BP were reduced by 4.5 and 2.3 mmHg, respectively, however four of the trials included patients with cardiac failure. Beneficial drug effects may therefore be due to cardio-protection rather than BP lowering per se. The cardio-protective effects of drugs may take several years to emerge. The beneficial effects of fluvastatin in renal Tx patients were only demonstrated after an extended period of follow up over seven years [22]. The proposed OCTOPUS trial [23] hopes to establish target blood pressure for hypertensive HD patients, the usefulness of home BP

monitoring and the effect of olmesartan. However, a potential limitation of OCTOPUS is its short duration; it is scheduled to run for 3 years, and consequently may not achieve its aims.

It is hoped that over the next few years, renal IT systems will be increasingly used to record patient drug

information. Consequently, the UKRR will be able to analyse whether the significant drop in blood pressure during the first year on dialysis identified in the longitudinal analyses reflects medication or ultrafiltration.

Conflict of interest: none

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